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Fading premiums: The effect of light rail on residential property values in Minneapolis, Minnesota

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ABSTRACT

This study uses property-level repeat sales transaction data to test for the presence of a premium for single-family homes within half a mile of stations on the METRO Blue Line in Minneapolis, Minnesota. Using a difference-in-differences approach, we find that the premium for station proximity varies substantially depending on control group and period definitions for "after" light rail. Using homes in the rest of Minneapolis as controls yields growing positive premiums from proximity to light rail stations, while using homes in neighborhoods similar to those near stations yield smaller premiums that fade to zero over time.

Does light rail induce households to move closer to rail stations and reduce automobile use, thereby reducing congestion and pollution? If it does, increased demand for locations closer to rail will push up prices of homes near stations. The presence or absence of premiums from proximity therefore serves as evidence of whether light rail induces the behavioral responses required for it to change transportation patterns and reduce pollution and other externalities. This study uses property-level repeat sales transaction data to test for the presence of such a premium for single-family homes within half a mile of stations on the METRO Blue Line in Minneapolis, Minnesota.[1] Our data, which cover home sales from 1990 to 2014, enable us to use a difference-in-differences approach to estimate the effects of light rail on single-family home values using three different control groups and assuming all possible definitions of "before" and "after" periods, and to disaggregate our estimates by station area.

The METRO Blue Line is Minneapolis' first light rail project. First envisioned in 1985 as a pollution and congestion mitigation strategy for a highway in the corridor, it became a reality when it received both federal and state funding in 1998. After six years of planning and construction, the Blue Line commenced full service between downtown Minneapolis, the Minneapolis-Saint Paul International Airport, and the Mall of America in December 2004. The project cost $715.3 million (nominal) dollars and surpassed its 2020 ridership forecast of 24,600 daily boardings in 2006 (Metro Transit, 2010).

More than one hundred studies estimate the effect of transit on property values. The majority use cross-sectional data (see for example Cervero and Duncan (2002a, 2002b), Duncan (2008)).[2] Such studies can obtain detailed estimates of property value gradients at a given point in time, but may suffer from omitted variable bias and cannot isolate the effects of rail from other housing market shocks. Estimates from the broader literature may therefore depend critically on researchers' choice of approach. Indeed, meta-analysis shows that estimates from studies on transit and property values differ substantially depending on the type of data and the methods used (Debrezion et al. (2007), Hamidi et al. (2016), Mohammad et al. (2013)).

To address possible omitted variable bias, some studies use repeat sales data, which enable them to control for any time-invariant property or neighborhood characteristics. McMillen and McDonald (2004) use a repeat-sales estimator and data from before and after the introduction of Chicago's Midway line. They demonstrate that locations close to rail

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[1] The METRO Blue Line was referred to as the "Hiawatha Line" until 2013, when the color nomenclature was adopted during construction of a second line, the METRO Green Line.

[2] Bowes and Ihlanfeldt (2001) has five years of data that enables use of a lag structure, but does not have panel data.

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stations command premiums even before a rail enters service and that premium magnitudes differ by time period after the line was introduced.[3] Chatman et al. (2012) and Kim and Lahr (2013) also use repeat-sales models and long before-and-after time frames to examine the effects of two light rail lines, one urban and the other suburban, on home values in New Jersey.

Other studies account for the possibility that movements in prices of homes near rail stations are determined by factors other than the introduction of a rail line. For example, Billings (2011) and Wagner et al. (2017) use difference-in-differences approaches to compare prices of homes near light rail in Charlotte, North Carolina, and Hampton Roads, Virginia, respectively, with prices of homes in corridors that were considered for light rail but were ultimately not selected.[4] Cao and Lou (2017) compare values of homes close to the Green Line in Saint Paul Minnesota with those along two other transportation corridors, before and after the introduction of the Green Line in Saint Paul, Minnesota.[5]

Two studies estimate the effect of the METRO Blue Line on values of nearby properties using difference-in-differences approaches. Goetz et al. (2010) uses single-family home transaction price data from 1997 to 2007 and estimates a premium of $7188 in 2014 dollars, or about four percent of the average home price, for homes located within half a mile of a station relative to the rest of south Minneapolis. Ko and Cao (2013) perform a similar analysis using data through 2008 and find small but positive premiums for commercial and industrial properties.

Findings from these two studies stand somewhat in contrast with those in Hurst and West (2014), which shows that neither construction nor operation of the Blue Line affects land use change relative to the time before construction, relative to similar parcels in well-defined control areas. Unlike the earlier studies on the effect of the Blue Line on prices, theirs examines a longer time period after the introduction of the light rail, which suggests that results may be sensitive to assumptions about the appropriate definition of "before" and "after" light rail. Of course, it is entirely possible that home prices capitalize effects even in the absence of effects on land use, particularly in neighborhoods dominated by single family homes like those along the Blue Line.

Our sales price data from Minneapolis' Tax Assessment Office run from 1990 to 2014, and are dense enough with repeat sales to allow us to estimate effects of light rail in all possible combinations of "before" and "after" time frames within that period. They also allow us to use home fixed effects to control for time-invariant characteristics correlated with proximity to stations and to examine the possibility that effects of light rail are heterogeneous across different neighborhoods. While previous studies have found evidence that the magnitude of light rail effects changes as the time from opening lengthens (McMillen and McDonald, 2004) or recommend examining changes over time (Kim and Lahr, 2013), ours is the first study that we know of that uses repeat sales data to estimate difference-in-differences models to understand how the shock of light rail is transmitted into home prices as time accumulates between opening date and home sale date.

