

Hedonic Amenity Valuation and Housing Renovations

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Abstract

Hedonic and repeat sales estimators are commonly used to value such important urban amenities as schools, environmental quality and access to transit. Given that property data often omits information on quality differences between same-aged homes as well as changes in structural attributes over time, researchers must assume that property renovations are uncorrelated with neighborhood amenities. We formally test if this assumption is valid by incorporating detailed data on renovations in Charlotte, NC. We begin by testing how the inclusion of minor and major home improvements influences hedonic and repeat sales indices. Results find limited bias in hedonic indices and that renovated properties are no more likely to be sold than non-renovated properties. Using the introduction of Charlotte's light rail-transit system in 2000, we estimate a positive bias of between 1.6% and 19.9% on the capitalized benefits of access to light rail due to omitted information on renovations. Our results show that a number of common data cleaning techniques used to address missing information on structural improvements may worsen this bias.

Keywords: renovations; amenity valuation

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1 Introduction

The use of hedonic methods to value neighborhood amenities (e.g. school quality, access to transit) is widespread in the urban economics and real estate literature. The implementation of housing price hedonic models requires a rich set of covariates for structural and neighborhood attributes in order to address concerns regarding omitted variable bias. Data is often available for basic housing attributes such as number of bathrooms, square footage as well as Census based neighborhood characteristics and school assignment, but this data rarely contains detailed housing attributes (e.g. kitchen upgrades, home maintenance). Researchers address missing details on structural attributes by assuming they are unrelated to the urban amenity under investigation. This assumption may be nontrivial if neighborhood amenities correlate with unobserved structural attributes. Furthermore, changes in neighborhood amenities alter the option value of existing properties, which may lead to changes in structural attributes through the expansion of existing structures or renovations within a home. [Harding et al. \(2007\)](#) and [McMillen and Thorsnes \(2006\)](#) show that the presence of renovations leads repeat sales indices to overstate housing price appreciation by between 0.2 and 0.5 percentage points annually. Correspondingly, this same upward bias in estimated appreciation rates may be present in the capitalization of neighborhood amenities.

Estimating hedonic models requires data from county tax records, multiple listing services or survey based reporting of home values. All of these datasets contain incomplete information about the quality or attribute specific age¹ of a home beyond the date of initial construction. To deal with this omitted information, the literature makes two implicit assumptions regarding the influence of renovations on housing prices. First, a home's structural attributes, such as age or square footage, accurately predict renovations. In this case, coefficients on structural attributes will incorporate the value added of renovations. The common incorporation of a polynomial specification of the age of a home as well as square footage in hedonic regressions aid in incorporating highly probable renovations.² Second, the likelihood of a home being sold is not related to renovations beyond

¹The attribute specific age would provide how many years since the remodeling of a kitchen or the construction of an additional bedroom.

² [Shilling et al. \(1997\)](#) and [Lee et al. \(2005\)](#) highlight the nonlinear depreciation of housing stock, while [Helms \(2003\)](#) finds that older homes and multiple story homes are more likely to be renovated.

structural and neighborhood attributes.

Both assumptions may be problematic for estimating price indices over time if renovations occur in preparation of the sale of a home or if renovations occur more frequently over time for a study area. The resulting self-selection of sold properties may bias estimates of housing price appreciation upward if they include a large portion of recently renovated homes.³ Additionally, housing renovations are likely correlated with observable and unobservable neighborhood attributes. As a neighborhood increases in school quality or access to transit, individual households will sort to these amenity-improving neighborhoods thereby impacting the selection of properties sold. Households may substitute neighborhood quality for housing quality with the later altered through housing renovations. Therefore, any positive bias from omitted renovations may be a result of unobserved positive neighborhood attributes, while negative bias may occur from a household substituting between neighborhood and structural quality.

This paper contributes to literature by modeling and testing if home renovations correlate with neighborhood amenities and the degree to which these structural improvements bias hedonic estimators. In order to measure housing renovations, we take advantage of a detailed database on building permits in the city of Charlotte, NC. We merge over 200,000 residential building permits between 1995 and 2008 with detailed parcel level data on single-family homes in Mecklenburg County, which captures the entire city of Charlotte. We are able to determine the dollar value of renovations prior to a home's transacted sale as well as between repeat sales of a home. We use this database to first determine the influence of omitted renovations on hedonic and repeat sales indices as well as test if recently renovated homes are more likely to be sold. We then hedonically estimate access to light rail-transit (LRT) and examine potential bias when we exclude our measure of housing renovations. We determine the extent of bias for valuing access to transit when we incorporate different research designs as well as data cleaning techniques to minimize the inclusion of renovated properties.

