working paper

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# Is the Light Rail “Tide” Lifting Property Values? Evidence from Hampton Roads, Virginia

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FEDERAL RESERVE BANK OF CLEVELAND

**Working Paper 16-26** November 2016

# Is the Light Rail "Tide" Lifting Property Values? Evidence from Hampton Roads, Virginia

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In this paper we examine the effect of light rail transit on the residential real estate market in Hampton Roads, Virginia. The Norfolk Tide light rail began operations in August 2011 and has experienced disappointing levels of ridership over its first four years of operations. We estimate the effect of the Tide using a difference-in-differences model and consider several outcome variables for the residential housing market, including sales price, sales-list price spread and the time-on-market. Our identification strategy exploits a proposed rail line in neighboring Virginia Beach, Virginia, that was rejected by a referendum in 1999. Overall, the results show negative consequences from the constructed light rail line. Properties within 1,500 meters experienced a decline in sales price of nearly 8 percent, while the sale-list price spread declined by approximately 2 percent. Our results highlight the potential negative effects of light rail, when potential accessibility benefits do not outweigh apparent local costs.

Keywords: light rail transit, housing market, difference-in-difference.

JEL Classification: R3, R4.

Suggested citation: Wagner, Gary, and Timothy Komarek and Julia Martin, "Is the Light Rail "Tide" Lifting Property Values? Evidence from Hampton Roads, Virginia," Federal Reserve Bank of Cleveland, Working Paper no. 16-26.

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# 1 Introduction

Rail transit systems have become an increasingly popular transportation alternative in many U.S. metropolitan areas. Public funds are often used not only to finance construction, but also to subsidize operating costs. A Brookings Institution report on transportation infrastructure shows that 31 large metro systems operated at a loss in 2013.[1] Further, systems with fewer total passengers tended to lose more money per passenger ride than their more heavily used counterparts. Cities often justify the use of public funds by citing the benefits of rail transit systems, such as reducing traffic congestion and emissions, providing an affordable and sustainable mode of transport, and spurring economic activity (Mohammad et al. (2013)). The degree of public financing along with the purported local economic benefits make measuring the local effect of rail transit an important consideration for policy makers.

A popular strategy for measuring the effect of rail transit projects on local residents is examining the capitalization of stations on nearby home values. Researchers often argue that the main benefit to rail transit stations comes from increased access to regional amenities such as central business districts, education centers, entertainment and recreation venues, etc. In this light, land and housing markets should adjust to account for the benefits to increased accessibility. There is a large literature measuring the effect rail transit on various measures of the residential and commercial real estate market. The results have been mixed with studies suggesting a positive effect and others questioning the benefits (Debrezion, Pels, and Rietveld (2007)).

Billings (2011) suggests that the variation in estimated impacts could be due to the use of inadequate control groups, and along with Parmeter and Pope (2013) argues for leveraging quasi-experimental estimation techniques. Several studies have used quasi-experimental techniques. For example, research has considered areas outside of a pre-determined threshold (Gatzlaff and Smith (1993); McMillen and McDonald (2004); Hurst and West (2014)) or pro-

[1] http://www.hamiltonproject.org/assets/files/six_econ_facts_transportation_infrastructure_united_states_final.pdf

posed rail corridors (Billings (2011)) as control groups, or used the opening of new stations and service frequency in long-standing rail transit lines (Gibbons and Machin (2005); Dubé, Thériault, and Des Rosiers (2001)). These studies have aided in further shedding light on this policy debate by credibly identifying the effect of rail transit on real estate values.

In this paper we estimate the effect of Norfolk, Virginia's light rail system, named the Tide, on the residential housing market. Our estimates use data from a multiple listing service (MLS) for southeast Virginia and consider three housing outcomes: sales price, sales-list price spread, and time-on-market. Our identification strategy uses a difference-in-difference hedonic model for the Tide, a light rail transit system that began construction in 2007 and opened in 2011. We use proposed station locations in neighboring Virginia Beach, Virginia as the control group. Voters in Virginia Beach rejected a referendum for a proposed light rail line in 1999. The results show a negative of the Tide light rail on the local residential real estate market. In particular, homes within 1,500 meters of a constructed station sold for approximately 8% less than similar homes in the control group. Homes near constructed stations also sold for a lower amount versus the original list price (the sales-list price spread) compared to the control group.

The paper contributes to the literature in several ways. First, we use a credible identification strategy by considering areas along a proposed route that was not ultimately developed. Our strategy is similar to that used by Billings (2011) to evaluate the light rail in Charlotte. Second, in addition to sales price, we also examine several outcome variables that are often neglected in the academic literature such as time-on-market and the sale-list price spread. To accomplish this we leverage information in our data that provides details on a wide-variety of status changes for every property listing, including re-listings and original list prices. Finally, the previous academic literature has focused on successful light rail systems, at least in terms of ridership. However, the Norfolk Tide has struggled financially as well as with low ridership. For example, the City of Buffalo has a similar population to Norfolk, about

250,000 residents, yet has 3.5 times the light rail ridership.[2] Odell (2016), an editorial writer for *The Wall Street Journal*, recently went so far to say "The Tide moves from places you don't work to areas you don't wish to visit." Thus, our results are useful in evaluating light rail transit systems with low ridership and potentially low accessibility benefits.

## 2 Background and Literature Review

Economic theory suggests that rail transit could have either a positive or negative effect on the residential housing market (Bowes and Ihlanfeldt (2001)). For instance, homeowners could benefit from increased accessibility and transit related economic development. Conversely, homes in a close proximity to rail transit could experience disamenity effects from crime, noise and parking issues. The competing theoretical predictions make evaluating the effect of rail transit systems on local residents an important empirical consideration for local policy makers.

There is a vast literature on the effect of rail transit on residential housing. Studies have analyzed a wide range of cities, types of rail systems, property types, and identification strategies.[3] Debrezion, Pels, and Rietveld (2007), Hess and Almeida (2007) and Mohammad et al. (2013) each provide reviews of the early empirical literature. Debrezion, Pels, and Rietveld (2007) note large variation in the estimated effects, which range from -12% to 38%. The average estimated impact of a single family residential property within a quarter mile of a rail station was 4.8%. The authors perform a meta-analysis of the literature up to the mid 2000s and notes the challenges in comparing across studies due to wide variations in proximity measures, regression specifications, among other issues. In general, they find that the rail transit premium is higher for commercial compared to residential properties.

[2]The Virginia Beach-Norfolk-Newport News MSA is also larger than the Buffalo-Niagara MSA. The light rail ridership numbers are provided by the Brookings Institution for 2013 and show 1.76 million annual light rail trips on the Norfolk Tide and 6.3 million annual trips on the Buffalo Metro Rail.

[3]Previous studies have investigated the effects of rail systems in Atlanta, Buffalo, Calgary, Charlotte, Chicago, Dallas, London, Los Angeles, Manchester, Miami, New York, Philadelphia, Portland, Sacramento, St. Louis, San Diego, San Francisco, San Jose, Santa Clara, Seoul, Taipei, and Washington D.C.

Furthermore commuter rail tends to outperform light and heavy rail transit.