We compare prices of homes near stations to those in three control groups and find that the premium for station proximity varies substantially depending on what we use as a control area, and depending on period definitions for "after" light rail. The more similar the comparison area, the smaller and less significant are our estimates of light rail effects. Comparison to the rest of the city suggests that premiums from light rail are significant and grow over time. But this comparison could reflect changes over time in the relative attractiveness of south Minneapolis relative to other neighborhoods, something for which we cannot adequately control in a full city specification. When we limit our comparison group to south Minneapolis or to an even smaller group within one mile of stations—to houses in neighborhoods that are much more similar to those within the light rail corridor—we find that homes sold at least twice in the light rail corridor experienced price increases ranging from 2.5 to 4 percent greater than homes sold twice in the rest of south Minneapolis, but only in the years immediately following the opening of the light rail. These results reproduce prior studies' positive premiums. But by 2011, seven years after service began, no premium is statistically greater than zero, no matter our definition of the before and after periods. Disaggregation by station area yields a positive premium for only one of six station areas.

In Section 1 we discuss our study area and time periods. In Section 2 we describe our data and present summary statistics. In Section 3 we explain our estimation methods and present our results. We conclude and offer directions for further research in Section 4.

1. Study area and time periods

1.1. Study area

The METRO Blue Line runs 12.3 miles from downtown Minneapolis in the north to the Mall of America in the south. As shown in Fig. 1, nineteen stations are located on the line, which passes through downtown Minneapolis, "south Minneapolis," and first ring suburb Bloomington.[6]

We define the treatment group as all single-family homes in south Minneapolis sold more than once and located within half a mile (804 m) of the Franklin Avenue, Lake Street, 38th Street, 46th Street, 50th Street and VA Medical Center stations.[7] We limit the treatment to repeat sales because we want to use home fixed effects to control for time-invariant determinants of sale price that may be correlated with proximity to light rail. We omit residences in the downtown area because they are condominiums, a housing type for which a separate study is warranted. We do not consider homes near stations in the airport, Bloomington, or Mall of America areas, as they are very few, and their surroundings differ dramatically from any potential control group area.[8]

Ideally we would compare the changes in sale prices for these homes with changes in sale prices for identical homes along an identical corridor that does not have light rail. Such homes, of course, do not exist. Planners did not formally consider another corridor for a within-city north-south light rail line; we cannot use a method similar to Billings (2011) or Wagner et al. (2017) to choose a control group. We therefore choose homes in an area with homes and neighborhoods very similar to the treatment area—those located in the rest of the south Minneapolis submarket bounded by Interstates 35 W and 94, State Highway 62 and the Mississippi River. Fig. 2 shows this study area, the stations in south Minneapolis, and the innermost ring station areas within south Minneapolis. We also consider a narrower control group of single family homes in south Minneapolis located just outside the rail corridor, between ½ mile and one mile (1609 m) from LRT stations. We depict these areas in Fig. 2, marking these areas with a second set of rings around stations. As we show in the summary statistics section below, home prices and neighborhood characteristics are very similar in our treatment area and in the two south Minneapolis control areas before light rail is introduced,

[3] Simply issuing plans for light rail may affect property values, as Knaap et al. (2001) finds for vacant land prices in Washington County, Oregon.

[4] Wagner et al. (2017) focuses on a light rail system that had low ridership numbers relative to lines in other cities, and is one of the few studies to find a negative effect of proximity on property values. Diao et al. (2017) also uses a difference-in-differences technique and finds positive effects of a new rail line on non-landed residences in Singapore. Neither study uses repeat sales.

[5] Billings (2011) uses repeat sales in robustness tests, and struggles to some degree with small sample sizes. Cao and Lou (2017) do not use repeat sales, instead attempting to address potential omitted variable bias using a set of home and neighborhood controls. Their study examines effects only in the first two years after the line went into service.

[6] We follow Twin Cities residents by referring to our study area as "south Minneapolis," even though it is in the southeast corner of the city. Locals use "southeast Minneapolis" to refer to a much smaller neighborhood immediately southeast of downtown.

[7] Results when we instead assign homes within 1 km of stations to the treatment group are very similar.

[8] The VA Medical Center station is located outside Minneapolis. However, many homes near this station are located within Minneapolis city limits, and are included in the home sales data made available by the city.

Fig. 1. The METRO blue line. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

and home prices in these areas move closely together in our before-LRT period. To understand the effects of narrowing the control groups in these ways, we compare results with those using homes sold more than once in the rest of Minneapolis.

