Does a streetcar increase desire for housing? Evidence from a constructed and an abandoned project in Cincinnati

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Abstract

The city of Cincinnati constructed a streetcar system in the downtown area in 2016. This paper examines the effects of constructing the streetcar, as well as abandoning another proposed route on nearby residential property values and housing flows using a difference in differences approach. The results provide evidence purchasers of single family homes outside of the downtown area may view the streetcar as a disamenity, while buyers of condos value the streetcar in both uptown and downtown neighborhoods.

The most recent version of this paper can be found at beausauley.weebly.com/research

1 Introduction

Light rail and streetcar transit systems have become a favored project for many urban areas to add an alternative transportation option to the automobile. Thirteen separate streetcar systems opened in the United States from 2014-2020. Most of these projects make many promises, often including increasing property values along the route, which can be particularly attractive for cities which hope to revitalize a downtown area.

With all of the additions of streetcar and light rail systems throughout the country, there has been a lot of research completed assessing the effect of these interventions on property values. A 2013 meta-analysis by Mohammad et al. suggests change in property values from the addition of light rail can range from decreasing property values by 45% to increasing them over 100%, with the majority of studies finding a positive effect and a mean change in price of 8%. More recent studies have shown differing results as well.

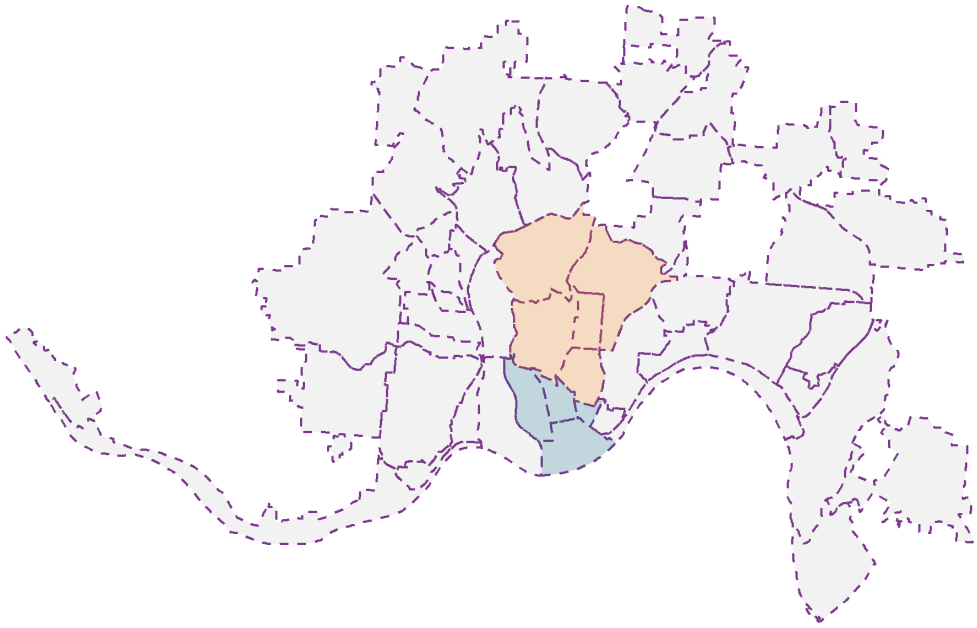
Diao et al. (2017) use a spatial difference in differences technique to show the addition of light rail in Singapore leads to a 8.6% increase in all property values. No significant change in price was found in Camins-Esakov and Vandegrift (2018) study of the extension of rail in New Jersey. Wagner et al. (2017) find property values decrease by 8% along the new route in Norfolk, VA. The new light rail in Denver, CO was found to increase median home price by over 25% in Bardaka et al. (2018), and the new light rail in Charlotte, NC was found to increase condominium property values by 13% in Billings (2011).

The city of Cincinnati completed construction of their own streetcar in September of 2016. This paper is the first to look at the effect of the streetcar built in downtown Cincinnati on housing prices, as well as housing flows. Due to the multiple changes the project experienced in the 14 years since it was first proposed, a difference in differences estimator is used to assess the change in property values and flows along the constructed streetcar route, as well as providing the unique opportunity to study the effect of eliminating a portion of rail which was planned to be constructed. Contradictory results are found depending on the type of housing near the canceled route. While condos see the route as an amenity, the results suggest single family housing does not find the streetcar a desirable public service.

2 Public Transportation in Cincinnati

Figure 1 shows a map of the neighborhoods within Cincinnati. Because the city limits are so large and the streetcar is contained to the downtown area, it is unlikely that many of these housing sales should be considered as comparable homes to houses near the streetcar. Highlighted neighborhoods in blue (Central Business District, Over-the-Rhine, Pendelton, and the West End) will henceforth be referred to as downtown, and neighborhoods in orange (Avondale, Clifton, Corryville, CUF Heights, and Mt. Auburn) will henceforth be referred to as uptown.

Figure 1: All neighborhoods in Cincinnati



Note: Blue neighborhoods represent the treatment area of the constructed route (downtown), including the neighborhoods of Central Business District, Over-the-Rhine, Pendelton, and the West End. The orange neighborhoods represent the proposed routes treatment area (uptown), including the neighborhoods of Avondale, Clifton, Corryville, CUF Heights, and Mt. Auburn.

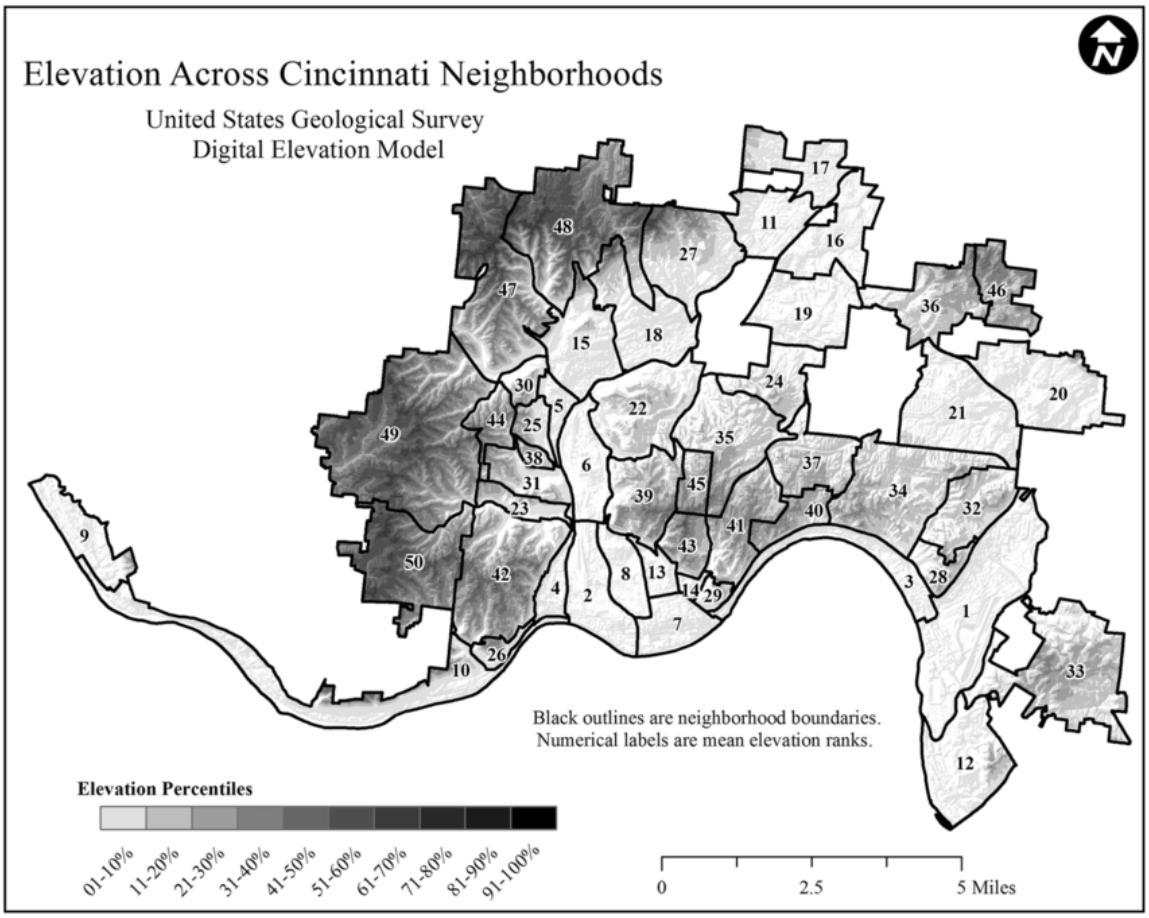
Cincinnati is a city naturally divided by its many hills. The area chosen to represent downtown has similar housing types available and lies nested in a valley surrounded by many of these hills. Figure 2 is a topographical map created by Haberman and Kelsay (2020) showing the elevations of neighborhoods within the city limits. While the neighborhood of Queensgate also lies in this valley, it is west of interstate 75, which provides another barrier separating the neighborhood from the areas included in downtown.