The early work often utilized traditional hedonic pricing models and relied on cross-sectional variation to measure the effect of rail transit on housing. Parmeter and Pope (2013) argue that the traditional hedonic model often fails to uncover causal relationships due to omitted variable issues. Instead, they advocate for quasi-experimental techniques for conducting hedonic property valuation. In a similar vein, Billings (2011) argues that the heterogeneity in estimated rail transit impacts could be due to studies using inadequate control groups.

In this light, we provide a brief review of the quasi-experimental literature on rail transit and the housing market. The difference-in-differences model is the most popular quasi-experimental technique employed. To identify the effect of a rail transit system researchers use a treatment and control comparison before and after construction or opening. However, there are differences in how the studies determine an appropriate control group.

The most popular identification strategy uses distance measures from rail transit stations compared to neighborhoods or areas just outside of a pre-determined cutoff from a station (e.g. 1,000 meters). Gatzlaff and Smith (1993) use repeated residential sales data to construct price indices for residential properties in Miami near transit stations compared to areas further away. They find modest evidence of capitalization from rail transit. McMillen and McDonald (2004) employ a similar technique along with using hedonic regression models. Their results show positive anticipation effects of the Midway Line in Chicago and suggest that home values appreciated around 7% compared to homes farther from the nearest transit station. Hurst and West (2014) look at land use changes in Minneapolis using parcel level data. They compare parcels within 0.5 miles of a station to parcels greater than 0.5 miles away. The results suggest that the rail stations induce land use changes for single-family residential parcels.

Several studies supplement a distance-based threshold strategy for determining the control group with service changes for some residents on established rail lines. Gibbons and

Machin (2005) use a 2-kilometer cutoff along with new station construction and an increase in the frequency of service (trains per hour) that effect some residents in London. Dube et al. (2013) undertakes a similar strategy for changes in station access and the number of daily trips for a transit line traveling into Montreal. Both studies examine heavily traveled rail transit systems and show positive premiums from the increased station access and service frequency.

There are several concerns with using properties outside of a distance threshold as the control group. First, the distance cutoffs are often arbitrary. This concern can be alleviated with sufficient sensitivity analysis for a range of cutoff distances. Secondly, the placement of stations may be placed in more desirable locations. Thus, it is important to show that the treatment locations were not in neighborhoods appreciating at a faster rate than the control neighborhoods further from the stations. This may be problematic in cities that place rail transit around major business centers, such that the type of properties further from stations are quite different than those around actual stations.

Several studies propose alternative control groups that are not based on a distance threshold from constructed transit stations. Dueker and Bianco (1999) study the light rail system in Portland by using a bus line as the control group. One of their outcome measures considers residential development and the results suggest a positive relationship with the light rail system. Billings (2011) examines the light rail system in Charlotte. The author uses a proposed corridor that was not ultimately selected as the first rail line for the control group. He examines the effect on the real estate market by comparing properties within one mile of the constructed line and the same distance around the proposed corridor. The results suggest residential homes (single family and condominiums) appreciate in value, but commercial properties remain unaffected.

# 3 Light Rail in Hampton Roads, Virginia

Hampton Roads, a metropolitan area made up of 16 independent cities and counties in southeast Virginia, has a long history of use and interest in commuter rail transit.[4] In the late 1990s the region considered a light rail project that would have connected a major tourist destination, the oceanfront in Virginia Beach, with the business center of the region in downtown Norfolk. The proposed line would have been partially built along a preexisting commercial rail corridor. In November 1999, residents from Virginia Beach rejected a referendum (55 percent to 45 percent vote) in support of the City Council's adoption of an ordinace to approve the development and finance of the Tide.[5] Nonetheless, the original proposed line through Norfolk and Virginia Beach was outlined in the final environmental impact statement submitted by the region's transit agency, Tidewater Transportation District Commission, to the U.S. Department of Transportation in 2000.[6]

Following the rejection of the proposed system, Norfolk ultimately constructed a light rail transit system confined within its city borders. Construction on the Tide began in December 2007 and the line ultimately opened for service in August 2011. The 7.4 mile route has 11 stations that include access to a large medical park, downtown Norfolk, a minor league baseball stadium, and Norfolk State University.[7] Figure 1 shows the constructed Tide light rail stations and line along with the original plan that included 13 stations ranging from Norfolk's downtown (and central business district) in the west to Virginia Beach's oceanfront area in the east. In Figure 1, the (original) proposed stations are depicted as

[4]For instance, the 2010 Hampton Roads State of the Region Report indicates that the region used electric trolley cars for public transit in the early 20th century. The Hampton Roads region is formally the Virginia Beach-Norfolk-Newport News metropolitan statistical area.

[5]The specific referendum read as follows: "Should the City Council adopt an ordinance approving the development and financing of the proposed Virginia Beach-Norfolk- Naval Base-Light Rail transit project?"

[6]The final environmental impact statement report is available on the region's current transit agency's website, Hampton Roads Transit (HRT): `http://gohrt.com/vbtes/norfolk-va-beach-feis.pdf`.

[7]There are approximately 7,000 students enrolled at Norfolk State University, while the medical park includes Sentara Norfolk General Hospital, Children's Hospital of the King's Daughter and Eastern Virginia Medical School. According to data from the Census Bureau's Longitudinal Employer-Household Dynamics Origin-Destination Employment Statistics (LODES), more than 28,000 jobs were located in the Census tract with Norfolk's downtown and medical complexes in 2014.

diamonds while the actual constructed stations are shown as circles. For reference purposes, the actual stations are labeled numerically from west to east with the prefix "A" and the proposed stations are labeled with the prefix "P". The actual light rail line is depicted as a black line in Figure 1 that ends at the Newtown Road station (A11 on Figure 1) that defines the border between Norfolk and Virginia Beach.

The original construction costs for the project totaled $232 million, however due to construction problems and delays the final cost tallied $338 million.[8] According the Brookings Institution, in 2013 the Tide had approximately 1.7 million passenger trips with fare revenue of $687,892 well below operating costs of $12,374,424. The Tide was the worst performing light rail system of 31 studied by Brookings in terms of finances and ridership.

## 4 Empirical Model

To measure the effect of the Tide light rail on residential real estate we use a hedonic model. Our identification strategy builds off the previous light rail literature by exploiting a quasi-experimental approach.[9] In particular, we use a difference-in-differences model to aid in overcoming issues with omitted variable bias that often plague traditional hedonic models. For example, the traditional hedonic model would be biased if light rail stations were located in more (or less) expensive housing areas due to unobserved factors. Our analysis begins with the following difference-in-differences empirical model:[10]

$$Y_{ijt} = \beta(post * LRT_{ijt}) + X_i\theta + Neighborhood_j\psi + YearMonth_t\phi + \epsilon_{ijt} \tag{1}$$

where $Y_{ijt}$ is an outcome variable (the log real sales price, sales-list price spread, and

[8] http://gohrt.com/services/the-tide/funding-cost-to-complete

[9] See Parmeter and Pope (2013) for a detailed discussion on quasi-experimental techniques with hedonic property valuation.

[10] This specification represents the generalized difference-in-difference model by including neighborhood fixed effects and year-by-month fixed effects.

time-on-market) of each house $i$ in neighborhood $j$ at time $t$.[11] $X_i$ is a vector of the housing characteristics for house $i$. Our data provides a wide range of housing characteristics that include the home's school district, 5 types of ownership and financing, 22 categories of architectural style, 12 interior features, 18 exterior features, among other relevant attributes. $Neighborhood_j$ is a vector of census block group fixed effects to account for time-invariant neighborhood effects such as urban and natural amenities, among others. $YearMonth_t$ is a vector of year-by-month dummy variables. The time fixed effects control for temporal changes that effect all homes such as seasonality and the local business cycle. The time fixed effects along with controls for the type of home construction and financing (e.g. REO, short sale and new construction) help mitigate issues from the housing collapse during the Great Recession.