1.2. Time periods

Talk of light rail service in south Minneapolis started as early 1985 when planners envisioned building a light rail line along Highway 55/

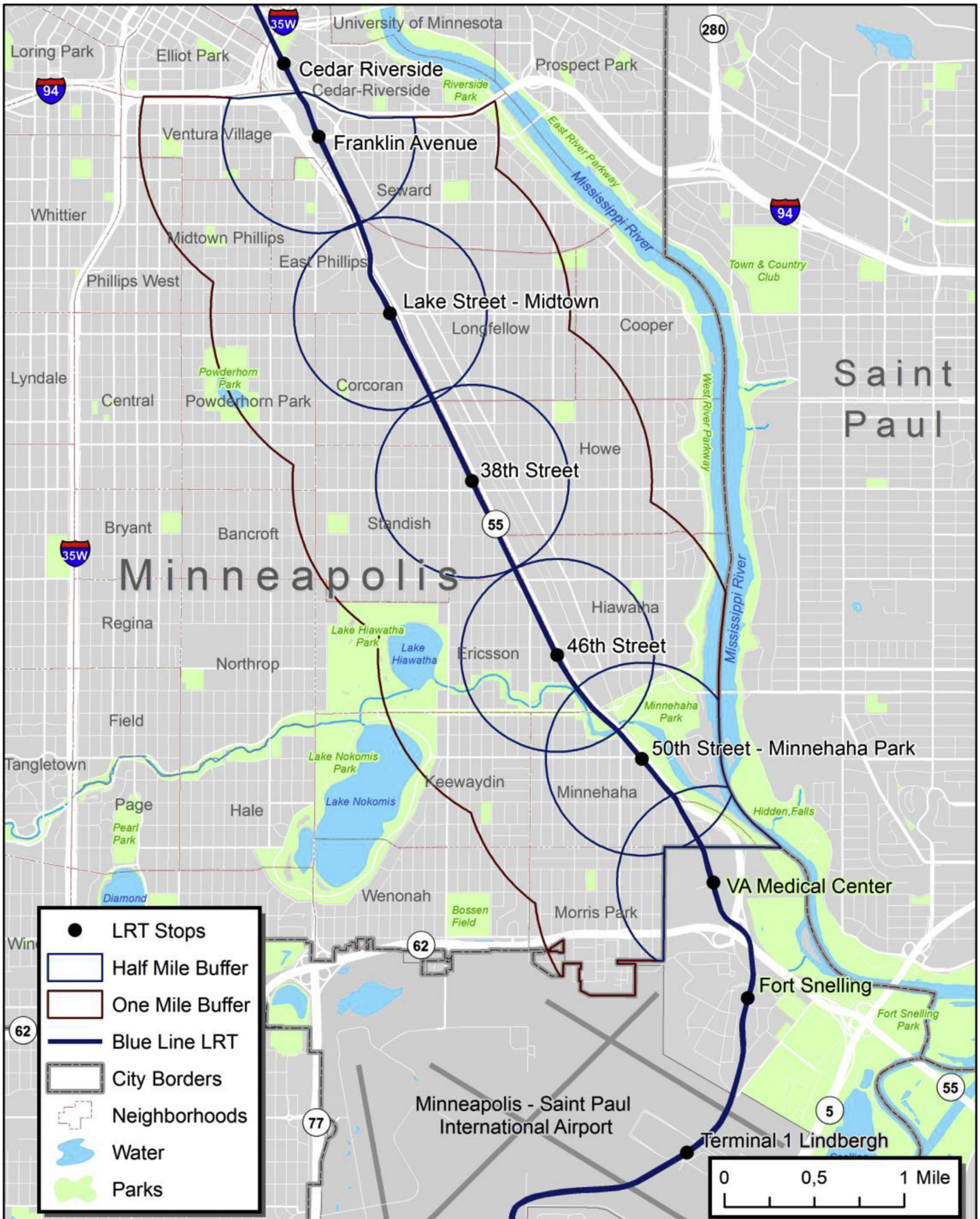

Fig. 2. Station areas in south Minneapolis.

Hiawatha Avenue (Metro Transit, 2010). As explained in Hurst and West (2014), the area in the corridor had been in limbo since the 1960s, when plans to construct an interstate were scrapped after homes had been torn down to make way. Goetz et al. (2010) explains that "real progress" on the line was made in 1998 and 1999, when the Minnesota legislature appropriated funding for the project and that local newspapers' references to a "Hiawatha corridor" light rail spiked in the first quarter of 1998. Our main estimation therefore uses 1998 as the first year "during

Table 1
Summary statistics by area.

	South Minneapolis Within ½ Mile		South Minneapolis ½ to 1 Mile		South Minneapolis Outside ½ Mile		All Minneapolis Outside ½ Mile	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Sale Price (2014 $)	$168,496	70,609	$173,960	76,759	$195,811	93,967	$228,241	193,156
Distance to Station (Meters)	585.3	157.5	1160.3	233.1	2219.8	1093.0	5070.1	2569.4
Distance to CBD (Meters)	5333.6	1825.0	4906.4	1824.3	5464.6	1766.1	5274.2	1924.3
Distance to Water (Meters)	940.8	444.8	838.2	351.9	826.5	447.2	908.1	463.9
% White	75.0	16.8	76.7	19.2	73.7	22.0	73.8	23.6
% African American	8.6	6.7	7.3	6.7	11.7	13.1	12.8	15.8
% American Indian	3.5	5.1	3.1	3.9	2.0	2.7	1.4	1.9
% Asian or Pacific Islander	2.6	1.4	2.8	2.1	2.9	2.2	4.4	4.5
% Percent Other Race	3.0	2.0	2.7	1.6	2.8	1.7	2.7	1.8
% Percent Hispanic	7.3	6.9	7.5	8.9	7.0	8.3	4.9	6.0
% Age $<$ 20	23.5	5.3	23.7	5.6	24.9	5.5	25.4	8.0
% 19 $<$ Age$<$ 66	64.2	6.1	64.9	5.4	64.4	4.8	63.8	7.4
% Age$>$65	12.3	6.8	11.4	6.2	10.7	4.8	10.7	5.3
Median Income (2014 $)	$54,533	11,904	$57,730	12,779	$65,407	17,745	$68,818	28,158
Number of Sales	5454		8919		23191		68998	
Number of Homes	2057		3364		8622		25577	

planning and construction" of the light rail. This period continues until June 26, 2004, the day the light rail commenced regular passenger service.[9] The years 1990 through 1997 are "before announcement" of the light rail project. Our data runs through July of 2014, ten full years after the light rail went into service and several years after the Twin Cities recovered from the housing market crisis.