Consistent with an equilibrium hedonic price function, we show that homes that have been

³Hwang and Quigley (2004)) find a systematically biased estimate of the value of housing stock due to the self-selection of homes sold in repeat sales indices. A number of scholars (Gatzlaff and Haurin (1997), Gatzlaff and Haurin (1998), Case et al. (1997), Englund et al. (1998)) find self-selection in the attributes of sold properties relative to the entire housing stock.

recently renovated are equally as likely to be sold as non-renovated homes. Furthermore, the capitalization of renovations leads hedonic and repeat sales indices to overstate appreciation rates by 0.05 and 0.11 percentage points annually. Hedonic estimates for access to light rail-transit reveal a range of possible biases that relate to both model specification and data cleaning techniques. We find that repeat sales models that exclude properties purchased and sold less than one year apart generate the largest bias due to omitted renovations. For valuing access to transit, coefficients are positively biased between 1.6% and 19.9% of their magnitude depending on model specification and data sample. Across models, the magnitude of overvalued amenities is relatively small with the estimated bias per sold property representing less than \$1,000 of the marginal impacts on a sold home from the introduction of LRT to a neighborhood. Conclusions suggest that researchers incorporate multiple hedonic methods in estimating neighborhood amenities and that covariates for neighborhood and structural attributes are unable to completely control for the confounding effects of renovations on hedonic estimates.

2 Hedonic Models and Renovations

We begin with a standard housing price hedonic model with Y representing a vector of single-family home transacted sales prices; S is a matrix of structural characteristics; N is a matrix of neighborhood characteristics and D indicates a matrix of indicators for year-quarter of transacted sale. We simplify our notation by defining $X = [S \ N \ D]$. We model property renovations as a form of measurement error where existing structural and neighborhood characteristics may be measured with error due to missing information on property improvements.⁴ Therefore, $\tilde{X} = X + U$ with U indicating omitted renovations. We typically only observe X and estimate Equation 1 with omitted renovations captured in the error term W .⁵ Of course, U is likely not orthogonal to a number of components of X , which generates multiple sources of potential bias in estimating β .

⁴Alternatively, one could model housing renovations as a form of omitted variable bias. Since we model our measurement error as unmeasured components of structural attributes, we are simply imposing a specific structure to our omitted variable bias.

⁵For notational simplicity, let $W = U\beta + e$ and $V_X = (X'X)^{-1}$

$$\begin{aligned}
Y &= \tilde{X}\beta + e \\
&= (X + U)\beta + e \\
&= X\beta + W
\end{aligned}
\tag{1}$$

$$\begin{aligned}
\hat{\beta} &= V_X(X'Y) \\
&= V_X(X'(X\beta + U\beta + e)) \\
&= \beta + V_X(X'(U\beta + e)) \\
E(\hat{\beta} - \beta|X) &= V_X E(X'(U\beta + e)) \\
E(\hat{\beta} - \beta|X) &= V_S E[S'U]\beta + V_N E[N'U]\beta + V_D E[D'U]\beta + V_X E[X'e]
\end{aligned}
\tag{2}$$

We can hypothesize about the relationship between omitted renovations and different structural and neighborhood attributes based on the literature as well as the intuition of residential sorting models. For example, [Dye and McMillan \(2007\)](#) find that the decision to tear down existing homes (extreme renovations) is influenced by the size and age of a home as well as access to transit. [Clapp and Salavei \(2010\)](#) develop a real options model to show the importance of structural characteristics including a home's intensity of land use and structural amenities such as pools or fireplaces.

We formally distinguish sources of bias for hedonic coefficients in Equation 2 above. Bias likely occurs for structural attributes that correlate with renovations. This bias may be positive ($V_S E[S'U]\beta > 0$) for higher priced structural attributes, such as multiple stories, size of home, number of bedrooms, and patio/porch that lead to more renovations.⁶ Negative bias may occur if

⁶See [Helms \(2003\)](#), [Gyourko and Saiz \(2004\)](#), [Boehm and Ihlanfeldt \(1986\)](#), [Reschovsky \(1992\)](#) and [Plaut and Plaut \(2010\)](#).

lower priced features, such as an older housing stock, lead to more renovations.⁷

Bias in neighborhood attributes may be positive or negative due to the hypothesis that $E[N'U] \leq 0$. Specifically, $E[N'U] > 0$ may be a result of higher amenity neighborhoods attracting greater property investment. A positive relationship between neighborhood quality and renovations is found in previous literature where higher crime leads to a lower probability of renovations, higher income neighborhoods renovate more often and the presence of renovating neighbors increases the probability of renovations.⁸ Furthermore, an increase in neighborhood quality may lead households to substitute structural for neighborhood quality and $E[N'U] < 0$ may occur as homeowners forgo home improvements or recently renovated homes to afford higher neighborhood quality.