An important aspect of the difference-in-differences strategy is choosing an appropriate control group. In Section 2 we described the different types of control groups used in the literature. Our preferred strategy follows Billings (2011) by using a proposed rail line that was not ultimately constructed. The proposed station locations on this line provide a useful counterfactual group for the constructed Tide light rail stations. We focus on homes within 1,500 meters of a constructed or proposed station. Since several of the proposed stations ultimately overlapped with actual stations, we limit our control group to proposed stations P7 through P13 in Figure 1. Proposed station P6 is omitted from the control group because the 1,500 meter perimeter around that station overlaps with the 1,500 meter perimeter around actual station A11. Moreover, both the proposed and constructed lines traveled along an abandoned portion of the Norfolk Southern Corporation right-of-way. This route was at least partially chosen because of financial and planning benefits of using the pre-existing rail right-of-way.

The goal of equation 1 is provide a clear examination of the effect of the light rail transit

[11]The sales-list price spread is the log difference between the final selling price and the original listing price for a property. The time-on-market is the number of days the property has been on the market up to the sale. Prices are adjusted to 2010 dollars using the Consumer Price Index (CPI).

system on the residential real estate market. The variable of interest is $post * LRT_{ijt}$, which interacts the treatment group indicator variable ($LRT$) with an indicator for either the start of construction (*post construction*), opening date (*post opening*), or construction period only (*construction only*). The parameter $\beta$ represents the difference-in-difference estimator that compares the contemporaneous average effect for homes near the constructed light rail against the control group near a proposed station. In some specifications, we also split the $LRT$ indicator into two separate indicators for homes within 800 meters ($within800m$) and homes between 800 and 1500 meters ($within1500m$) of an actual or proposed station to explore any potential differential effects for homes that are very close to stations.

The key identifying assumption of the difference-in-differences model is that the outcome variable (real sales price, sales-list price spread, and time-on-market) exhibit similar pre-existing trends (Angrist and Pischke (2009)). To test this assumption we also estimate the dynamic effect of the rail transit system. Estimating the dynamic model with numerous time periods lends itself to a test of causality in the spirit of Granger (1969). By conditioning on fixed effects the time-frame during the treatment (construction or opening of the light rail line) should predict the housing market outcome variables, while the leads before should not.

$$Y_{ijt} = \lambda_t LRT_{ijt} * Time_t + X_i\theta + Neighborhood_j\psi + YearMonth_t\phi + \epsilon_{ijt} \qquad (2)$$

Equation 2 shows the dynamic model, where the control variables and fixed effect strategy are the same as equation 1. $LRT_{ijt}$ indicates house $i$ in neighborhood $j$ at time t for the Tide light rail treatment group and $Time_t$ is a vector of half-year (6-month) time dummy variables. The coefficients $\lambda_t$ show average differences between light rail and non-light rail properties relative to the base time period. Furthermore, by including data prior to construction we measure anticipatory effects of the rail transit system, along with a direct test of the difference-in-difference's pre-existing trends assumption. We estimate each set of regressions with OLS and cluster the standard errors at the census block group.

# 5 Data

The real estate data come from Real Estate Information Network (REIN) a southeast Virginia MLS. It includes a number of structural housing characteristics for all homes listed for sale with a real estate agent within Norfolk and Virginia Beach, VA from 2002 - 2016. By having a complete data set of home listings and status changes allow us to accurately measure the time a home was on the market as well as the spread between the initial asking price and the final sale price. The structural housing attributes range from age, square footage and number and bathrooms to exterior features like the presence of a patio or a shed and whether or not the sale was a reo or short sale. A complete list of the housing characteristics can be found in Appendix A.

The data also include the postal address of each property, which we used to create longitude and latitude coordinates using GIS software. We used the geocoordinates to determine the census block group and distance of each property to the nearest constructed or proposed light rail station. In our primary analysis we focus on homes within 1,500 meters of a station. We also use Google's MAP API to calculate the walking time from each property to the nearest station. Standard data cleaning for missing characteristics and outliers resulted in 17,120 observations within 1,500 meters of a proposed or constructed light rail station.

Table 1 shows summary statistics for homes sold within 1,500 meters of constructed or proposed light rail stations. The real sales price in the treatment group ($239,516) is higher than the control group ($227,744). Furthermore, on average, the sales-list price spread and time-on-market is also larger in the control group. The treatment and control groups share similar observable housing characteristics, of which several selected variables are listed in Table 1. With the exception of average walk time to a station, the average difference in each housing characteristic between the treatment and control groups is not statistically significant at the 1 percent level. This suggests that there is a strong statistical overlap between treatment and control property characteristics.

# 6 Primary Empirical Results

We begin by providing estimates of the difference-in-difference hedonic model shown in equation 1. The results are separated by the dependent variable (the log real sales price, sales-list price spread, and time-on-market) used in the analysis. For each dependent variable we examine the overall neighborhood effect of light rail transit by comparing areas near constructed stations against proposed stations. In particular, we use distances between 800 and 1,500 meters and within 800 meters of a station. We also examine the light rail distance gradient by using the walk time from each property to the nearest station. Billings (2011) argues that is useful to consider the total neighborhood effects as well as the distance gradient, because of potentially misleading results when examining either by itself.

## 6.1 Sales Price

Table 2 shows difference-in-difference hedonic pricing estimates for properties within 1,500 meters of a Tide light rail station or a proposed station. The difference-in-difference estimate is given by the coefficient $\beta$ for the variable $postLRT_{ijt}$. Each column considers a different distance measure or time-frame for the light rail system. Column (1) shows the effect of being within 1,500 meters starting at the beginning of construction of the Tide (December 2007), while column (2) differentiates between the construction and operations phase. Both estimates show that the sales price declined in actual light rail neighborhoods relative to the control group. The average property depreciation from the start of construction (Column 1) was 7.8%. Furthermore, the results suggest that home sales fell by 4.8% during construction and by over 9% after the light rail began operations. This result is consistent with columns (4) and (5), which separate out properties within 800 meters with those over 800 meters up to 1,500 meters. Furthermore, they show that properties closer to the light rail stations experienced a larger price depreciation than those further away, compared to the control group.

In addition, the walk time gradient shows how the sales price changes as the walking distance from a station grows. The walk time gradient is consistent with the total neighborhood effect. The estimated coefficient shows that the sales price increases the further away a property is from a station. These results suggest that potential costs to light rail such as increases in perceptions of crime or nuisance effects outweigh the accessibility benefits.

## 6.2 Price Spread

Table 3 shows difference-in-difference results for the sales-list price spread. This provides another measure of price responsiveness of homeowners from light rail transit. The sales-list price spread is the log difference between the final selling price and the original listing price for a property. A positive price spread means the final sales price was higher than the original list price.