While we feel comfortable with our choice of time periods, we are also interested in understanding the effects of allowing for different years to be included in the before and after periods. In specific, we want to examine truncating before and after periods to reflect assumptions and data limitations in previous studies and to understand how the shock of light rail is transmitted into home prices as the time accumulates between opening date and sale date.

2. Data and summary statistics

2.1. Data

The three main datasets used in this project contain sales data, parcel and spatial data, and Census data. Sales data come from the City of Minneapolis' Tax Assessment Office and record all market transactions for single family homes in Minneapolis. These data are available starting in January 1983, but we use only 1990 forward in our estimation, to facilitate matching with 1990 and later census information. Variables included in this dataset are the parcel identification number, the address of the property, the date on which it was sold, and the nominal sales price, measured in dollars, which we inflate to year 2014 dollars using the Consumer Price Index for all Urban Consumers.

Parcel data come from MetroGIS, the Twin Cities Metropolitan Council's data kiosk. The data we use represent all parcels of land in Hennepin County (in which Minneapolis lies) in April 2014. We use these data to geocode each home. Light rail line and station shapefiles also come from MetroGIS, and represent the spatial locations of the light rail tracks and stations. Similarly, MetroGIS supplied GIS (Geographic Information Systems) polygon shapefiles for lakes, rivers and Minneapolis neighborhoods. We use GIS to generate straight line distance variables from parcels to the nearest light rail stations, to the central business district (downtown Minneapolis), and to the nearest lake, or, if closer than the nearest lake, to the Mississippi River.[10]

We draw demographic variables 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, we draw median incomes, the percentage of the population that is white, black, American Indian, Asian or Pacific Islander, or Hispanic, and the percentage over the age of 65, between 20 and 65 years old, and the percentage under the age of 20. The smallest spatial level of aggregation at which these variables are available from both the Census and from ESRI's demographic projections is the block group level, where one block group contains an average population of approximately 1000 people. Because block group boundaries changed between census years, we 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 contains estimates for 1990, 2000, 2011, and projections for 2016. We interpolate values for intervening years. In addition to these sources, we rely upon Geolytics' estimates for block group median household incomes for the year 2005, which are reported at the 2000 census block group level.

All datasets from the City of Minneapolis and from MetroGIS 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 by spatial location using GIS.

2.2. Summary statistics

Table 1 presents summary statistics for home sales within the ½ mile corridor in south Minneapolis, those in south Minneapolis between ½ and 1 mile from stations, those in all south Minneapolis outside the two ½ mile buffers, and those citywide outside the two ½ mile buffers. These statistics are over the whole sample period from 1990 to 2014. The average price paid for homes sold within a half mile during those years was $168,496 in 2014 dollars. That number is higher for homes in the half mile adjacent to the corridor, higher again for south Minneapolis as a whole, and highest, $228,241, for the whole city outside the corridor. Distances to central business district and nearest body of water are roughly similar across all groups. Statistics for race, age, and median income are by homes' block groups. Demographics within the corridor are most similar to those in the adjacent ring, while broader south Minneapolis and the city have fewer people who self-identify as white, American Indian, Hispanic, and other races, and more people who identify as Asian or Pacific Islander and African American. Median income is lowest in the corridor, on average, and highest for the rest of

[9] At its opening date, the Blue Line did not serve the Mall of America and the airport stations. Service to these stations began in December 2004.

[10] Estimates using Manhattan distances, which may better reflect true walking distances, are very similar to those using straight line distances.

Table 2
Sale price (2014 $) by period and area.

	Before (1990–1997)			During Construction (1998-mid2004)			After (mid2004-mid2014)		
	Mean	St. Dev.	Number of Sales	Mean	St. Dev.	Number of Sales	Mean	St. Dev.	Number of Sales
Within ½ Mile in south Minneapolis	$106,477	32,101	1858	$182,449	60,538	1970	$222,460	59,700	1626
1/2 to 1 mile in south Minneapolis	$110,588	36,782	3074	$186,518	66,598	3127	$231,185	68,593	2718
Outside ½ mile in south Minneapolis	$127,927	51,355	6941	$209,491	82,367	8118	$259,180	94,052	8132
Outside of ½ mile in all Minneapolis	$154,804	126,804	24207	$236,378	179,166	24302	$305,355	237,015	20489

Minneapolis. Our sample size is large given the requirement for a home to sell at least twice within the time frame of our analysis: 5454 sales occur of 2057 homes within the corridor; 8910 sales occur of 3364 homes between ½ and one mile of stations; and substantially more sales take place of homes outside the corridor in south Minneapolis and citywide.