The many hills throughout the city led Cincinnati to be an early adopter of light rail as a form of public transportation. At its peak, the streetcar system was composed of 222 miles of track in Cincinnati and Northern Kentucky, but this was dismantled in 1951 (City of Cincinnati, 2019). With the growing popularity of streetcars being adopted throughout the United States, and a desire to rehabilitate the historic neighborhoods downtown, the city of Cincinnati chose to invest in a new streetcar system. The current route is 3.6 miles long, and operates 18 hours a day most days, with modified hours of operation on weekends and holidays.

The constructed streetcar takes passengers from the area near the river known as "The Banks", through the central business district, and into Over-the-Rhine. According to Hamilton County (2019) between 1997-2019, Hamilton County has invested $2.8 billion in public/private funding developing The Banks alone. The Cincinnati Center City Development Corporation (3CDC), a non-profit developed by the city who's "mission and strategic focus is to strengthen the core assets of downtown by revitalizing and connecting the Central Business District and Over-the-Rhine", estimated in their 2013 Annual Report $711 million had been spent on redevelopment of the area, including $518 million from 3CDC and the city of Cincinnati since 2002. All of this coincides with the

development of the streetcar project downtown as well, leading to potential endogeneity concerns.

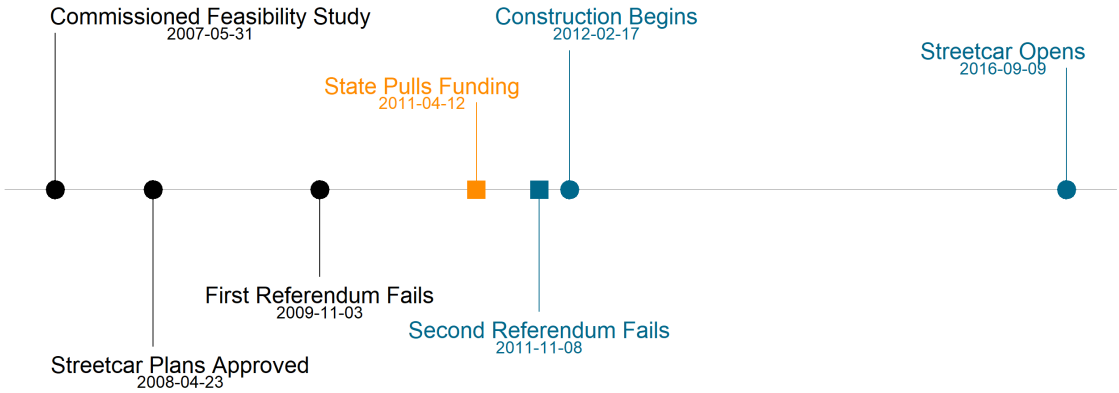
Figure 2: Topographical Map of Cincinnati



Earliest proposals for the streetcar were much more ambitious than what has been constructed. Original plans were developed to connect downtown to Union Terminal, on the West side of Cincinnati, Newport Kentucky, Broadway Commons, on the East side, and two sections of rail surrounding the University of Cincinnati to the North (HDR Engineers, 2007). Ultimately, approved plans for construction in 2008 were limited to downtown, and one uptown route along Vine St., connecting downtown to the University of Cincinnati's campus, Cincinnati Children's Hospital, and the Cincinnati Zoo.

Figure 3 shows a timeline of the construction of the light rail system. Both referendums in 2009 and 2011 were attempts from citizens to prevent the construction of new rail lines in the city. On April 12, 2011, the Ohio Transportation Review Advisory Council voted to withdraw the $51.8 million dollars in funding it had promised to the city of Cincinnati to aid in construction of the uptown route. After this vote, it became common knowledge the streetcar would be limited to the route constructed downtown. The second referendum, taking place on November 8, 2011, was the last attempt to prohibit the construction of light rail in the city. Following the failure of this mandate, it became apparent the city would move forward with construction along the proposed route. These two events provide the best indicators to measure a causal relationship from the addition of a streetcar, or lack there of, and thus will be used as treatment indicators for the estimations in this manuscript.

Figure 3: Timeline of Streetcar Events



Note: Black represents initiatives which would affect both routes, orange represents initiatives which would only affect the proposed route, and blue represents initiatives which would only affect the constructed rail line. The squares are used to denote events which are used as treatment for the analysis.

3 Data

Housing data has been collected for the state of Ohio with sale dates ranging 2001-2015 from CoreLogic. The data set was limited to only include housing sales within the city limits of Cincinnati. The data was then further trimmed to omit housing sales with missing values in covariates of interest, with the exception of acreage, and the top and bottom 1% of each variable included in the analysis were dropped to avoid outliers biasing the estimates in an extreme way.

The summary of statistics for the remaining housing sales can be seen in Table 1. Each covariate is collected at the individual sale level, leaving 33,892 individual housing sales in the data set.

The effect of public transportation being the same across different types of housing is likely a poor assumption. Single family homes are independent structures designed to house one family. There are no shared walls or utilities in these instances. Condominiums and multi-family homes may have shared walls, and can often house more than one family per building. These differences in housing characteristics likely lead to the housing types reacting to market stimuli differently. This paper will examine single-family homes separately from all other housing types, which together will be referred to as condos, for those reasons.