The results in Table 3 shows that on average homes were sold at a lower price than original asking price compared to the control group. The first column shows the effect after construction began, and through the operation phase of the light rail system. In particular, homes within 1500 meters of a station sold for approximately 2% less than the original asking price compared to the control group. Column 2 shows that the decline in the sales-list price spread is similar during construction and the operation phase. While the final 2 columns highlight a larger decline in the price spread among properties within 800 meters. The final column displays the walk-distance gradient. The positive coefficient for $Walktime * postconstruction$ means that the final sales price grew relative to the list price as distance from a light rail station increases.

These results indicate that sellers experience a decrease in the final sale price relative to the original list price due to the introduction of the light rail system. However, sellers expectations about the value of their property play an important role in evaluating changes in the sales-list price spread. For instance, one potential explanation for the negative sale-list price spread is that sellers, based on selected experiences in other areas, expect their property to appreciate in value due to light rail. This could result in some sellers attempting to price that premium in the original list price, which could decrease the sale-list spread. Further, if potential buyers do not value light rail's benefits over the potential costs then the reduction in offer values and subsequently sales amount could effect the price spread.

### 6.3 Time-on-Market

Table 4 provides results for time-on-market for properties within 1,500 meters of a constructed or proposed light rail station. The results show that properties near constructed light rail stations experiences a positive, but statistically insignificant increase in the days a property is on the market. This result is consistent among specifications and distances from the rail station. The point coefficient for time-on-market is larger, yet still not statistically significant at the 10% level, for homes within 800 meters compared to those over 800 meters up to 1,500 meters.

## 7 Robustness Checks and Dynamic Results

Next, we examine the robustness of the primary results discussed in section 6. We do so first by excluding proposed light rail stations P12 and P13 on Figure 1 from our control group. These proposed stations were eliminated because of their proximity to the Virginia Beach oceanfront. This part of Virginia Beach is primarily focused on recreation and tourism, and might not be an appropriate control group for the constructed Tide light rail stations that are much further away from similar amenities. Second, we provide results for the dynamic model depicted in equation 2. This provides information on how the residential real estate market evolved overtime due to the light rail. It also allows us to test the pre-existing trend assumption underlying the difference-in-difference results.

Table 5 shows the results for each dependent variable when eliminating proposed stations 12 and 13 (labeled P12 and P13 respectively in Figure 1) near the Virginia Beach oceanfront from the analysis. The first column displays results for the log sales price, while the subsequent columns show the price spread and time-on-market. In these results we focus on the difference-in-difference estimates for after the start of construction. The results are consistent when we consider the treatment time period as after the start of operations, or both the construction and operation phase.

First, the results show a negative and statistically significant effect on the sales price. In particular, sales prices decline by over 8% within 800 meters of a constructed station and approximately 7% for properties between 800 and 1,500 meters compared to the control group. In the same light, column 2 shows a negative relationship between the sales-list price spread. Finally, the results in column 3 show that the time-on-market was higher (and statistically significant at the 1% level) among constructed light rail stations relative to the control group. The robustness checks in Table 5 are consistent in magnitude and sign for the full sample of data.

We estimate equation 2 to examine the dynamic nature of the residential real estate market response to light rail transit. The model uses the same property level data and control variables as the earlier results as well as the full sample of data. However, we now use a light rail treatment indicator interacted with time indicators for every 6-months time period. We also consider time periods before the Tide light rail construction began. The baseline in the estimated dynamic models is the year 2003. This helps to shed light on the key assumption behind the difference-in-difference research design. A causal interpretation of the findings would be weakened if the real estate market outcomes were changing before construction began.

The dynamic results are displayed in the three panels in Figure 2 log sales price (top panel), sales-list price spread (middle panel) and time-on-market (bottom panel) respectively. In each figure the solid line represents estimated coefficients, while the shaded area is the 95% confidence interval. The log sales price depicted in Figure 2 shows the difference in the treated and control group compared to the baseline year 2003. It shows the average effect for 2004 - 2006 as statistically indistinguishable from zero at the 10% level. It also shows that the average sales price near light rail stations began to fall during the construction phase and remained negative and statistically significant for the end of construction and the operation phase. This provides evidence that the sale price results are not driven by differing pre-existing trends for the treatment and control group.

Next, the middle and lower panels in Figure 2 show similar graphs for the sales-list price spread and time-on-market. These figures also provide some evidence that the results for each outcome measure were not driven by pre-existing trends. However, the estimated treatment effect in these figures are not as well-defined as the log sales price. The results do suggest a negative average treatment effect for the sales-list price spread. Dynamic results, like those displayed in Figure 2 are often plagued with large standard errors due to the high correlation between the treatment and time interactions.

# 8 Conclusion

Light rail transit systems are under growing scrutiny, because of the increasing use of public funds to finance construction costs as well as to subsidize operating expenses. Researchers have often turned to the real estate market to examine the impact of light rail on the local area. This study adds to this growing literature by estimating the effect of the Norfolk Tide light rail on three residential real estate market outcomes: the real sales price, sales-list price spread, and time-on-market. We accomplish this by using a difference-in-differences empirical model. We exploit a proposed, but not constructed rail line in neighboring Virginia Beach, Virginia as the control group.

Our estimates show that the Tide light rail system had a negative effect on homes within 1,500 meters of constructed stations. The estimates show that the sales price declined in actual light rail neighborhoods relative to the control group by 7.8% from the start of construction. Thus, using our preferred hedonic pricing estimate, the aggregate decline in housing values due to the light rail was approximately $75 million. Furthermore, homes within 1500 meters of a station sold for approximately 2% less than the original asking price compared to the control group. The time-on-market for each property increased for those in light rail areas, however the increase was not statistically significant at the 10% level.

It is useful to put our results into context based on the academic literature. The previous quasi-experimental studies focused on the effect of light rail transit on residential housing prices in large metropolitan areas. These studies examined either the construction of a new light rail system or the opening of new stations and service frequency for long-standing rail transit lines. The results in the previous literature generally show a positive effect for rail transit on residential housing. Billings (2011) estimates a 4% increase in the sales price for single family homes in Charlotte, while McMillen and McDonald (2004) note an average increase of $6,000 in Chicago. (Gibbons and Machin (2005) and Dubé, Thériault, and Des Rosiers (2001)) both examine the expansion of an existing rail line for London and Montreal, respectively. They both find positive effects on home values. In contrast, (Gatzlaff and Smith (1993) find only weak evidence that the announcement of the Miami Metrorail system positively impacted residential home values. Each of the cities in the previous literature have a larger population and ridership than Norfolk. Furthermore, the connectivity of the rail tranist lines in these cities provide arguably greater accessibility benefits to homeowners living near stations. Therefore, the capitalization effects of the rail lines on the real estate market are larger than the Norfolk Tide.

The results reported in this paper measure the effect of the Tide light rail on the residential housing market for the construction phase and the first 4 years after the start of operations. Thus, the results are limited in the benefits and costs to light rail that are capitalized in the housing market. For instance, our estimates do not include benefits from any future transit oriented economic activity that could be capitalized by homeowners near Tide stations. Nor do they include any increases in accessibility from future rail line expansions or general equilibrium effects to the area as a whole from reduced traffic congestion and pollution or business attraction. Nonetheless, our results suggest that light rail proponents should take caution in encouraging projects that do not provide accessibility benefits that outweigh any potential costs.