Table 2 breaks home sale prices down further by period for the treatment group and three controls. Unadjusted for other determinants of changing relative home prices, homes ½ to 1 mile from light rail stations in south Minneapolis experienced the greatest percentage change in real prices between the before and after periods (109.05%), followed by homes in the corridor in south Minneapolis (108.93%), homes in south Minneapolis outside the corridor (102.60%), and homes citywide outside the corridor (97.25%).

For a closer look at the time series of home prices in within the corridor and in the three comparison areas, consider Fig. 3. The four series generally move in concert. Prices in areas closest to the corridor are the most similar to prices within the corridor, and notably are very similar to prices within the corridor before construction. A small degree of divergence in prices inside the corridor versus prices between half a mile and one mile from stations appears following the beginning of construction.

3. Estimation and results

3.1. Comparisons of estimates across three control groups

We estimate one difference-in-differences model for each of the three control groups that we compare to the treated homes within one half mile of Blue Line stations. The dependent variable is $\ln P_{ijt}$, the log of home sale price in 2014 dollars for home i in census block group j in period t. We estimate log price as a function of the variable H_i, an indicator equal to one if the parcel is within half a mile, and a vector of time period indicators, T_t, which differentiate the effects of the line being announced, under construction ("during") and of the line being in service ("after"). 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, geographically-clustered residuals suggested that price effects of such characteristics did. To control for these trends, we include an interaction term between time periods and a vector L_i of the distances between property i and both downtown Minneapolis and the nearest body of water, where a body of water is either the Mississippi River or the nearest lake, whichever is closer. To account for changes in neighborhood characteristics over time other than the introduction of the Blue Line LRT, we include a vector D_{jt} of demographic control variables for each census block group j at the time t for each property i. These demographics include the share of the population that is white, the share that is African American, the share that is Asian or Pacific Islander, the share that is American Indian, the share that is Hispanic or Latino, the share that identifies as another race, the share that is under the age of 20, between 20 and 65, the share that is over the age of 65, and the log of median income.

Our repeat sales data from 1990 to July 2014 enable us to use home fixed effects, γ_i, to control for time-invariant home characteristics that may be correlated with proximity to light rail, and year-of-sale (θ_y) and month-of-sale (μ_m) fixed effects to account for city-wide trends and seasonality that affect all homes equally:

$$\ln P_{ijt} = \alpha + \beta_1 \boldsymbol{T_t} + \beta_2 \boldsymbol{H_i T_t} + \beta_3 \boldsymbol{L_i T_t} + \beta_4 \boldsymbol{D_{jt}} + \beta_5 \boldsymbol{\theta_y} + \beta_6 \boldsymbol{\mu_m} + \gamma_i + \varepsilon_{itj} \tag{1}$$

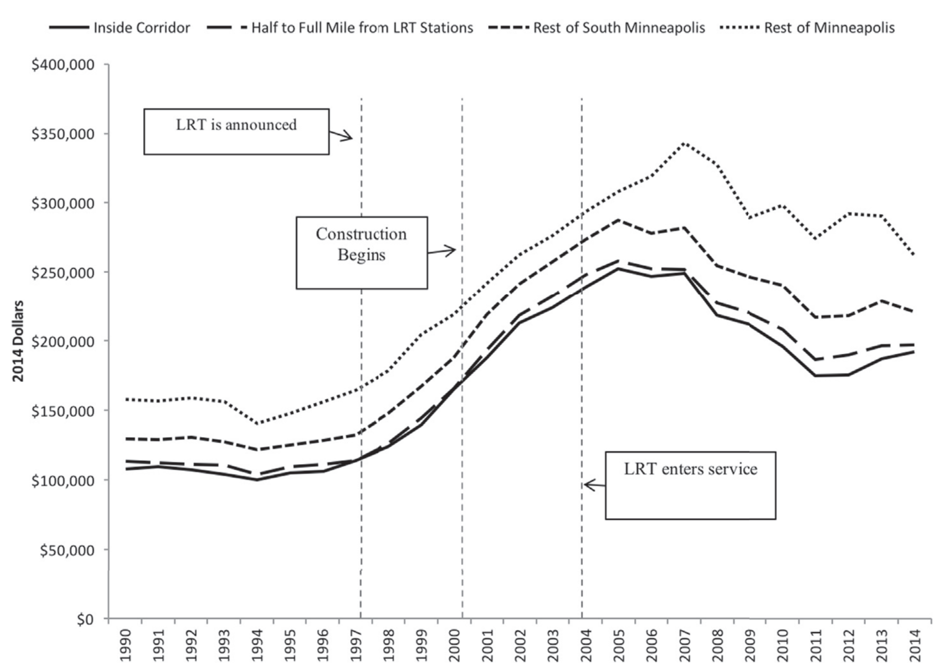

Fig. 3. Home prices in Minneapolis, 1990–2014 ($2014).

We estimate this model using OLS. We are interested in the coefficients in the vector β_2, the average treatment effects, as they tell us the additional effect of being within a half mile that occurs only during construction ($t = 2$) or after the light rail went into service ($t = 3$).

We estimate equation (1) separately for three different control groups: homes in south Minneapolis, a narrower group of homes between one half mile and one mile in south Minneapolis, and a broader group consisting of homes outside the corridor citywide. We adjust the standard errors to account for spatial correlation in residuals across properties (Goetz et al., 2010; Hess and Almeida, 2007; Paez, 2006; Du and Mulley, 2006). We cluster observations on the smallest geographic boundary available—2010 census block groups—of which there are 350 in our citywide sample, 125 in south Minneapolis, 83 within one mile of stations, and 44 within one half mile of stations.