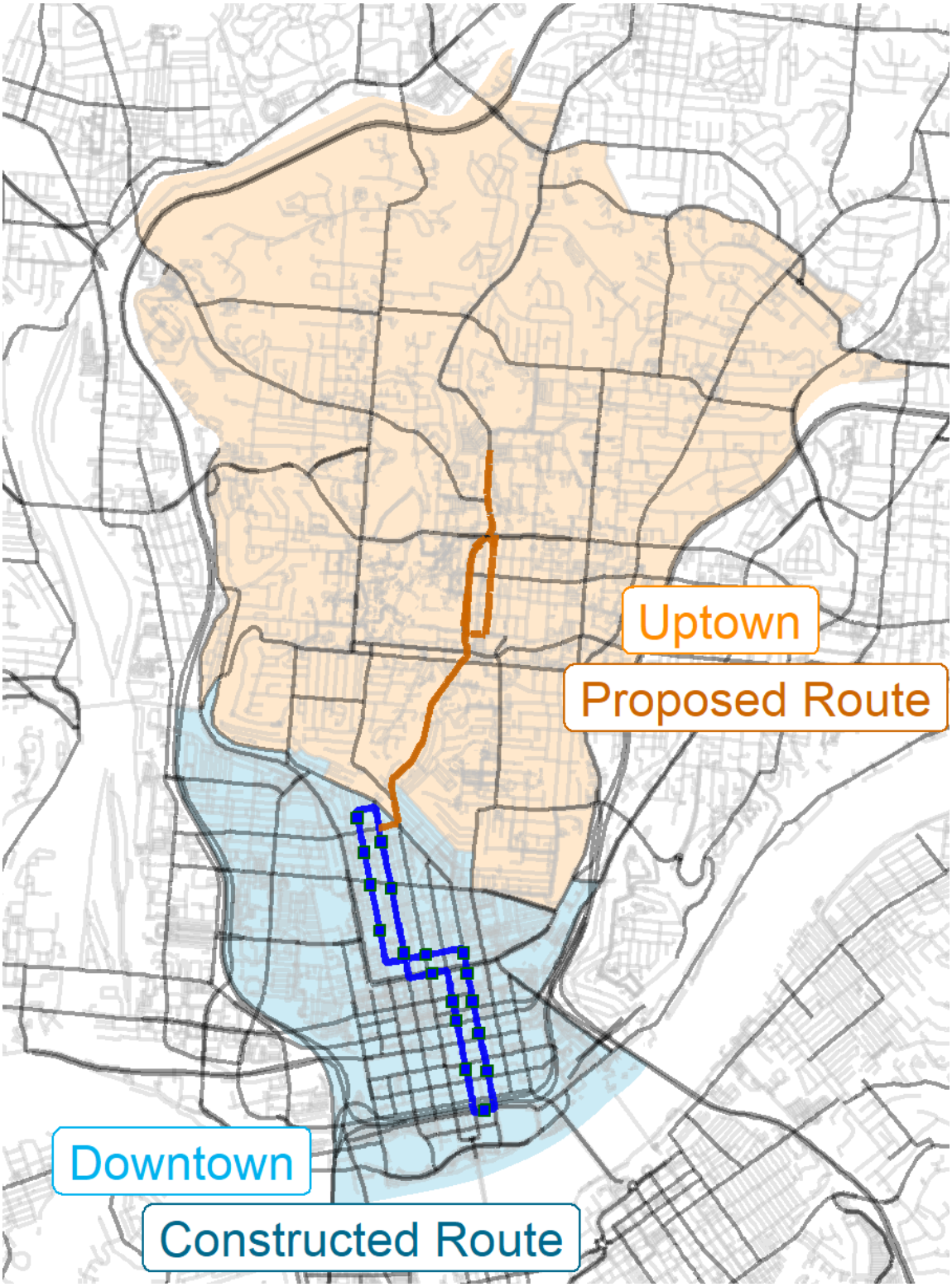
As discussed in the introduction, this study is concerned with housing sales located in uptown and downtown Cincinnati, near where the streetcar was constructed, and where the proposed route was designed. Figure 4 shows a road map of the constructed streetcar (blue) and the proposed route (dark orange), while highlighting uptown (orange) and downtown (light blue). While it is common practice to use Euclidean distance from a rail stop, the stops were not made publicly available for the uptown route, therefore the treatment area in this case will be all housing sales within 2 blocks (approximately 500

Table 1: All neighborhoods in Cincinnati

Statistic	N	Mean	St. Dev.	Min	Max
Price	33,892	143.674	128.775	5.001	1,015.100
Sqft	33,892	1,735.515	665.215	216	4,984
Acres	29,880	0.186	0.407	0.001	44.100
Beds	33,892	2.859	0.889	1	5
Baths	33,892	1.928	0.833	1	4
Ballot	33,892	0.357	0.479	0	1
Streetcar	33,892	0.014	0.118	0	1
Treatment	33,892	0.010	0.098	0	1
Funding	33,892	0.390	0.488	0	1
Proposed	33,892	0.006	0.078	0	1
Placebo	33,892	0.003	0.052	0	1
Year	33,892	2,008.332	4.625	2001	2015

feet) anywhere along the streetcar line.

Figure 4: Selected neighborhoods in Cincinnati



Note: Blue represents the constructed route's treatment area (downtown), while the orange represents the proposed route's treatment area (uptown).

Limiting the data set to these areas severely limits the number of housing sales, but also ensures each of the dwellings used will be a suitable comparison. Table 2 shows the data on condos sold downtown both prior to and after the ballot initiative, while Table

3 shows the data on condos sold uptown both prior to and after the additional $51.8 million dollars of funding for the proposed route was retracted from the state of Ohio.

Table 2: Downtown Condo Sales

	Pre-Failed Referendum					Post-Failed Referendum				
Statistic	N	Mean	St. Dev.	Min	Max	N	Mean	St. Dev.	Min	Max
Price	381	244.226	183.464	5.900	998	466	230.608	132.620	5	878
Sqft	381	1,750.459	747.057	575	4,422	466	1,487.567	700.329	464	4,606
Acres	134	0.408	0.880	0.021	2.657	88	0.294	0.755	0.021	2.657
Beds	381	2.147	0.929	1	5	466	1.861	0.681	1	4
Baths	381	2.055	0.703	1	4	466	1.861	0.681	1	4
Streetcar	381	0.378	0.486	0	1	466	0.624	0.485	0	1
Year	381	2,006.643	2.595	2001	2011	466	2,013.509	1.140	2011	2015

Table 3: Uptown Condo Sales

	Pre-Funding Pulled					Post-Funding Pulled				
Statistic	N	Mean	St. Dev.	Min	Max	N	Mean	St. Dev.	Min	Max
Price	812	119.073	91.614	5	910	646	129.345	121.431	5.5	983
Sqft	812	2,106.608	812.682	448	4,727	646	2,054.076	823.364	473	4,907
Acres	625	0.111	0.071	0.022	0.717	455	0.111	0.070	0.029	0.553
Beds	812	3.122	1.141	1	5	646	3.094	1.137	1	5
Baths	812	2.307	0.648	1	4	646	2.262	0.664	1	4
Proposed	812	0.067	0.249	0	1	646	0.059	0.235	0	1
Year	812	2,005.308	2.631	2001	2011	646	2,013.584	1.329	2011	2015

Tables 2 and 3 show the vast differences in the housing market in these two areas. While the average price of a condo downtown is over $100,000 more than a condo uptown, the uptown homes are both larger and come with more bedrooms and bathrooms on average. This suggests the two areas are vastly different, and the housing market in each area will react differently to all stimuli.

Another important thing to note here is the difference in number of sales in each area pre-treatment and post-treatment. More condos were sold in the downtown area in just four years following the failed referendum than were sold in the same area in the eleven years prior, whereas uptown the number of sales per year increased, but not nearly as drastically.

The most striking finding the reader should be aware of from these two tables is the vast difference in the proportion of sales which take place within the constructed streetcar treatment area pre-treatment and post-treatment in Table 2. Sales within two city blocks of the streetcar route composed of 37.8% of all condo sales pre-treatment, which jumps to 62.4% post-treatment. The proposed streetcar route takes up a much smaller portion of uptown, which leads to the sales being a much smaller fraction of overall sales, only 6.7% pre-treatment, but unlike the constructed route, this proportion does not increase post-treatment, falling to just 5.9% of all condo sales.

Table 4 shows the limited number of single family home sales downtown, with an average of 16 sales a year prior to treatment, and only eleven total sales within the treatment area prior to treatment. There is an extremely large jump in both average price and percent of homes sold within the treatment area in the post-treatment data.

Both of these changes occur without much change in the mean of the covariates to be considered. Table 5 shows there is much more single family housing sold uptown, more consistency among covariates, and a more modest increase in price and quantity sold within the treatment area.