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Figure 1: Proposed and Actual Stations for the Tide

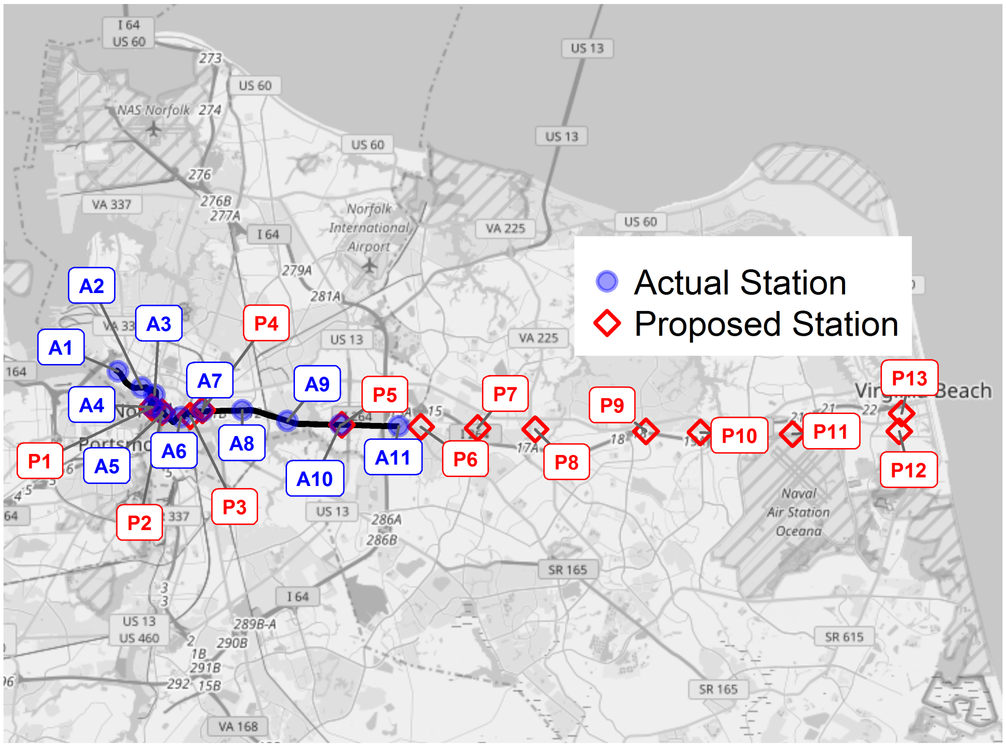
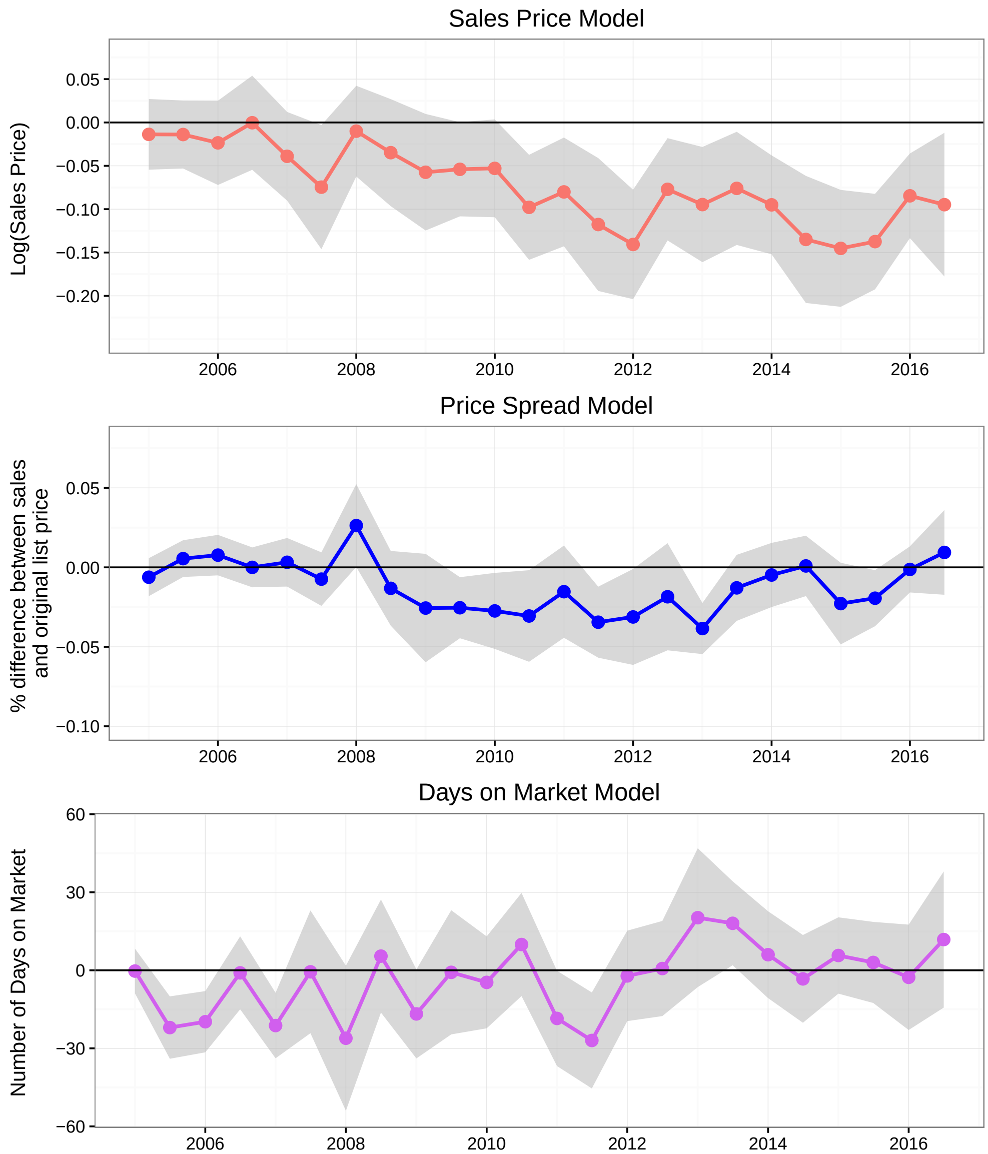