Table 3 shows results from this estimation. To interpret the coefficients on indicator variables as percentage changes in home price, we transform the coefficients of interest according to Halvorsen and Palmquist (1980). Because the coefficients are small, the percentage changes are very similar to the estimated coefficients. Still, we report the percentages, along with p-values on non-linear Wald tests for statistical significance of the percentages, in Table 4.

To interpret these results relative to others that follow, keep in mind that our baseline "before" period is from 1990 to 1997, "during" is 1998 through mid-2004, and "after" is mid-2004 until our sample ends in mid-2014. Using all of south Minneapolis as the comparison group (results in column 1), the "after" difference in differences—the additional change in home value after the rail went into service compared to before the light rail was announced, compared to the change in home value for homes outside the corridor in those same time periods, is small (about 1 percent) and not statistically different than zero. The estimate using the narrower control group of homes (column 2) between one half and one mile is of similar size and also is not statistically significant.

In contrast, when comparing differences in home values in the corridor to differences in home values outside the corridor citywide (column 3), a comparison we think is unwise, the difference in differences is a statistically significant 4.29 percent. That is, homes in the corridor appear to have appreciated by more than homes outside the corridor, controlling for changes in demographics, time-invariant home characteristics, and changes in the value of proximity to bodies of water and the central business district. This suggests that choice of control group has important effects on estimated effects of proximity to the METRO Blue line.

Table 3
Estimation results, three comparison groups, full time period 1990–2014.

	(1) South Minneapolis	(2) Within One Mile	(3) All Minneapolis
After*Inside Corridor	0.00978	0.0124	0.0421***
	(0.0137)	(0.0134)	(0.0146)
During*Inside Corridor	0.0150	0.0117	0.0250**
	(0.0102)	(0.00957)	(0.0114)
After	2.006***	1.739***	1.881***
	(0.206)	(0.254)	(0.146)
During	1.506***	1.201***	1.359***
	(0.173)	(0.224)	(0.109)
After*(Ln Distance to Water)	0.0165*	0.0121	0.0209***
	(0.00893)	(0.0135)	(0.00661)
During*(Ln Distance to Water)	0.0160*	0.0163	0.0332***
	(0.00870)	(0.0136)	(0.00564)
After*(Ln Distance to CBD)	−0.159***	−0.124***	−0.151***
	(0.0209)	(0.0249)	(0.0147)
During*(Ln Distance to CBD)	−0.103***	−0.0653***	−0.101***
	(0.0172)	(0.0195)	(0.0112)
Percent Black	−0.510***	−0.279	−0.671***
	(0.108)	(0.183)	(0.0782)
Percent American Indian	−0.301	−0.612**	−0.817***
	(0.202)	(0.259)	(0.210)
Percent Asian or Pacific Islander	0.153	−0.0299	−0.496***
	(0.299)	(0.418)	(0.162)
Percent Other Race	0.140	−0.0319	0.00377
	(0.347)	(0.386)	(0.334)
Percent Hispanic	0.200*	0.0834	0.0414
	(0.110)	(0.142)	(0.0988)
Percent Under 20	−0.00438	−0.264	0.856***
	(0.180)	(0.255)	(0.146)
Percent Over 65	0.213*	0.0399	0.433***
	(0.123)	(0.129)	(0.104)
Log Median Income	0.0307	0.0185	0.0733***
	(0.0319)	(0.0451)	(0.0260)
Constant	11.38***	11.42***	10.82***
	(0.370)	(0.517)	(0.297)
Number of sales	28645	14373	74452
Number of homes	10679	5421	27634
Number of block groups	125	82	350
R-squared	0.759	0.760	0.725

All regressions include home, year, and month fixed effects. Standard errors (in parentheses) are calculated clustering on 2010 census block group. *** $p < .01$, ** $p < .05$, * $p < .1$.

Table 4
Transformed coefficients of interest.

	(1) South Minneapolis	(2) Within One Mile	(3) All Minneapolis
After*Inside Corridor	0.0098	0.0125	0.0429***
During*Inside Corridor	0.0151	0.0117	0.0253**

Multiply by 100 to obtain percentage change in home price.
Statistical significance of nonlinear Wald test of transformed coefficients *** *p.01*, ** *p.05*

3.2. The effect of sample time periods on estimates of LRT on home value

Most previous studies of the effects of light rail on home price, including one on the Blue Line (Goetz et al., 2010) find positive and statistically significant effects of light rail on home prices. Perhaps our statistically insignificant results are due to the fact that we estimate effects over a longer time frame. To explore this possibility we run the specification in equation (1) not just over a few alternate sample periods, but trimming our data to start in each of the possible start years between 1990 and 1997 combined with each possible end year between 2004 and 2014.[11]

Table 5 presents Halvorsen and Palmquist (1980) adjusted coefficients, the additional percent change in home price attributable to being within one half mile of a station after Blue Line service began. To understand this table, first note that the lower leftmost number in Panel A is 0.0098, which is our number of interest using the rest of south Minneapolis as a control group, presented earlier in Table 4. It says that the premium from being within a half mile of stations when the line is in service is a statistically insignificant 0.98 percent. It is estimated using all of the years of our sample, 1990 through mid-2014. Next, look for example at the number in the cell in the fourth column and fourth row in Panel A. That number, 0.0397, is estimated assuming that the "before" period starts in 1993, and includes homes sold through 2007. Under that assumption and for that sample, homes within half a mile experience a statistically significant and nearly 4 percent premium compared to homes in the rest of south Minneapolis.[12]

[11] We also experimented with extending the before period to include sales from in the period after announcement but before construction began (1998, 1999, and the first part of 2000). Results from moving 1998 to the before period in this way are similar to the results we report below, but moving the "during construction" year 1999 or both 1999 and 2000 to the before period changes results substantially, suggesting that these years are different than other "before" years, and should be treated as such.