Bias in structural and neighborhood characteristics also may result from the self-selection of properties sold under hedonic analysis. If renovated properties sell more or less often over our study period, then $E[D'U] \neq 0$ due to the over or under-representation of renovated properties captured in our dataset of sold properties. Changes in the portion of renovated properties sold over time is problematic for event studies such as the introduction of transit to a neighborhood or temporal trends in other amenities such as school quality or crime.

The final concern of bias common to all hedonic studies are omitted neighborhood attributes. We assign unobserved neighborhood characteristics to e and hypothesize that $E[X'e] \neq 0$ in standard hedonic models. We later implement a quasi-experimental research design to highlight the role of unobserved neighborhood attributes in assessing any bias when omitting housing renovations.

We update our notation for repeat sales estimation in equation 3. We define Δ for any matrix A such that $\Delta A = A(t) - A(t - 1)$ and indicates that matrix A in time $t - 1$ is subtracted from matrix A in time t .⁹ Repeat sales analysis may alleviate some sources of bias, but exacerbate other causes of bias. Likely, bias may be worsened as renovations correlate with the structural attributes of repeat sales properties, for which short holding times may be indicative of renovations. The presence of short holding times may represent housing 'flips', where the second transaction occurs as soon as property renovations are completed and thus $E[\Delta D' \Delta U] \neq 0$. Additionally, $E[\Delta N' \Delta U]$

⁷See Helms (2003) and Gyourko and Saiz (2004)

⁸See Helms (2003), Gyourko and Saiz (2004), Boehm and Ihlanfeldt (1986), Reschovsky (1992) and Helms (2011).

⁹For notational simplicity, let $\Delta W = \Delta U\beta + \Delta e$ and $V_{\Delta X} = (\Delta X' \Delta X)^{-1}$

is still not equal to zero as changes in neighborhood amenities are correlated with renovations. The value of $V_{\Delta X}(\Delta X' \Delta e)$ decreases as time invariant neighborhood unobservables are removed, but changes in neighborhood amenities may still correlate with neighborhood unobservables in hedonic models that incorporate non-experimental research designs. In order to test for all of these potential sources of bias, we need to incorporate parcel data with information on sales, structural attributes and neighborhood characteristics as well as linked data on renovations. The next section details the data incorporated into our study.

$$\begin{aligned}
\Delta Y &= \Delta \tilde{X} \beta + \Delta e \\
&= (\Delta X + \Delta U) \beta + \Delta e \\
&= \Delta X \beta + \Delta W
\end{aligned} \tag{3}$$

$$\begin{aligned}
\hat{\beta} &= V_{\Delta X}(\Delta X' \Delta Y) \\
&= V_{\Delta X}(\Delta X'(\Delta X \beta + \Delta U \beta + \Delta e)) \\
&= \beta + V_{\Delta X} E[\Delta X'(\Delta U \beta + \Delta e)] \\
E(\hat{\beta} - \beta | \Delta X) &= V_{\Delta X} E[\Delta X'(\Delta U \beta + \Delta X' \Delta e)] \\
E(\hat{\beta} - \beta | \Delta X) &= V_{\Delta S} E[\Delta S' \Delta U] \beta + V_{\Delta N} E[\Delta N' \Delta U] \beta + V_{\Delta D} E[\Delta D' \Delta U] \beta + V_{\Delta X} E[\Delta X' \Delta e]
\end{aligned} \tag{4}$$

3 Data

The Mecklenburg County assessor's office maintains detailed electronic data on all parcels in its jurisdiction, which includes the entire city of Charlotte, NC. This data provides a number of standard structural attributes including bedrooms, bathrooms, building area (square footage), lot size (acres) as well as more detailed information on building attributes, with 55 unique building

attributes¹⁰ available in this dataset. The County assessor's office also maintains a database of all parcel sales transactions from 1994 through 2008. Since this research focuses on renovations that may change structural attributes, a relevant question is how often and when the county assessor updates parcel records. Countywide reassessment is scheduled to occur every 7 years in Mecklenburg County and in our study time period occurred in 1998 and 2003. According to the county assessor, the assessed value for a parcel is updated based on a property sale or permitted housing renovations, but structural attributes are typically only updated as part of countywide reassessments. Since county records give no indication of the quality of structural attributes, only the addition of new bedrooms, bathrooms or square footage would lead to any change in structural variables.¹¹ Kitchen, bathroom or other home renovations would not be captured in the assessor's records other than through assessed value or sales price.