Figure 2: Results from Dynamic Models




Grey shading represents 95% confidence intervals

Table 1: Descriptive Statistics

| Group | Variable | Mean | Median | StdDev | Max |
|---|---|---|---|---|---|
| Treatment | sales price | 227755.543 | 203930.000 | 136529.623 | 3050000.000 |
| Control | sales price | 239516.367 | 211000.000 | 148233.909 | 1500000.000 |
| Treatment | price spread | -0.040 | -0.020 | 0.115 | 7.125 |
| Control | price spread | -0.067 | -0.031 | 0.176 | 8.618 |
| Treatment | time-on-market | 60.081 | 33.000 | 82.656 | 1500.000 |
| Control | time-on-market | 76.746 | 48.000 | 93.304 | 1443.000 |
| Treatment | distance to station | 1002.240 | 1060.129 | 346.984 | 1499.861 |
| Control | distance to station | 806.641 | 809.073 | 377.473 | 1499.261 |
| Treatment | walking time | 20.330 | 19.500 | 7.771 | 45.717 |
| Control | walking time | 14.084 | 13.250 | 8.193 | 54.683 |
| Treatment | age | 36.061 | 34.000 | 17.730 | 118.000 |
| Control | age | 53.578 | 53.000 | 33.150 | 124.000 |
| Treatment | bedrooms | 2.975 | 3.000 | 0.790 | 11.000 |
| Control | bedrooms | 2.998 | 3.000 | 1.066 | 8.000 |
| Treatment | full baths | 1.857 | 2.000 | 0.593 | 5.000 |
| Control | full baths | 1.839 | 2.000 | 0.687 | 5.000 |
| Treatment | half baths | 0.547 | 1.000 | 0.510 | 5.000 |
| Control | half baths | 0.468 | 0.000 | 0.533 | 3.000 |
| Treatment | new home | 0.123 | 0.000 | 0.329 | 1.000 |
| Control | new home | 0.120 | 0.000 | 0.325 | 1.000 |
| Treatment | off street parking | 0.187 | 0.000 | 0.390 | 1.000 |
| Control | off street parking | 0.264 | 0.000 | 0.441 | 1.000 |
| Treatment | pool | 0.082 | 0.000 | 0.274 | 1.000 |
| Control | pool | 0.048 | 0.000 | 0.213 | 1.000 |
| Treatment | reo | 0.067 | 0.000 | 0.249 | 1.000 |
| Control | reo | 0.096 | 0.000 | 0.295 | 1.000 |
| Treatment | short sale | 0.034 | 0.000 | 0.182 | 1.000 |
| Control | short sale | 0.028 | 0.000 | 0.166 | 1.000 |
| Treatment | sqft | 1.563 | 1.498 | 0.528 | 6.200 |
| Control | sqft | 1.763 | 1.594 | 0.820 | 9.105 |
| Treatment | waterfront | 0.080 | 0.000 | 0.271 | 1.000 |
| Control | waterfront | 0.091 | 0.000 | 0.288 | 1.000 |

The treatment and control group sample sizes include 10,404 and 6,716 sales, respectively. Distance to the nearest (actual or proposed) station is measured in meters "as the crow flies" from each home's geocoordinates. Walking time is measured in minutes and calculated using Google's MAP API.

Table 2: Sales Price Results
(control group = homes with 1500m of proposed stations)

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | lnsales | lnsales | lnsales | lnsales | lnsales |
| age | -0.0089*** | -0.0088*** | -0.0089*** | -0.0089*** | -0.0090*** |
| | (0.0009) | (0.0009) | (0.0008) | (0.0008) | (0.0009) |
| agesq | 0.0001*** | 0.0001*** | 0.0001*** | 0.0001*** | 0.0001*** |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) |
| sqft | 0.6313*** | 0.6318*** | 0.6296*** | 0.6302*** | 0.6285*** |
| | (0.0506) | (0.0506) | (0.0507) | (0.0508) | (0.0500) |
| sqftsq | -0.0629*** | -0.0629*** | -0.0626*** | -0.0627*** | -0.0625*** |
| | (0.0097) | (0.0097) | (0.0097) | (0.0097) | (0.0095) |
| bedrooms | 0.0034 | 0.0034 | 0.0038 | 0.0038 | 0.0038 |
| | (0.0065) | (0.0065) | (0.0065) | (0.0065) | (0.0065) |
| full baths | 0.0730*** | 0.0729*** | 0.0730*** | 0.0728*** | 0.0725*** |
| | (0.0102) | (0.0102) | (0.0103) | (0.0103) | (0.0102) |
| half baths | 0.0328*** | 0.0328*** | 0.0330*** | 0.0330*** | 0.0333*** |
| | (0.0127) | (0.0127) | (0.0127) | (0.0128) | (0.0124) |
| waterfront | 0.1493*** | 0.1499*** | 0.1482*** | 0.1488*** | 0.1477*** |
| | (0.0200) | (0.0201) | (0.0199) | (0.0200) | (0.0198) |
| new home | 0.0782*** | 0.0783*** | 0.0781*** | 0.0780*** | 0.0785*** |
| | (0.0154) | (0.0156) | (0.0154) | (0.0156) | (0.0150) |
| pool | 0.0268** | 0.0280** | 0.0264** | 0.0276** | 0.0249** |
| | (0.0129) | (0.0129) | (0.0128) | (0.0128) | (0.0124) |
| off street parking | -0.0034 | -0.0035 | -0.0034 | -0.0034 | -0.0031 |
| | (0.0063) | (0.0063) | (0.0063) | (0.0063) | (0.0062) |
| reo | -0.2981*** | -0.2979*** | -0.2983*** | -0.2982*** | -0.3002*** |
| | (0.0165) | (0.0164) | (0.0165) | (0.0164) | (0.0169) |
| short sale | -0.2003*** | -0.2009*** | -0.2010*** | -0.2015*** | -0.1985*** |
| | (0.0146) | (0.0145) | (0.0146) | (0.0146) | (0.0145) |
| LRT | 0.0567 | 0.0562 | | | |
| | (0.0736) | (0.0742) | | | |
| LRT*post construction | -0.0788*** | | | | |
| | (0.0188) | | | | |
| LRT*construction only | | -0.0486*** | | | |
| | | (0.0183) | | | |
| LRT*post opening | | -0.0976*** | | | |
| | | (0.0212) | | | |
| within800m | | | 0.0246 | 0.0249 | |
| | | | (0.0765) | (0.0770) | |
| within1500m | | | 0.0529 | 0.0528 | |
| | | | (0.0744) | (0.0750) | |
| within800m*post construction | | | -0.0869*** | | |
| | | | (0.0256) | | |
| within1500m*post construction | | | -0.0707*** | | |
| | | | (0.0208) | | |
| within800m*construction only | | | | -0.0530* | |
| | | | | (0.0275) | |
| within1500m*construction only | | | | -0.0451** | |
| | | | | (0.0184) | |
| within800m*post opening | | | | -0.1072*** | |
| | | | | (0.0263) | |
| within1500m*post opening | | | | -0.0874*** | |
| | | | | (0.0261) | |
| walktime | | | | | 0.0013 |
| | | | | | (0.0012) |
| walktime*post construction | | | | | 0.0017* |
| | | | | | (0.0010) |
| N | 17120 | 17120 | 17120 | 17120 | 17120 |
| F-statistic | 223.741*** | 223.594*** | 222.860*** | 222.136*** | 222.764*** |
| $R^2$ | 0.839 | 0.839 | 0.839 | 0.840 | 0.839 |
| Adj. $R^2$ | 0.835 | 0.836 | 0.836 | 0.836 | 0.835 |

Standard errors are in parentheses and are clustered at the Census block group level. *** denotes significance at the one percent level, ** at the five percent level, and * at the ten percent level. Each model includes unreported Census block group fixed effects, (month x year) fixed effects, and indicator variables for the home's high school district, the home's ownership type (5 categories), style of the home (22 categories), interior features (12 categories), and exterior features (18 categories). Our sample includes all sales from July 2002 through August 2016. LRT is a treatment indicator for homes within 1500 meters of an actual light rail station, while within800m and within1500m are indicators for homes between 0-800 meters and between 800-1500 meters of a station, respectively.