[12] The number in the rightmost column, third row, 0.0319, corresponds with assumptions and sample used by Goetz et al. (2010). It is not statistically different from zero. We hesitate to directly compare out results with those of Goetz et al., however, because their model has no home fixed effects and instead attempts to control for time invariant home characteristics by including some of such characteristics directly. We do not have such characteristics in our sample; when we run our estimation without home fixed effects, our estimates of interest are all negative and statistically insignificant.

Table 5
Transformed coefficients, control group comparison, all sample periods.

	1990	1991	1992	1993	1994	1995	1996	1997
Panel A: Rest of South Minneapolis								
2004	0.0382	0.0498	0.0624	0.067*	0.0581	0.0584	0.0572	0.0711
2005	0.0302	0.0349*	0.041*	0.0439**	0.039*	0.0314	0.0338	0.0299
2006	0.0305*	0.0336*	0.0426**	0.0488**	0.0439**	0.0345	0.0352	0.0446*
2007	0.024	0.0272*	0.0332**	0.0397**	0.0327*	0.0244	0.0252	0.0319
2008	0.0199	0.023	0.0284*	0.034*	0.0284	0.0191	0.0181	0.0241
2009	0.0187	0.0207	0.0251*	0.0306*	0.0263	0.0159	0.0153	0.0149
2010	0.0165	0.0181	0.0221	0.0271*	0.0233	0.0145	0.0124	0.0109
2011	0.014	0.0159	0.0202	0.0252	0.0228	0.0134	0.0121	0.0075
2012	0.0111	0.0124	0.0165	0.0221	0.0189	0.0077	0.0062	0.0054
2013	0.0106	0.0127	0.0159	0.0211	0.0191	0.0127	0.0093	0.0086
2014	0.0098	0.0118	0.0149	0.0209	0.0194	0.0131	0.01	0.0101
Panel B: Between One Half Mile and One Mile of Stations								
2004	0.0479	0.058	0.0696*	0.0767*	0.062	0.0611	0.0543	0.0768
2005	0.0278	0.0305	0.0359	0.0376	0.0334	0.02	0.0201	0.0142
2006	0.0286	0.0308	0.0399*	0.045**	0.041*	0.0266	0.0248	0.0302
2007	0.0207	0.0239	0.0296	0.0351*	0.0286	0.016	0.015	0.0167
2008	0.0172	0.0202	0.0256	0.0302	0.0245	0.0114	0.0093	0.0106
2009	0.0172	0.0187	0.0236	0.028	0.0245	0.0098	0.0085	0.0016
2010	0.0162	0.0173	0.0218	0.0257	0.0242	0.0108	0.0083	−0.0026
2011	0.0155	0.0172	0.0215	0.0256	0.0253	0.0117	0.0093	−0.0031
2012	0.0136	0.0144	0.0179	0.0227	0.0218	0.0054	0.002	−0.0042
2013	0.0134	0.0156	0.0179	0.0224	0.0219	0.0108	0.0048	−0.0003
2014	0.0125	0.0145	0.017	0.0224	0.0228	0.0114	0.006	0.0021
Panel C: Rest of All Minneapolis								
2004	0.0206	0.028	0.0413	0.04	0.0285	0.0256	0.0138	0.0253
2005	0.0071	0.0086	0.0142	0.0147	0.0066	0.0023	0.0005	−0.0041
2006	0.0081	0.0091	0.0178	0.0221	0.0145	0.0103	0.0064	0.0148
2007	0.0049	0.0066	0.013	0.019	0.0103	0.0093	0.0077	0.0152
2008	0.0064	0.0083	0.0147	0.0208	0.0135	0.0133	0.0102	0.0191
2009	0.0165	0.018	0.0247*	0.0317*	0.0279	0.0274	0.027	0.0336*
2010	0.0222	0.0246*	0.0312**	0.039**	0.0362**	0.0382**	0.0383*	0.045**
2011	0.0278*	0.0314**	0.0386***	0.048***	0.0471***	0.0483**	0.0497**	0.0552***
2012	0.0337**	0.0376***	0.0453***	0.0563***	0.0548***	0.0553***	0.0585***	0.067***
2013	0.041***	0.0464***	0.0536***	0.0644***	0.0632***	0.0671***	0.0696***	0.0799***
2014	0.0429***	0.0483***	0.0556***	0.0669***	0.0665***	0.0704***	0.0731***	0.0847***

Each estimate is obtained using data that begins in the year indicated at the top of the estimate's column and that ends in the year to the far left of the estimate's row. Multiply by 100 to obtain percentage changes in sale price calculated using the Halvorsen and Palmquist (1980) adjustment.
Statistical significance of nonlinear Wald test of transformed coefficients *** *p.01,* ** $p < .05$, * $p < .10$.