Table 4: Downtown Single Family Housing Sales

	Pre-Failed Referendum					Post-Failed Referendum				
Statistic	N	Mean	St. Dev.	Min	Max	N	Mean	St. Dev.	Min	Max
Price	161	153.212	90.775	6	375	137	211.850	160.005	5.043	894.000
Sqft	161	1,927.764	638.763	960	4,947	137	2,004.686	690.289	780	4,395
Acres	160	0.051	0.018	0.023	0.126	137	0.052	0.024	0.010	0.160
Beds	161	2.689	0.691	1	5	137	2.730	0.743	1	5
Baths	161	2.559	0.835	1	4	137	2.672	0.758	1	4
Streetcar	161	0.068	0.253	0	1	137	0.255	0.438	0	1
Year	161	2,005.292	2.664	2001	2011	137	2,013.387	1.139	2011	2015

Table 5: Uptown Single Family Housing Sales

	Pre-Funding Pulled					Post-Funding Pulled				
Statistic	N	Mean	St. Dev.	Min	Max	N	Mean	St. Dev.	Min	Max
Price	1,283	143.071	118.470	6	925	821	181.720	158.535	6	1,015
Sqft	1,283	1,901.266	733.712	372	4,951	821	1,946.524	722.683	544	4,821
Acres	1,283	0.171	0.301	0.019	5.662	821	0.168	0.371	0.007	7.683
Beds	1,283	3.069	0.925	1	5	821	3.072	0.904	1	5
Baths	1,283	2.009	0.905	1	4	821	2.068	0.909	1	4
Proposed	1,283	0.045	0.208	0	1	821	0.065	0.246	0	1
Year	1,283	2,005.203	2.739	2,001	2,011	821	2,013.457	1.296	2,011	2,015

Using a treatment area of two city blocks (approximately 500 ft.) from the streetcar route and proposed route respectively, Figure 5 and Figure 6 display condo sales in the neighborhoods of interest. Figure 5 shows the location of downtown condo sales both prior to and after the failed referendum in 2011. Figure 6 is a map of condo sales prior to and after the state of Ohio pulled the funding appropriated to Cincinnati for construction of the streetcar, and specifically designated for the uptown route. In each case, the size of the dot indicates sale price, with larger dots selling for a higher price.

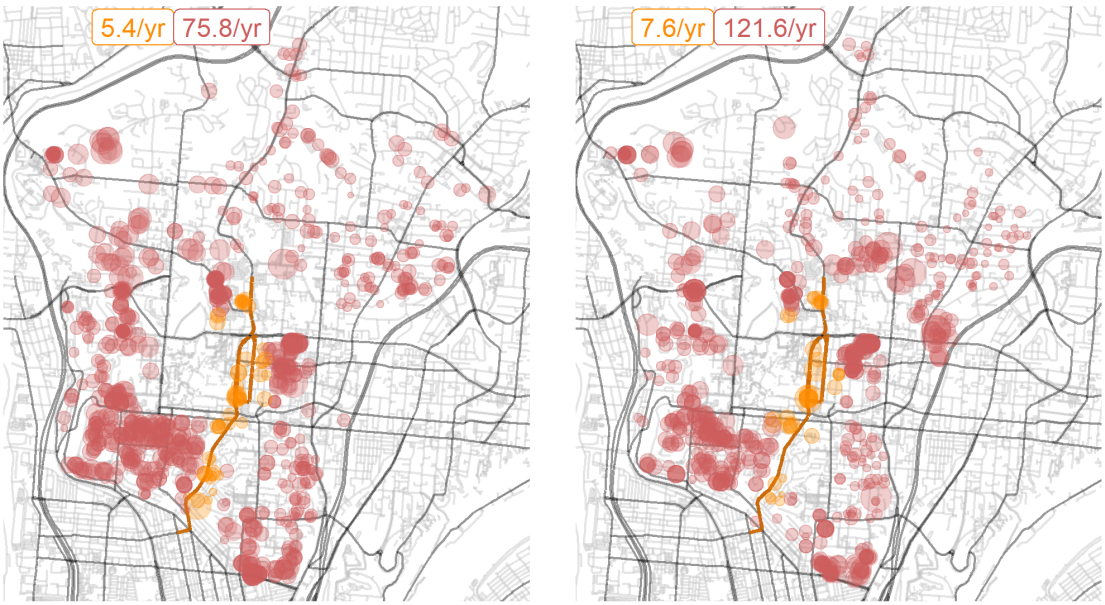
As annotated on the maps, the quantity of housing sales in the treated area increase nearly 4.5 times per year, or 3 times more than the surrounding area downtown. Uptown and the proposed route show a different story. Quantity of housing sales near the proposed route increase only about 1.5 times, and the surrounding area increases 1.6 times, suggesting there is likely no change in quantity of housing sales attributed to the scraping of this streetcar route.

Figures 7 and 8 show each condo sale by price and year. For ease of readership, these only include sales over $50,000. The top plot in both instances shows all of the sales for that group of neighborhoods, and the second plot shows sales within the group of neighborhoods which are not deemed close enough to the specified treatment. The third plot shows sales within the group of neighborhoods which are deemed close enough to the streetcar route to be treated.

Figure 5: Housing Sales Downtown: Pre and Post Treatment

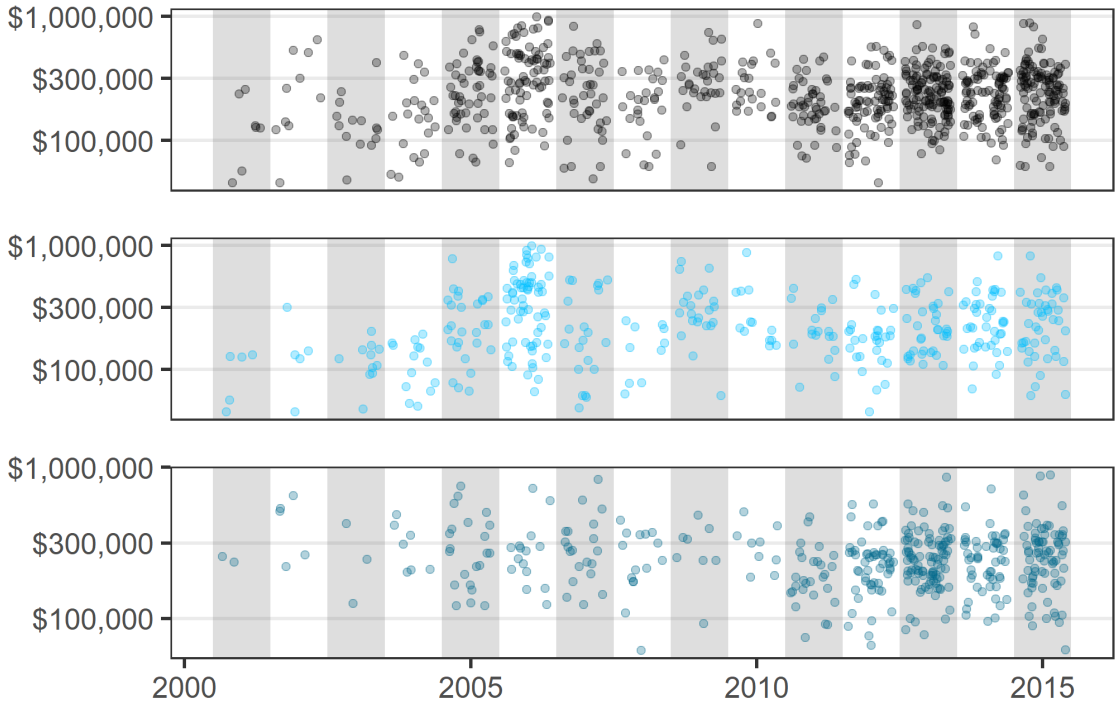
Note: Dark blue dots represent a condo sale within the treated area, while light blue dots represent sales in an untreated area. Larger dots sold for a higher price

Figure 6: Housing Sales Uptown: Pre and Post Treatment



Note: Orange dots represent a condo sale within the treated area, while red dots represent sales in an untreated area. Larger dots sold for a higher price

Figure 7: Jitter Plot of Condo Sales Downtown



Note: Black dots represent all condo sales in downtown, or the combination of the plots below. Light blue are condo sales downtown which are not in the treated area, while dark blue are condo sales downtown in the treated area.