We limit our sample from the assessor's records to only include single-family homes sold from 1996 through 2008 in order to incorporate our data on renovations, which is limited to 1995 through 2008. A total of 102,863 out of 226,240 single-family parcels are included in hedonic analysis because they contain a recorded property sale of at least \$10,000 since 1996, contain complete structural or geospatial information, have a lot size less than 5 acres and at least one bathroom. We also verify that properties sold prior to 2003 involved parcels on improved lots. In addition, the repeat sales estimator included a parcel more than once if it contained more than two sales transactions by treating each pair of transactions as a separate observation.

We augment parcels records with additional data, including Euclidean distance to the Downtown (*Distance to CBD*) and distance to the closest of Interstates 77, 85 or 485 (*Distance to Interstate*). For later analysis, we include include proximity to light rail-transit for which we computed the Euclidean distances from the centroid of each parcel to its nearest LRT station (*Distance to LRT*). We assign each parcel to its corresponding elementary school based on geospatial maps provided by Charlotte-Mecklenburg Schools. We include a measure of school quality based on annual averages

¹⁰Building attributes are based on subclassifications within attributes for foundations, exterior walls, heating/AC, style of home, number of stories

¹¹The updating of structural attributes by the county assessor is of limited concern for this study since only about 10% of the value of housing renovations is attributable to structural additions or alterations that would change structural variables.

of math and reading scores for third through fifth graders on state end-of-grade exams.

3.1 Renovations

Our measure of renovations is based on county building permits that are matched to specific parcels. A homeowner must obtain a building permit for any improvement that is valued at more than \$5,000 as well as renovations less than \$5,000 that include building, electrical, heating, air conditioning or plumbing work. This data captures most renovations of substantial value, but would exclude minor home improvements such as painting or home-owner replacement of flooring, carpeting, fixtures or appliances.

One concern when using building permits to measure housing renovations is that building permits fail to capture minor home improvements and non-permitted (owner or contracted) renovations, which leads one to undervalue renovations. The impact of this type of measurement error is likely small given that home-owner improvements are often smaller in value and thus less likely to be incorporated into offer prices of homebuyers. The scope of non-permitted (illegal) renovations is also limited given the ease of obtain building permits electronically and the cost of building permits, which are typically between 1% and 2% of total construction costs. Since we cannot directly address this issue, we assume that non-permitted renovations are proportional to permitted renovations. Specifically, we expect that for a typical stock of renovations, some portion is permitted, while the remaining renovations are captured in minor home improvements and regular maintenance. This assumption still generates an upward bias on our estimated coefficient for renovations due to non-permitted renovations, but does preserve the relative rankings of our renovation variable across observations. Under this assumption, any relationship between renovations and neighborhood amenities should be unaffected by this form of measurement error.

Another issue with constructing a variable for renovations is how to address renovations occurring in different time periods prior to the sale of a home. Renovations occurring multiple years prior to a transacted sale are likely discounted as they depreciate from their original construction date and value. At the same time, inflation in renovation costs would limit the depreciated value of prior renovations. Therefore, we adjust the nominal value of renovations to real dollars by assuming a

depreciation rate of 3% annually (estimated gross-of-maintenance rate of housing depreciation by [Harding et al. \(2009\)](#)).¹² We also adjust nominal renovation values by a measure of inflation in construction costs based on average materials and labor costs for a typical home according to [R. S. Means Company \(1998/2004\)](#). Our inflation rate of 2.0% for all renovations is based on the national appreciation of construction costs from \$65.35 a square foot in 1998 to \$73.15 a square foot in 2004.

In order to construct our measure of renovations, we begin by limiting our analysis to building permits assigned to single-family parcels and time periods that did not result in the classification of the property as a new construction. Our database begins with 203,103 building permits with detailed valuation and descriptions of contracted work. After eliminating permits for new construction, a total of 64,283 building permits with an average value of \$23,568 occur over our study period for existing single-family parcels. We construct our measure of renovations, *Reno Value*, for each sales price or repeat sales price observation by taking the value of renovations stated on each building permit for a given parcel and adjusting it to real dollars for the year a property is sold. For repeat sales, all building permits are aggregated in real dollars for only the years between property sales. For single sale hedonic models, all building permits prior to a property sale since 1995 are aggregated in real dollars to generate *Reno Value*. Since, we are assuming a linear additive relationship for renovations over time, we tested the sensitivity of results to two alternative measures of renovations. First, we constructed a squared term for aggregate renovations to date and included it in our hedonic models. To deal with nonlinearities in the impacts of renovations, we then disaggregated our measure of renovations to three separate variables: total value of renovations in the previous three years, total value of renovations three to six years ago and the total value of renovations greater than six years ago. In the end, these nonlinear measures of renovations generate similar results as *Reno Value*.