Examining the rest of the table enables us to consider the effects of shortening the assumed "before" period or lengthening the "after" period. Looking at the estimates from left to right across columns, we see that there is some variation across columns, but that generally changing the before period has only small (and no statistically significant) differences in estimated premiums from proximity. In contrast, looking down any one of the columns in Panel A, we see a distinct pattern. The first row, labelled "2004" shows estimates using a sample that includes only sales that occurred in 2004. The second row, labelled "2005," shows estimates using data from both 2004 and 2005, the third row labelled "2006" shows estimates using data from 2004, 2005, and 2006, etc. As we include data from more years since service began, estimates of premiums decline monotonically from a range of 3.82%–7.11% immediately following opening between 0.98% and 2.09% and statistically insignificant when all sales from 2004 to 2014 are included. While a number of price premium estimates are statistically significant in the years immediately following initiation of service, we estimate no statistically significant premium from proximity by 2011, even though sample sizes grow as the sample period lengthens.

Panel B focuses on the control group of homes in south Minneapolis and between ½ and 1 mile from stations. Again, find the estimate of interest from Table 3, 0.0125, in the lower leftmost cell. Results are very similar to those for the broader south Minneapolis control group in Panel A, but with statistical significance fading even earlier, by 2008.

In stark contrast, estimates in Panel C, which are calculated using the rest of all of the city of Minneapolis as a comparison area, show premiums that rise in magnitude and statistical significance over time. While these numbers suggest that houses in the corridor appreciated by more (or depreciated by less) than those outside of the corridor citywide, they do not control for the possibility that homes within south Minneapolis as a whole appreciated more (or depreciated less) than homes citywide.

3.3. Estimation by Station Area

Results from estimation explained in previous sections may conceal heterogeneity in effects of LRT on home prices, as neighborhoods along the line differ. For example, neighborhoods nearest the Franklin and Lake Street stations are mixed use neighborhoods with more than half of the land area devoted to commercial, industrial, and multifamily home uses, while neighborhoods near the remaining stations are at least 70 percent residential (Hurst and West, 2014). Home buyers purchasing houses in these different areas may have different preferences or needs for light rail transportation; that is, housing markets within the corridor might be segmented. We therefore estimate (1) separately for each station area, using the two narrowly defined control groups and the full sample of sales from 1990 through 2014. Table 6 shows that home premiums are statistically different than zero for one station—the 46th street station. Homes within a half mile of that station experience a bump in home price of about 3 percent relative to homes in the rest of south Minneapolis, comparing prices after light-rail service to before service. Estimates for other station areas range in size and magnitude, and none are statistically significant.

Table 6
Transformed coefficients on After*Inside, by nearest station.

Station	Control: Homes in Rest of South Minneapolis			Control: Homes Between ½ and 1 mile		
	Transformed Coefficient	Number observations Inside Corridor	Number observations Outside Corridor	Transformed Coefficient	Number observations Inside Corridor	Number observations Outside Corridor
Franklin Avenue	−0.0117	277	615	−0.0305	277	518
Lake Street	−0.0327	474	4148	0.0579	474	1722
38th Street	−0.0036	1869	8492	−0.0168	1869	3309
46th Street	0.0292**	1419	6643	0.0285	1419	1663
50th Street	−0.0009	811	2718	0.0040	811	1158
VA Hospital	0.0024	604	575	−0.0045	604	541

Multiply by 100 to obtain percentage change in home price.
Statistical significance of nonlinear Wald test of transformed coefficients ** *p*.05.

4. Conclusions and directions for further research

We use data on repeat sales of single family homes in Minneapolis to estimate the effect of proximity to stations on the METRO Blue light rail line on residential home sale prices. A naïve, and we think, unfair, comparison of homes that are close to stations with homes in the rest of Minneapolis suggests that homes within ½ mile of stations experience meaningful premiums and that these premiums are growing. In contrast, comparisons with more similar homes in more similar neighborhoods adjacent to areas within half a mile suggest that only in years immediately following the opening of the light rail line did homes close to it experience a premium from this proximity. By 2011, or perhaps as early as 2008, proximity to rail yielded no statistically significant price premium on average across homes within the corridor relative to homes outside the corridor. Accounting for the potential heterogeneity of effects across neighborhoods generally corroborates these findings; homes in only one station area of six experience premiums from station proximity.

These results underscore the importance of carefully choosing control groups, and of paying close attention to the amount of time that has elapsed since introduction of a new form of public transit. Previous studies suggest that the effects of the introduction of rail can take decades to be transmitted through adjacent neighborhoods. One decade after the METRO Blue line went into service, we find the opposite pattern; effects are measurable in the years immediately following initiation of service, but faded to a statistical zero as time passed. While these results should not be interpreted as implying that proximity to the light rail line will not ever be valued by households buying homes in south Minneapolis, they do suggest that such valuation is not happening, on average, over the full sample of homes within the corridor, ten years since initiation of light rail service.

Further research might consider the effects of light rail on condominiums and multifamily home prices, as Billings (2011) and Duncan (2008) suggests that such effects might be larger than for single family homes. Our results suggest that insight about the effects of the introduction of light rail might be gained from use of an impulse-response framework, as the effects of rail on home prices change over time. Our findings also suggest that estimated effects of light rail on home prices depend critically on the choice of comparison group and differ depending on station area. Planners, researchers, and officials should keep this heterogeneity in mind when estimating and predicting the effects of other light rail lines.

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