Both the final ballot referendum and the pulling of state funding occurred during 2011. Looking at the bottom plot in Figure 7 it should be apparent that the quantity of housing sales per year greatly increased in the treated area. Figure 8 on the other hand does not tell the same story. It appears the quantity of condo sales remains fairly constant around the proposed streetcar route throughout the time frame examined, but the number of sales in the untreated area vastly increase.

These base findings will be tested in Section 5 using methods outlined in Section 4.

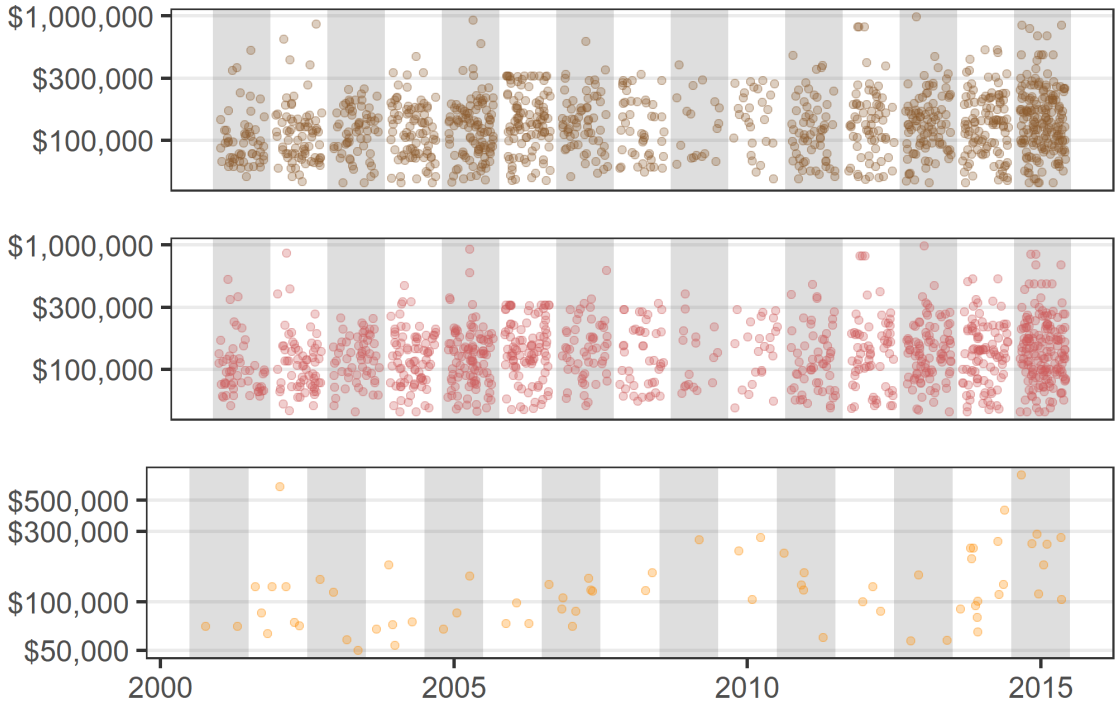
4 Methods

Quantifying the effect of government intervention on property values comes with its share of typical endogeneity concerns. For example, the roads which were chosen to construct the streetcar on were selected by politicians, among a litany of other issues. To overcome this, along with other endogeneity concerns, a common difference in difference technique is employed.

As discussed in Section 2, a failed referendum will be used as the treatment indicator for the constructed streetcar route downtown, while the date the state of Ohio chose to pull funding for the project, causing the city to abandon the uptown route will be used as the treatment indicator for the abandoned line to connect uptown.

To estimate the effect of each treatment on price, the following difference in difference estimation procedure is employed:

Figure 8: Jitter Plot of Condo Sales Uptown



Note: Brown dots represent all condo sales in uptown, or the combination of the plots below. Red dots are condo sales uptown which are not in the proposed route treated area, while orange dots are condo sales uptown in the proposed treated area.

$$P_{ijt} = \beta X_{ijt} + \alpha B_t + \delta SC_{ij} + \gamma C_{ijt} + \lambda M_i + \eta N_{jt} + \tau_t + \varepsilon_{it} \tag{1}$$

where P_{ijt} is the log of the sale price in 2010 dollars of the dwelling i, in neighborhood j, at time t, X_{it} is a matrix of individual housing features. B_t denotes whether the sale occurred after the specified treatment date, equal to one if the treatment event (city referendum, or state funding retraction) had taken place prior to the sale and zero otherwise, SC_{ij} indicates whether the address is within the effected streetcar area equal to one if so and zero otherwise, and C_{it} signifies the interaction of B_t and SC_{ij}.

M_t is a dummy variable for the month the sale took place. N_{jt} is a dummy variable for the individual neighborhoods in Cincinnati. Annual fixed effects are also included and denoted by τ_t.

To estimate the effect of each treatment on quantity, the following difference in difference estimation procedure is employed:

$$Q_{ht} = \beta \bar{X}_{ht} + \alpha B_t + \delta SC_h + \gamma C_{ht} + \tau_t + \epsilon_{ht} \tag{2}$$

where Q_{ht} is the number of sales in a month, within or outside the treatment area h, at time t. If no sales occurred in a treated area in a given month, the month is not included in the analysis, since there would be no housing characteristics to average over either. $\bar{X}_{ht}$ is a matrix of the annual average of individual housing features, where individual sales are averaged based on vicinity to the streetcar (h). B_t denotes whether the sale occurred after the specified treatment date, equal to one if the treatment event (city referendum, or state funding retraction) had taken place prior to the sales, SC_h indicates whether

the address is within the effected streetcar area and equal to one if so, C_{ht} signifies the interaction of B_t and SC_h, and annual fixed effects are also included and denoted by τ_t. All observations from the year 2011 are omitted from the quantity regressions, to prevent dividing the years sales between the pre and post treatment group.

5 Empirical Results

A hedonic difference in difference specification is utilized to estimate how the addition of a streetcar, and the cancellation of a proposed streetcar route, altered the housing market in Cincinnati, as outlined in Section 4. These methods incorporate housing characteristics, as well as neighborhood, monthly, and annual differences while estimating a causal relationship between the treatment effect and surrounding housing prices.

As laid out in Section 3, a total of four separate data sets will be utilized to estimate these effects. Condominium and multi-family housing sales are separated from single family housing sales due to the many differences between the two groups creating separate markets for housing. The models for the completed route connecting neighborhoods in downtown Cincinnati uses the failed referendum in November of 2011 designed to cancel the route as a treatment indicator, and all analysis for this route only includes residences sold within neighborhoods defined as downtown. The models for the canceled route which was planned to connect uptown to downtown only include dwellings sold in neighborhoods defined earlier as uptown. The canceled route uptown uses April 12, 2011, the date the state of Ohio revoked the funding it had promised to the city of Cincinnati to aid in construction of the uptown route, as its treatment indicator.