Table 1 provides summary statistics for all single-family parcels between 1996 and 2008 and by quintiles of median household income based on Census 2000 block groups (CBG). We characterize a parcel as sold if it was subject an arm's length transaction (greater than \$10,000 on an improved

¹²Results are similar with the use of depreciation rates of between 1% and 6%

lot) between 1996 and 2008 and as renovated if building permits were issued to a given parcel at any time from 1996 through 2008. Renovation value per parcel contains the aggregate value of all renovations in nominal dollars during this time period and averaged \$6,696 per parcel. These values indicate that renovations are common in this dataset and not inconsequential in monetary value. A typical home in our dataset is 2,050 square feet of building area on a third of an acre with 3 bedrooms and 2 baths. About five percent of all parcels are within one mile of LRT stations and the average school test score is similar to the state normalized mean of zero for reading and math with a score of -0.008 .

The more compelling results are across quintiles. As expected, wealthier neighborhoods contain larger homes on larger lots with better schools. Wealthier neighborhoods have parcels that sell more often, contain renovated homes and average the highest value for renovations. The presence of a number of renovations in poor neighborhoods is indicative of the older housing stock in these neighborhoods. The average year built in the poorest neighborhoods is 1965 compared to an overall average year built for all parcels of 1981. School quality is lower and access to light-rail transit is higher in poor neighborhoods. The variation in both neighborhood amenities as well as renovations across neighborhoods emphasizes the importance of including these variables in hedonic models.

3.2 Renovations and Sold Properties

Before we estimate any relationship between renovations and property appreciation or amenity valuation, we want to first examine if renovated properties are more likely to be sold and thus more likely to be included in a sample of sold properties. Any relationship between renovations and a property being sold may exacerbate potential bias due to omitted renovations. One could imagine two scenarios that could positively or negatively influence a property being sold. First, a seller may renovate their home in order to improve a home's curb appeal in preparation of a property being sold or as part of a sales agreement. Second, a buyer may purchase a home with the intention of 'flipping' or renovating the home which may lead to the sale of a non-renovated home. Either case will influence the relationship between renovations and price indices as well as estimates of amenity valuation.

We formally test if renovated homes are more likely to be sold over our study period in Figure 1. This figure provides a year by year comparison of the portion of homes sold in each CBG neighborhood for two groups of properties, renovated homes and non-renovated homes. We define a home as renovated for a given year if the parcel was renovated within the previous three years and all other parcels and years are classified as non-renovated. The shaded areas in each figure highlight the 95% confidence bands for each group of properties on an annual basis and indicate if a given year contains significance differences in the portion of properties sold for our sample of renovated versus non-renovated homes. The top part of Figure 1 includes all parcels sold at least once and shows that between 1996 and 2008 renovated parcels are not any more likely to be sold than non-renovated parcels. In fact, 1999 through 2003 found non-renovated homes were sold more often and this difference averaged about one percentage point. Results are similar for the bottom panel, which is based on parcels that sold more than once over the study period and we determine sales year based on the most recent sales date. We do find some self-selection as renovated parcels were sold more often for 2006 through 2008, but the magnitude of this difference is small. Similar likelihood of sale between renovated and non-renovated homes supports the role of price in equating quality differences between homes and thus the capitalization of renovations. This result provides evidence that the presence of renovations is not a major determinant of a home being sold in our sample of properties.

4 Renovations and Price Indices

As discussed by [McMillen and Thorsnes \(2006\)](#), renovations may lead repeat sales indices to overstate housing price appreciation. This relationship between renovations and housing price indices may also occur in non-repeat sales indices too. Here, we test if the presence of renovations leads to inflated estimates of housing price appreciation in our dataset for both a single sale hedonic price index as well as a repeat sales index. We begin by estimating housing price indices for a parcel's most recent sale and then extend our analysis to different subsets of neighborhoods and years to test the role of renovations in rich and poor neighborhoods as well as for high and low appreciation years.

$$\ln(P_{i,t}) = \alpha + \beta_1 \text{RenoValue}_{i,t} + \beta_2 S_{i,t} + \eta N_{i,t} + \sum_{j=1}^{n_j} \delta_j D_{i,j} + \varepsilon_{i,t} \quad (5)$$