Table 3: Price Spread Results (ln(sales)-ln(list))
(control group = homes with 1500m of proposed stations)

| | (1) price spread | (2) price spread | (3) price spread | (4) price spread | (5) price spread |
|---|---|---|---|---|---|
| age | -0.0008*** | -0.0008*** | -0.0008*** | -0.0008*** | -0.0008*** |
| | (0.0002) | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| agesq | 0.0000** | 0.0000** | 0.0000** | 0.0000** | 0.0000** |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) |
| sqft | 0.0017 | 0.0017 | 0.0016 | 0.0017 | 0.0015 |
| | (0.0082) | (0.0081) | (0.0082) | (0.0082) | (0.0082) |
| sqftsq | -0.0036** | -0.0036** | -0.0036** | -0.0036** | -0.0036** |
| | (0.0015) | (0.0015) | (0.0015) | (0.0015) | (0.0015) |
| bedrooms | -0.0001 | -0.0001 | -0.0001 | -0.0001 | -0.0001 |
| | (0.0020) | (0.0020) | (0.0020) | (0.0020) | (0.0020) |
| full baths | 0.0124*** | 0.0124*** | 0.0124*** | 0.0124*** | 0.0124*** |
| | (0.0028) | (0.0028) | (0.0028) | (0.0028) | (0.0028) |
| half baths | 0.0083*** | 0.0083*** | 0.0083*** | 0.0083*** | 0.0083*** |
| | (0.0029) | (0.0029) | (0.0029) | (0.0029) | (0.0028) |
| waterfront | -0.0140*** | -0.0140*** | -0.0141*** | -0.0141*** | -0.0136*** |
| | (0.0050) | (0.0050) | (0.0050) | (0.0050) | (0.0050) |
| new home | 0.0268*** | 0.0268*** | 0.0268*** | 0.0267*** | 0.0264*** |
| | (0.0070) | (0.0070) | (0.0069) | (0.0068) | (0.0071) |
| pool | 0.0061* | 0.0061* | 0.0060* | 0.0060* | 0.0060* |
| | (0.0032) | (0.0032) | (0.0032) | (0.0032) | (0.0034) |
| off street parking | -0.0032 | -0.0032 | -0.0032 | -0.0032 | -0.0034 |
| | (0.0028) | (0.0028) | (0.0028) | (0.0028) | (0.0028) |
| reo | -0.0389*** | -0.0389*** | -0.0389*** | -0.0389*** | -0.0393*** |
| | (0.0054) | (0.0054) | (0.0054) | (0.0054) | (0.0054) |
| short sale | -0.0820*** | -0.0820*** | -0.0820*** | -0.0820*** | -0.0816*** |
| | (0.0103) | (0.0102) | (0.0103) | (0.0103) | (0.0102) |
| LRT | 0.0071 | 0.0071 | | | |
| | (0.0176) | (0.0177) | | | |
| LRT*post construction | -0.0195*** | | | | |
| | (0.0050) | | | | |
| LRT*construction only | | -0.0203*** | | | |
| | | (0.0073) | | | |
| LRT*post opening | | -0.0190*** | | | |
| | | (0.0047) | | | |
| within800m | | | 0.0077 | 0.0078 | |
| | | | (0.0185) | (0.0186) | |
| within1500m | | | 0.0048 | 0.0049 | |
| | | | (0.0179) | (0.0180) | |
| within800m*post construction | | | -0.0224*** | | |
| | | | (0.0072) | | |
| within1500m*post construction | | | -0.0167*** | | |
| | | | (0.0054) | | |
| within800m*construction only | | | | -0.0221* | |
| | | | | (0.0117) | |
| within1500m*construction only | | | | -0.0186** | |
| | | | | (0.0074) | |
| within800m*post opening | | | | -0.0226*** | |
| | | | | (0.0060) | |
| within1500m*post opening | | | | -0.0155*** | |
| | | | | (0.0058) | |
| walktime | | | | | -0.0004* |
| | | | | | (0.0002) |
| walktime*post construction | | | | | 0.0006*** |
| | | | | | (0.0002) |
| N | 17117 | 17117 | 17117 | 17117 | 17117 |
| F-statistic | 10.390*** | 10.363*** | 10.339*** | 10.287*** | 10.313*** |
| $R^2$ | 0.195 | 0.195 | 0.195 | 0.195 | 0.194 |
| Adj. $R^2$ | 0.176 | 0.176 | 0.176 | 0.176 | 0.175 |

Standard errors are in parentheses and are clustered at the Census block group level. *** denotes significance at the one percent level, ** at the five percent level, and * at the ten percent level. Each model includes unreported Census block group fixed effects, (month x year) fixed effects, and indicator variables for the home's high school district, the home's ownership type (5 categories), style of the home (22 categories), interior features (12 categories), and exterior features (18 categories). Our sample includes all sales from July 2002 through August 2016. LRT is a treatment indicator for homes within 1500 meters of an actual light rail station, while within800m and within1500m are indicators for homes between 0-800 meters and between 800-1500 meters of a station, respectively.

## Table 4: Time-on-Market
## (control group = homes with 1500m of proposed stations)

| | (1)<br>days on market | (2)<br>days on market | (3)<br>days on market | (4)<br>days on market | (5)<br>days on market |
|---|---|---|---|---|---|
| age | -0.2722 | -0.2813 | -0.2747 | -0.2856 | -0.2408 |
| | ( 0.3262) | ( 0.3299) | ( 0.3237) | ( 0.3295) | ( 0.3234) |
| agesq | 0.0024 | 0.0025 | 0.0024 | 0.0025 | 0.0021 |
| | ( 0.0026) | ( 0.0026) | ( 0.0026) | ( 0.0026) | ( 0.0026) |
| sqft | 4.7042 | 4.5967 | 4.6693 | 4.4768 | 4.8624 |
| | ( 5.8988) | ( 5.9322) | ( 5.8978) | ( 5.9639) | ( 5.7908) |
| sqftsq | 1.1817 | 1.1877 | 1.1841 | 1.1970 | 1.1454 |
| | ( 0.9488) | ( 0.9523) | ( 0.9554) | ( 0.9623) | ( 0.9350) |
| bedrooms | -1.5773 | -1.5872 | -1.5444 | -1.5474 | -1.6424 |
| | ( 1.6349) | ( 1.6393) | ( 1.6352) | ( 1.6426) | ( 1.6281) |
| full baths | -2.7465 | -2.7094 | -2.7708 | -2.7145 | -2.7603 |
| | ( 1.8440) | ( 1.8381) | ( 1.8526) | ( 1.8418) | ( 1.8530) |
| half baths | -4.1508** | -4.1385** | -4.2574** | -4.2577** | -4.3079** |
| | ( 1.9699) | ( 1.9653) | ( 1.9471) | ( 1.9355) | ( 1.9265) |
| waterfront | 9.9669** | 9.8457** | 10.0677** | 9.9403** | 10.1325** |
| | ( 4.6680) | ( 4.6164) | ( 4.7913) | ( 4.7175) | ( 4.7661) |
| new home | 16.8631 | 16.8598 | 16.8103 | 16.9148* | 17.0596 |
| | (10.6063) | (10.4679) | (10.5304) | (10.2576) | (10.4111) |
| pool | -5.3835 | -5.6333 | -5.3097 | -5.5344 | -4.8985 |
| | ( 3.4205) | ( 3.4417) | ( 3.3969) | ( 3.4139) | ( 3.3566) |
| off street parking | 3.1229* | 3.1399* | 3.1248* | 3.0923* | 3.1254* |
| | ( 1.6830) | ( 1.6828) | ( 1.6784) | ( 1.6784) | ( 1.6743) |
| reo | -9.3253*** | -9.3518*** | -9.3448*** | -9.3544*** | -9.0516*** |
| | ( 2.9172) | ( 2.9121) | ( 2.8772) | ( 2.8603) | ( 2.8878) |
| short sale | 94.1647*** | 94.2834*** | 94.0911*** | 94.1691*** | 94.1619*** |
| | ( 6.8142) | ( 6.8077) | ( 6.8106) | ( 6.8040) | ( 6.7736) |
| LRT | -44.2330*** | -44.1252*** | | | |
| | (15.1408) | (14.9652) | | | |
| LRT*post construction | 6.2924 | | | | |
| | ( 4.8760) | | | | |
| LRT*construction only | | 0.0637 | | | |
| | | ( 5.2415) | | | |
| LRT*post opening | | 10.1803* | | | |
| | | ( 5.9095) | | | |
| within800m | | | -48.5711*** | -48.8040*** | |
| | | | (16.0067) | (15.9104) | |
| within1500m | | | -40.7524*** | -40.7749*** | |
| | | | (15.2543) | (15.1591) | |
| within800m*post construction | | | 10.3967 | | |
| | | | ( 7.4067) | | |
| within1500m*post construction | | | 2.3036 | | |
| | | | ( 3.9758) | | |
| within800m*construction only | | | | 1.2586 | |
| | | | | ( 6.3496) | |
| within1500m*construction only | | | | -1.0515 | |
| | | | | ( 5.4686) | |
| within800m*post opening | | | | 15.8365* | |
| | | | | ( 9.3552) | |
| within1500m*post opening | | | | 4.5651 | |
| | | | | ( 3.9531) | |
| walktime | | | | | 0.0878 |
| | | | | | ( 0.2114) |
| walktime*post construction | | | | | -0.4063 |
| | | | | | ( 0.2737) |
| N | 17114 | 17114 | 17114 | 17114 | 17114 |
| F-statistic | 9.429*** | 9.432*** | 9.394*** | 9.382*** | 9.407*** |
| $R^2$ | 0.180 | 0.181 | 0.180 | 0.181 | 0.180 |
| Adj. $R^2$ | 0.161 | 0.162 | 0.161 | 0.162 | 0.161 |