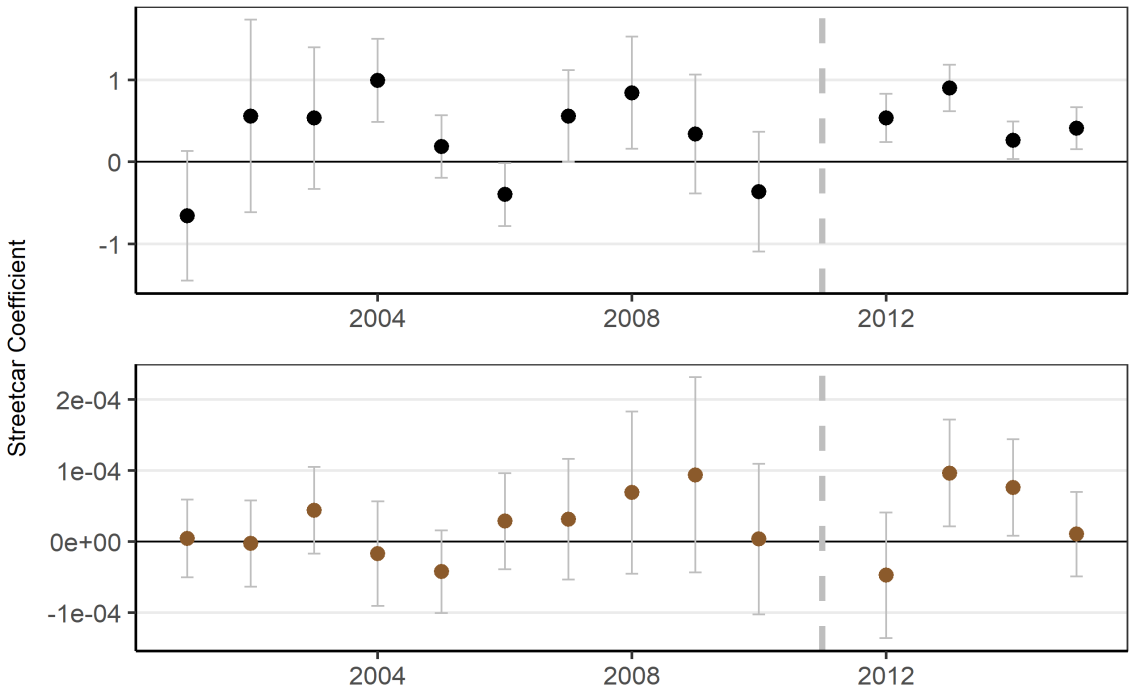
Obtaining a causal measure from difference in differences relies on the assumption of parallel trends, which is often tested graphically. Figure 7 and Figure 8 show similar trends for quantity of housing sold in treatment and control areas prior to treatment. Regressions were run annually to create Figure 9 to test this assumption for the change in price. Because of the limited number of observations available in each year, these regressions were run on all housing data used in this analysis. The point represents the coefficient estimate of the effect of homes being in the treatment area in that year, with 95% confidence intervals surrounding each point.

These figures provide evidence the parallel trends assumption holds. Downtown, being within two blocks of the constructed streetcar only has a significant effect for two of the ten years prior to treatment, while post treatment this is significant for all years. Uptown shows no significant effect prior to treatment, providing even stronger evidence of parallel trends.

Table 6 and Table 7 show the estimates of the treatment effect calculated using the difference in difference technique on condos and single family housing respectively.[1] In each case, two separate hedonic models are run to determine the effect of the streetcar being constructed on price. The first model includes housing characteristics, monthly dummy variables, annual fixed effects, treatment time, treatment area, and treatment time and area interaction term. The second model adds neighborhood dummy variables, and is the same as Equation 1. The third model in each case is looking at the change in housing flows instead of price. These estimates are obtained using the model described in Equation 2.

[1]Estimates of other coefficients as well as treatment estimates using expanded data sets are available in the Appendix.

Figure 9: Annual Coefficient Estimates of Treatment Area



Note: Black dots represent all sales downtown, where the coefficient is measuring the effect on log(Price) of being within two blocks of the constructed streetcar. Brown dots represent all sales uptown, where the coefficient is measuring the effect on log(Price) of being within two blocks of the canceled streetcar route.

Table 6: Treatment Estimation Results: Condos

	Downtown			Uptown		
	log(Price)		log(Quantity)	log(Price)		log(Quantity)
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.353***	0.474***	0.831***	0.143	0.105	−0.580***
	(0.103)	(0.089)	(0.162)	(0.181)	(0.169)	(0.155)
Housing Char	✓	✓	✓	✓	✓	✓
Annual FE	✓	✓	✓	✓	✓	✓
Monthly D	✓	✓	-	✓	✓	-
Nhood D	-	✓	-	-	✓	-
Observations	847	847	266	1,458	1,458	246
R^2	0.398	0.554	0.180	0.214	0.317	0.724

*p<0.1; **p<0.05; ***p<0.01

Looking at the effect estimates on condos of the constructed streetcar downtown, it seems the housing within the streetcar route increased in value by 47%, while the quantity of housing sold increased by 83%. As discussed in previous sections, it is likely the estimate of treatment for the streetcar which was constructed downtown suffers from a litany of endogeneity issues, and is not the sole driver of the increase in housing demand in the surrounding area. Using estimates from both models, a 35-48% increase in price seems beyond a believable premium people would pay to be near a vehicle which is only capable of going in a 3.6 mile loop. The city of Cincinnati spent a lot of money and effort to revitalize the downtown area, and Over-the-Rhine in particular, which included the streetcar, as well as many other projects as discussed in Section 2, which likely also contribute to this rise in demand.

The analysis of the canceled streetcar line does provide more interesting results. While the change in price is positive, it is insignificant, and change in housing flows is drastic. Though a positive impact on price is not expected, it is also not unheard of (Mohammad et al., 2013; Wagner et al., 2017; Camins-Esakov and Vandegrift, 2018), and the results are insignificant, suggesting there may not have been any effect on price whatsoever.

Combined with the lack of change in price, the decrease in quantity of condos sold would suggest there was a sharp decrease in people interested in condos near the proposed route once the plan was canceled. This result may seem large, but this route was supposed to connect uptown citizens with the improving downtown neighborhoods. Based on the large increase in demand for housing near the streetcar downtown, a 58% decrease in quantity of housing sold near the route which would have provided quick and easy transportation there does make sense.

Table 7: Treatment Estimation Results: Single Family

	Downtown			Uptown		
	log(Price)		log(Quantity)	log(Price)		log(Quantity)
Treatment	1.197***	1.120***	0.123	0.349**	0.318**	0.072
	(0.286)	(0.271)	(0.249)	(0.145)	(0.138)	(0.159)
Housing Char	✓	✓	✓	✓	✓	✓
Annual FE	✓	✓	✓	✓	✓	✓
Monthly D	✓	✓	-	✓	✓	-
Nhood D	-	✓	-	-	✓	-
Observations	298	298	158	2,104	2,104	248
R^2	0.547	0.600	0.100	0.405	0.463	0.767

*p<0.1; **p<0.05; ***p<0.01

Looking at the effect sizes on single family homes tells a similar story downtown. The results suggest single family homes within two blocks of the streetcar line will experience a 112-120% increase in price. While this estimate suffers from the same endogeneity concerns as the estimate of the effect on condos, there are also far fewer single family homes sold downtown. Of the 298 houses sold, only 46 are within the treated area, and only 11 of those properties were sold prior to the failure of the ballot initiative in 2011. These price results are reported for transparency, but should not be considered as a viable estimate of the effect of the streetcar on housing downtown.

While the number of single family structures sold increased dramatically, from eleven structures in ten years to 35 houses solid in the next four, the quantity of single family housing sold also increased dramatically in the surrounding areas downtown. This should shed some light on the insignificant result on the effect of the downtown streetcar on quantity.