We construct a single sale hedonic price index based on Equation 5 where *RenoValue* is our renovations variable equal to the aggregate value of renovations in real dollars; $S_{i,t}$ indicates a vector of structural attributes; $N_{i,t}$ indicates a vector of neighborhood attributes and $D_{i,j}$ represents a dummy for each year-quarter of sale from 1996:2 through 2008:4 with 1996:1 omitted; $\delta_j =$ coefficient for sale period j binary variable ($j = 1, 2, \dots, n_j$); and $\varepsilon_{i,t} =$ error term for property i in period t .¹³

In order to compare this price index with and without renovations, we estimate Equation 5 to indicate the index with renovations and estimate Equation 5 with $\beta_1 = 0$ to indicate the no renovations index. We create our index based on the estimated coefficients for our year-quarter dummies (δ_j) and add 100 to each coefficient so that the first quarter of year 1996 is equal to 100. We compute all appreciation rates for the single sales hedonic based on this index of coefficients.

We then estimate a repeat sales index by first differencing the original hedonic model for those properties with more than one sale during our study period based on the model specified in Equation 6. In this case, each variable indicates the change in value from sales time period $t - 1$ to t and $\Delta \text{RenoValue}_{i,t}$ indicates any new renovation in real dollars between time period t and $t - 1$ for each pair of repeat sales. $D^*_{i,j} = -1$ if property i sold for the first time in period j ($j = 1, 2, \dots, n_j$); equals $+1$ if property i sold for the second time in period j ; and equals zero otherwise.

$$\ln(P_{i,t}) - \ln(P_{i,t-1}) = \beta_1 \Delta \text{RenoValue}_{i,t} + \sum_{j=1}^{n_j} \delta_j D^*_{i,j} + \Delta \varepsilon_{i,t} \quad (6)$$

After estimating Equation 6 on our sample of repeat sales observations, we create our repeat sales index based on the estimated coefficients for our year-quarter dummies (δ_j). As with the single sales index, we scale our coefficients so that the first quarter of year 1996 is equal to 100. We estimate both price indices using the full set of single-family homes sold in Mecklenburg County,

¹³See Table 3 for specific structural and neighborhood variables. We do include standard structural variables (e.g. baths, square footage, etc.) as well as a number of neighborhood attributes collected by the city of Charlotte. In most cases, neighborhood attributes offer minimal influence on our results and thus we limit our discussion of them here.

NC from 1996 through 2008. Figure 2 graphically depicts our price indices for models with and without our renovation variable (*RenoValue*) for a standard hedonic index in the top panel and a repeat sales index in the bottom panel. When we calculate property appreciation from 1st quarter 1996 through the height of property values in 1st quarter 2008, we find an annual appreciation rate of 3.31% for the without renovations index and 3.26% for the with renovations index. This difference corresponds to 0.05% annually or about \$120 annually for the average transacted sales price of \$239,928.

For the repeat sales index on the bottom of Figure 2 between 1st quarter 1996 and 1st quarter 2008, we calculate an annual appreciation rate of 3.65% without renovations and 3.54% with renovations. The difference of 0.11% represents about \$214 annually for the average purchase price of \$194,593. Since the relationship between prices indices and renovations may vary by high appreciation and low appreciation years as well as rich and poor neighborhoods, we estimate these indices for four subsets of data. We estimate our indices for neighborhoods above and below the median Census Block Group 2000 median household income in our sample as well as years with above or below median annual appreciate rates. We report the annual appreciation rates for these different indices as well as our main index in Table 2. We present annual appreciation rates in each cell for the corresponding index given in row headings and the sample of properties given by column headings. Most of the alternative estimates of annual appreciation rates differ from each other statistically, but these differences are small in magnitude. Results across indices indicate that omitted information on renovations generates an upward bias in all indices, but only between 0.03 and 0.19 percentage points or at most one-fifth of one percent.

We do find that repeat sales indices generate about twice the magnitude of bias due to renovations, which may be consistent with homeowners renovating homes as part of growing number of housing flips that coincided with the high housing price appreciation rates of the 2000s. Surprisingly, we find limited differences in appreciation rates as well as similar estimates of bias due to omitted renovations when we bisect our data into rich and poor neighborhoods. When we segment our data into year-quarters with higher or lower appreciation rates than average, we find that high appreciation quarters generate larger biases than low appreciation quarters. In the end, we find

evidence that omitting renovations generates a small upward bias in estimates of housing price appreciation over time.