Standard errors are in parentheses and are clustered at the Census block group level. *** denotes significance at the one percent level, ** at the five percent level, and * at the ten percent level. Each model includes unreported Census block group fixed effects, (month x year) fixed effects, and indicator variables for the home's high school district, the home's ownership type (5 categories), style of the home (22 categories), interior features (12 categories), and exterior features (18 categories). Our sample includes all sales from July 2002 through August 2016. LRT is a treatment indicator for homes within 1500 meters of an actual light rail station, while within800m and within1500m are indicators for homes between 0-800 meters and between 800-1500 meters of a station, respectively.

Table 5: Robustness Checks
(control group = homes with 1500m of proposed stations excluding VB Oceanfront Stations)

| | (1) lnsales | (2) price spread | (3) days on market |
|---|---|---|---|
| age | -0.0088*** | -0.0009*** | -0.2831 |
| | (0.0010) | (0.0003) | ( 0.3997) |
| agesq | 0.0001*** | 0.0000** | 0.0025 |
| | (0.0000) | (0.0000) | ( 0.0031) |
| sqft | 0.5584*** | 0.0029 | 3.2772 |
| | (0.0543) | (0.0094) | ( 5.4929) |
| sqftsq | -0.0543*** | -0.0037** | 0.9740 |
| | (0.0098) | (0.0016) | ( 0.8152) |
| bedrooms | 0.0077 | -0.0013 | -0.7197 |
| | (0.0068) | (0.0022) | ( 1.5788) |
| full baths | 0.0910*** | 0.0133*** | -2.5805 |
| | (0.0106) | (0.0032) | ( 1.9030) |
| half baths | 0.0515*** | 0.0090*** | -3.7204** |
| | (0.0134) | (0.0033) | ( 1.8824) |
| waterfront | 0.1433*** | -0.0132** | 11.0562** |
| | (0.0183) | (0.0052) | ( 4.9781) |
| new home | 0.0794*** | 0.0304*** | 11.4715 |
| | (0.0171) | (0.0082) | (12.3908) |
| pool | 0.0320** | 0.0050 | -5.8097 |
| | (0.0139) | (0.0040) | ( 3.7746) |
| off street parking | -0.0061 | -0.0039 | 2.7885* |
| | (0.0073) | (0.0032) | ( 1.6201) |
| reo | -0.3093*** | -0.0418*** | -7.5002** |
| | (0.0175) | (0.0057) | ( 2.9601) |
| short sale | -0.2144*** | -0.0851*** | 98.3754*** |
| | (0.0161) | (0.0117) | ( 6.6283) |
| within800m | 0.0205 | 0.0003 | -48.2017*** |
| | (0.0869) | (0.0203) | (14.7600) |
| within1500m | 0.0535 | -0.0011 | -40.9787*** |
| | (0.0854) | (0.0192) | (14.0236) |
| within800m*post construction | -0.0841*** | | 15.2346** |
| | (0.0261) | | ( 6.7318) |
| within1500m*post construction | -0.0686*** | | 6.5149* |
| | (0.0213) | | ( 3.4101) |
| within800m*post opening | | -0.0150*** | |
| | | (0.0046) | |
| within1500m*post opening | | -0.0095* | |
| | | (0.0055) | |
| N | 14014 | 14012 | 14008 |
| F-statistic | 190.047*** | 9.147*** | 8.657*** |
| $R^2$ | 0.838 | 0.200 | 0.191 |
| Adj. $R^2$ | 0.834 | 0.178 | 0.169 |

Standard errors are in parentheses and are clustered at the Census block group level. *** denotes significance at the one percent level, ** at the five percent level, and * at the ten percent level. Each model includes unreported Census block group fixed effects, (month x year) fixed effects, and indicator variables for the home's high school district, the home's ownership type (5 categories), style of the home (22 categories), interior features (12 categories), and exterior features (18 categories). Our sample includes all sales from July 2002 through August 2016. LRT is a treatment indicator for homes within 1500 meters of an actual light rail station, while within800m and within1500m are indicators for homes between 0-800 meters and between 800-1500 meters of a station, respectively.

# Appendix A Additional Home Characteristics

Table 1: Complete List of Home Characteristics Accounted for in Empirical Models

| Interior Features | Exterior Features | Style Features | Ownership Type |
|---|---|---|---|
| gas fireplace | barn | 2 unit condo | simple |
| pull-down attic access | cul-de-sac | apartment | condo |
| walk-in closet | deck | bungalow | cooperative |
| window treatments | golf course lot | cape cod | timeshare |
| skylights | greenhouse | cluster | leasehold |
| scuttle access | gazebo | colonial | |
| wood burning stove | horses allowed | contemp | |
| bar | inground sprinklers | cottage | |
| permanent attic stairs | irrigation control | farmhouse | |
| master bedroom fireplace | tagged items | hi-rise | |
| cedar closet | patio | mobilie home | |
| handicap access | pump | modular | |
| | rain water harvesting | other | |
| | shed | quadraville | |
| | stables | ranch | |
| | tennis | spanish | |
| | wells | split-level | |
| | wooded | townhouse | |
| | | traditional | |
| | | tri-level | |
| | | twinhouse | |
| | | victorian | |