The proposed and canceled route uptown does show some interesting findings. The results from model 4 and 5 in Table 7 suggest the cancellation of the uptown route led to an increase in the value of single family homes near the proposed route of 32-35%, while model 6 suggests there is no significant change in quantity of housing sold from treatment. This would indicate single family houses along the proposed streetcar route are more desirable after the extension is canceled, meaning the public transit is viewed as a disamenity by single family home buyers.

The different effect sizes for condos and single family homes also provide more evidence these two groups of housing are different markets. It appears individuals purchasing condos are more willing to move to the ameninities they desire, as evident by the quantity regressions, while individuals in single family housing may be less interested in things like public transportation.

Billings (2011) and Wagner et al. (2017) use the proposed light rail additions in Charlotte, and Norfolk and take the difference in price of housing along the constructed rail and the price along the proposed, to calculate a treatment effect. This works in their situations, as the housing along the proposed route is similar to that along the route where the railway was constructed. While this analysis would be possible, it is not recommend based on the differences in housing characteristics in the two treatment areas, as outlined in Section 3.

6 Conclusion

Difference in difference estimates of the construction and cancellation of a streetcar route on sale price as well as the change in quantity of condo and single family home sales in Cincinnati lead to mixed results. For condos, the construction of the streetcar led to a 35-45% increase in the price, and an increase of in sales of condos per month of 83%, while the cancellation of the proposed route led to an insignificant increase of 10-14% in price of condos, with an added loss of 58% of sales per month. Single family housing regressions tell a different story, with a larger, unreliable effect estimate downtown, but an increase in price along the proposed route, with no change in quantity. Along the canceled route, single family homes see an increase in property values, suggesting people in this market may view the streetcar as a disamenity.

These estimates suffer from omitted variables bias, since the streetcar addition was only one of many projects going on in downtown Cincinnati at the time. Examining the changes in other amenities and including these amenities as variables in this estimation process would likely improve the results, though there is evidence increasing property values leads to increasing amenities, which increase property values and so on Zheng et al. (2016).

It would also be beneficial to include a spatial autoreggressive or spatial Durbin model estimation. As is well known, not controlling for spatial heterogeneity when it is present can lead to biased estimates LeSage and Pace (2009); Diao et al. (2017); Bardaka et al. (2018). This would likely change the magnitude of the results, and could provide a better

understanding of how these effects spill from properties near the streetcar to properties further away.

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Appendix

Table 8: Condos: log(Price)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log(Sq. Ft.)	0.451***	0.363***	0.556	0.451***	0.361***	0.409***	0.275***	0.297***
	(0.034)	(0.067)	(0.350)	(0.034)	(0.067)	(0.035)	(0.069)	(0.085)
Baths	0.178***	0.179***	−0.115	0.178***	0.180***	0.178***	0.198***	0.172***
	(0.017)	(0.034)	(0.178)	(0.017)	(0.034)	(0.018)	(0.035)	(0.041)
Beds	−0.237***	−0.324***	0.043	−0.237***	−0.324***	−0.275***	−0.384***	−0.193***
	(0.012)	(0.022)	(0.098)	(0.012)	(0.022)	(0.012)	(0.022)	(0.027)
Age	−0.015***	−0.007***	−0.169	−0.015***	−0.007***	−0.017***	−0.007***	−0.019***
	(0.001)	(0.002)	(0.106)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)
Age^2	0.0001***	0.00002**	0.001	0.0001***	0.00002**	0.0001***	0.00003***	0.0001***
	(0.00001)	(0.00001)	(0.0004)	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00002)
Excellent	0.832***	0.731**		0.833***	0.762**	0.772***	0.662*	0.870**
	(0.203)	(0.370)		(0.203)	(0.371)	(0.211)	(0.385)	(0.369)
Very Good	0.674***	0.369***	0.585	0.675***	0.364***	0.547***	0.151	0.625***
	(0.052)	(0.099)	(0.521)	(0.052)	(0.099)	(0.053)	(0.101)	(0.107)
Good	0.371***	0.245***	0.888**	0.371***	0.243***	0.325***	0.150***	0.415***
	(0.027)	(0.050)	(0.375)	(0.027)	(0.050)	(0.027)	(0.051)	(0.054)
Poor	−1.039***	−1.008***	−0.472**	−1.038***	−1.009***	−1.072***	−1.034***	−0.670***
	(0.051)	(0.082)	(0.200)	(0.051)	(0.082)	(0.053)	(0.085)	(0.114)
Ballot	1.028***	−0.308	−0.649	1.041***	−0.321			
	(0.110)	(0.257)	(1.175)	(0.113)	(0.260)			
Streetcar	0.854***	0.539***	−0.167	0.855***	0.527***			
	(0.071)	(0.078)	(0.276)	(0.071)	(0.078)			
TConstructed	0.281***	0.222**	1.584***	0.282***	0.233**			
	(0.085)	(0.094)	(0.397)	(0.085)	(0.094)			
Funding				−0.046	0.026	0.201**	0.113	−0.132
				(0.094)	(0.184)	(0.095)	(0.187)	(0.206)
Proposed				−0.067	−0.199*	−0.147	−0.266**	−0.085
				(0.109)	(0.114)	(0.112)	(0.117)	(0.117)
TCanceled				0.186	0.192	0.133	0.124	0.143
				(0.170)	(0.177)	(0.176)	(0.183)	(0.181)
Observations	8,827	2,305	141	8,827	2,305	8,827	2,305	1,458
R^2	0.313	0.286	0.415	0.313	0.287	0.262	0.233	0.214

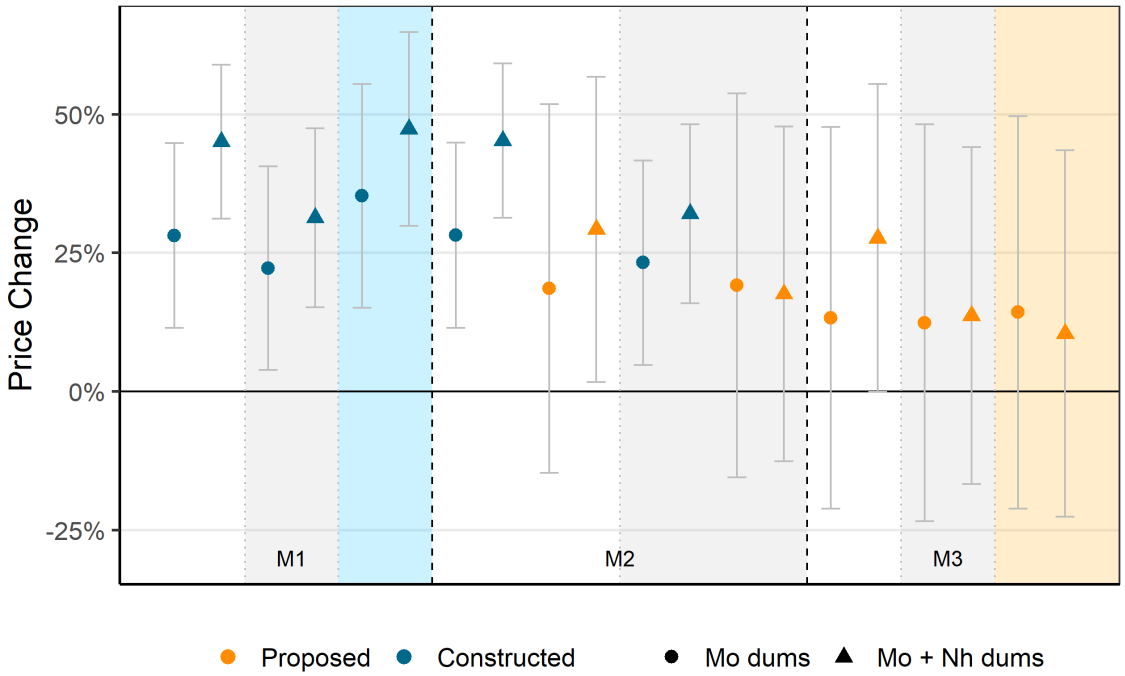
Note: Model 1, 4, and 6 are estimated using city wide data. *p<0.1; **p<0.05; ***p<0.01
Model 2, 5, and 7 are estimated using both downtown and uptown sales.
Models 3 and 8 use only downtown and uptown sales respectively