5 Light Rail - Transit and Renovations

Since we are concerned that housing renovations may correlate with changes in neighborhood amenities, we test if omitted renovations impacts hedonic estimates of a new neighborhood amenity in the city of Charlotte. Specifically, we examine the impact of estimating the value of proximity to a new light rail-transit (LRT) system announced in 2000. This analysis primarily replicates the methodology of [Billings \(2011\)](#) with new analysis focusing on the impact of renovations on hedonic estimates of structural coefficients and the value of access to LRT. We present limited background on LRT in Charlotte as well as limited details on the research design since readers can consult [Billings \(2011\)](#) for more in-depth discussion and methodological details.

5.1 Light Rail-Transit in Charlotte

A number of scholars estimate the benefits of light rail-transit (LRT) based on the premise that access to transit lowers commuting costs and increases neighborhood amenities.¹⁴ Therefore, local land markets should capitalize these benefits into property values. In summarizing the literature, [Debrezion et al. \(2007\)](#) find a median property value increase of 2.6% as one moves 820 feet closer to a rail transit station. Similar to a number of studies in this literature, our analysis focuses on estimating the impacts of LRT on property values within a single city.

Consistent with a number of medium size U.S. cities, Charlotte proposed the introduction of light rail-transit to address a growing population and associated traffic congestion as well as a means to promote neighborhood economic development. The history of LRT in Charlotte began with discussions in the late 1980s and in 1994, the city adopted a land use plan that targeted five transit corridors radiating out from the downtown. Then in November 1998, residents of Mecklenburg County voted to approve a one-half cent sales tax increase to fund light rail-transit. The announcement of the first alignment of LRT in the city of Charlotte occurred in September of

¹⁴See [Hess and Almeida \(2007\)](#) and [Debrezion et al. \(2007\)](#) for recent reviews of this literature.

2000, when the Metropolitan Transit Commission made the official decision to establish light rail for the South transit corridor.

This initial LRT alignment consists of a 9.6 mile route stretching southwest from the downtown nearly to the county line with 15 stations along the route. The South Line officially began service in November of 2007. The final construction costs were about \$49 million dollars a mile with a total cost of over \$450 million.¹⁵ The planning process for choosing the South Line identified two alternate corridors, the Northeast and Southeast.¹⁶ These ‘finalist’ corridors were considered throughout the entire planning process up until the announcement of the South Line in September 2000. All three alignments contain a number of similarities including connecting downtown to residential neighborhoods as well as using existing transportation corridors and right of ways to determine the placement of the LRT alignment. The two alternate alignments (Northeast and Southeast) represent a reasonable control group in order to implement a quasi-experimental research design in subsequent analysis.¹⁷

As discussed by [Billings \(2011\)](#), the announcement of LRT may have two effects on property values. The first effect is a shift in the property value gradient based on distance to a LRT station. The second effect is the overall appreciation of LRT neighborhoods due to neighborhood development in both residential and commercial properties and associated externalities from new development. Since [Billings \(2011\)](#) finds only the second effect to be statistically and economically significant, we focus on estimating the effects of the announcement of LRT on property values within 1 mile of LRT stations.

Before estimating the effect of omitted renovations on hedonic estimates of the capitalization of LRT, we want to determine if LRT neighborhoods contain more or less renovations than other neighborhoods. [Figure 3](#) graphs the average annual value of renovations per parcel from 1996 through 2008 highlighting the time of announcement by the solid line in November 2000. In order to focus on the relationship between the decision to renovate and LRT announcement, we graph

¹⁵Source: [Charlotte Area Transit System \(2009\)](#).

¹⁶Information about the planning process for light rail transit in Charlotte is based on discussions with CATS officials and city of Charlotte planning documents.

¹⁷See [Billings \(2011\)](#) for further details on LRT in Charlotte as well as greater description of LRT and control neighborhoods.

annual renovations for parcels within 1 mile of actual LRT stations (LRT Neighborhoods), within 1 mile of proposed LRT stations (Control Neighborhoods) and all parcels (All Neighborhoods). As seen in Figure 3, the value of renovations is similar across neighborhoods prior to the announcement of LRT and then increases at a greater rate for control and LRT neighborhoods starting in 2003. The fact that both control and treatment neighborhoods increase in permits is indicative of the fact that actual and proposed LRT stations are primarily located in transitional or improving neighborhoods. By 2005, LRT neighborhoods average twice the renovation value per parcel as other neighborhoods. The average value of renovations is approximately \$451 per parcel prior to announcement in LRT neighborhoods and then increases to \$790 per parcel between 2001 and 2004. A substantial increase in renovations to \$1,429 per parcel occurs between 2005 and 2008 within 1 mile of LRT stations. This figure highlights that renovations in LRT neighborhoods appear to positively correlate with the announcement of LRT. Since LRT neighborhoods vary along other dimensions, we turn to formally estimating a number of hedonic models to quantify the influence of renovations on valuing the amenity benefits of LRT.