Table 9: Condos: log(Price), Including Neighborhood Dummies

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log(Sq. Ft.)	0.435***	0.352***	0.570***	0.436***	0.352***	0.412***	0.326***	0.281***
	(0.029)	(0.059)	(0.083)	(0.029)	(0.059)	(0.030)	(0.060)	(0.081)
Baths	0.073***	0.107***	0.020	0.075***	0.110***	0.073***	0.119***	0.131***
	(0.015)	(0.030)	(0.045)	(0.015)	(0.030)	(0.015)	(0.030)	(0.039)
Beds	−0.097***	−0.144***	−0.177***	−0.097***	−0.143***	−0.096***	−0.147***	−0.098***
	(0.010)	(0.021)	(0.035)	(0.010)	(0.021)	(0.010)	(0.021)	(0.026)
Age	−0.011***	−0.005***	0.002	−0.011***	−0.005***	−0.011***	−0.004***	−0.015***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Age^2	0.00002***	0.00000	−0.00004***	0.00002***	0.00000	0.00002***	0.00000	0.0001***
	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00002)
Excellent	0.754***	0.744**		0.764***	0.759**	0.777***	0.749**	0.734**
	(0.169)	(0.324)		(0.169)	(0.324)	(0.171)	(0.327)	(0.345)
Very Good	0.384***	0.537***	−0.337	0.379***	0.525***	0.369***	0.506***	0.561***
	(0.044)	(0.088)	(0.252)	(0.044)	(0.088)	(0.045)	(0.089)	(0.100)
Good	0.226***	0.248***	0.200**	0.223***	0.241***	0.216***	0.224***	0.283***
	(0.023)	(0.045)	(0.100)	(0.023)	(0.045)	(0.023)	(0.045)	(0.051)
Poor	−0.848***	−0.908***	−1.251***	−0.847***	−0.911***	−0.857***	−0.939***	−0.597***
	(0.043)	(0.073)	(0.094)	(0.043)	(0.073)	(0.044)	(0.074)	(0.107)
Ballot	0.809***	−0.578**	−0.581**	0.813***	−0.568**			
	(0.092)	(0.225)	(0.235)	(0.094)	(0.228)			
Streetcar	0.078	0.087	−0.036	0.071	0.076			
	(0.070)	(0.078)	(0.072)	(0.070)	(0.078)			
TConstructed	0.450***	0.314***	0.474***	0.453***	0.321***			
	(0.071)	(0.082)	(0.089)	(0.071)	(0.082)			
Funding				−0.022	−0.076	0.114	−0.151	−0.142
				(0.078)	(0.161)	(0.076)	(0.159)	(0.192)
Proposed				−0.337***	−0.298***	−0.350***	−0.291***	−0.262**
				(0.093)	(0.101)	(0.093)	(0.102)	(0.112)
TCanceled				0.292**	0.176	0.277*	0.137	0.105
				(0.140)	(0.154)	(0.142)	(0.155)	(0.169)
Observations	8,815	2,305	847	8,815	2,305	8,815	2,305	1,458
R^2	0.532	0.458	0.554	0.533	0.461	0.524	0.451	0.317

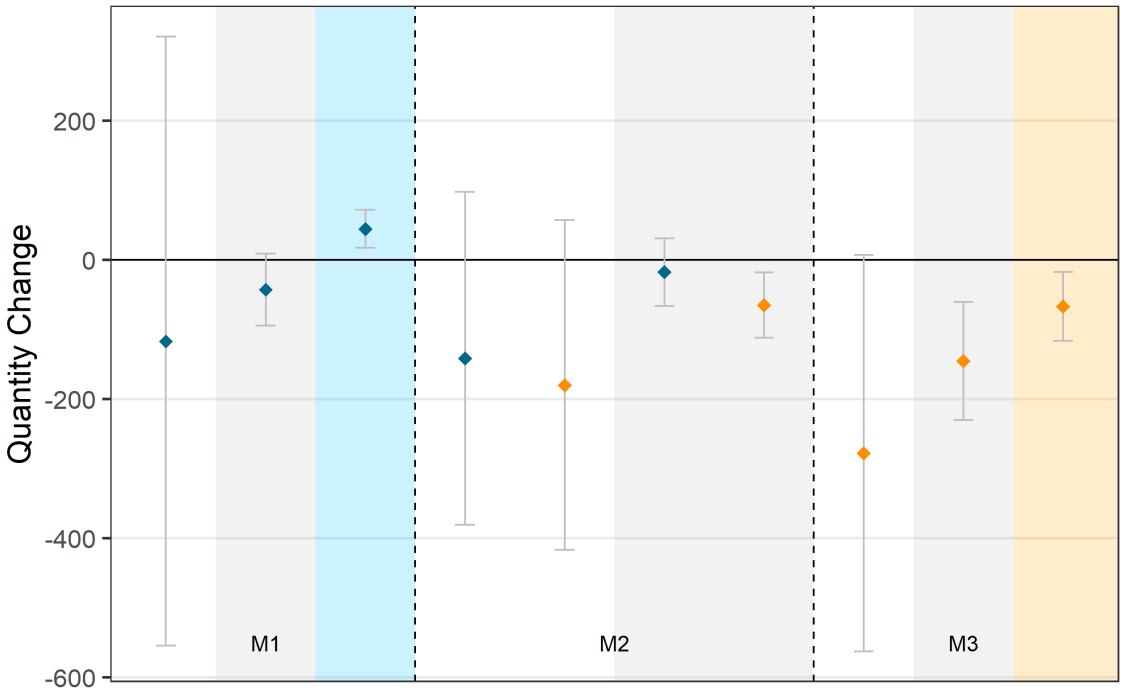
Note: Model 1, 4, and 6 are estimated using city wide data. *p<0.1; **p<0.05; ***p<0.01
Model 2, 5, and 7 are estimated using both downtown and uptown sales.
Models 3 and 8 use only downtown and uptown sales respectively

Figure 10: Treatment Effect Across Estimations - Condos



Note: Blue points represent the estimated effect of treatment from each model, while orange points represent the estimated effect of the placebo. Dots mean the estimate is from a model which did not include neighborhood fixed effects, while triangles display estimates from models including neighborhood fixed effects. A white background means all data for Cincinnati was used. A gray background shows all data for both uptown and downtown sales was used. Blue and orange backgrounds represent downtown and uptown respectively. M1 has only estimates of the treatment, while M2 contains parameter estimates of both the treatment and placebo, and M3 only includes estimates of the placebo. Error bars are 95% confidence intervals.

Figure 11: Estimates of Change in Quantity from Selected Models - Condos



Note: Each point is the mean point estimate for the effect on quantity of sales based on that model. Blue dots represent the effect in the treated area, while orange dots represent the estimated effect on condos near the proposed route. M1 denotes estimates of a DD only on the constructed route. M2 denotes estimates of a DD on both the constructed route and the proposed route. M3 denotes estimates of only the proposed route. This graphic shows regression results using only condo sales.