5.2 Hedonic Model Results

Formally, we estimate the model given by Equation 5 for standard hedonic models with a couple of additional variables to highlight the impact of LRT. Specifically, we estimate a difference-in-difference model comparing parcels within 1 mile of LRT stations with those parcels within 1 mile of proposed LRT stations and compare these neighborhoods before and after the announcement of LRT in 2000. For standard hedonic models, we attempt to highlight if omitted information on renovations leads to bias coefficients on the impact of LRT as well as common structural attributes in hedonic models (e.g. baths, square footage, etc.). As with earlier price indices, we estimate one model where we exclude our renovations variable (*RenoValue*) and a separate model where we include *RenoValue*. We present results for models with and without renovations in adjacent columns to highlight their differences as well as third column to provide difference in coefficient estimates between the two models with accompanying tests of statistical significance. We also test if the relationship between renovations and hedonic coefficients changes when researchers implement

different research designs. In our case, we can compare the difference-in-difference model when we use control neighborhoods based on proposed LRT alignments versus simply including all other neighborhoods in the city.

Table 3 reports the amenity coefficient for LRT ($LRTAnn*SouthLine$) as the interaction of a dummy equal to one after November 2000 and a dummy equal to one if a parcel is within 1 mile of a LRT station. We report structural as well as a few common neighborhood attributes, but do not report coefficients for our indicators of unique building attributes or year-quarter fixed effects since their interpretation is not part of our analysis of renovations.

The first set of results in Table 3 provides a basic model with the inclusion of all single-family parcels that contain sold properties between 1998 and 2008. The first two columns give the model with and without renovations respectively and the third column provides the percent bias in the no renovations model. The estimated impact of LRT is 16.8% of the average single-family home, which equates to \$35,777.¹⁸ This estimate is large and as discussed by Billings (2011) is likely biased by the self-selection of neighborhoods that receive LRT. Neighborhoods considered for LRT stations typically have higher household income, lower crime and have experienced higher rates of new development and property values prior to the announcement of LRT.

Our amenity coefficient decreases by 0.003 with the inclusion of renovations, which indicates about a 1.6% bias.¹⁹ The coefficient on *RenoValue* determines the marginal impact of \$1,000 in building permit value and can be used to estimate the capitalization rate of renovations. For the first model, the coefficient of 0.0018 for an average sales price of \$216,708, would represent a capitalization rate of 39.1%.²⁰ This capitalization rate indicates that homeowners receive about a 39 cent return on each dollar invested in renovations. This estimate of the return to renovations is reasonable given that renovations may represent individual preferences as well as the consumption value of those renovations to the seller that would not be fully capitalized by purchasers of a home.

¹⁸Coefficients (θ) differ from estimated impacts due to the use of the Halvorsen and Palmquist (1980) correction for interpreting dummy variable coefficients in a semilogarithmic equation. Estimated impact is given by $(e^\theta - 1)$ for all reported impacts.

¹⁹The difference between the LRT coefficient in the renovation and non-renovation models is statistically significant at the 1% level as indicated by the three stars next the cell value for Bias%. Subsequent tables adopt this same convention and provide stars for statistically significant differences.

²⁰Capitalization rate is equal to the coefficient on the capitalization variable times the average sales price of \$216,708 divided by \$1,000.

Coefficients for structural and neighborhood attributes provide additional insight into the relationship between renovations and property characteristics. We find a positive bias to those structural attributes that are more likely to be associated with renovations. Substantially older homes as well as those that have more bathrooms are more likely to have been subject to renovations and thus coefficients on bathrooms and age^2 incorporate omitted renovations, which correspond to an upward bias. The smaller negative value for $sqft^2$ is a result of a positive relationship with the likelihood of renovations for a variable with a negative coefficient. Homeowners in neighborhoods with higher test scores, lower population densities and closer to the CBD are more likely to invest in renovations and thus generate a positive bias. The presence of bias across a number of structural characteristics indicates that the value of renovations are being captured in structural coefficients and, often but not always, generate inflated values of structural attributes.

Our second pair of models in Table 3 use the quasi-experimental research design of Billings (2011) to test how bias may be addressed through variation in research design. Specifically, we limit our analysis to only South Line (treatment group) and the proposed Northeast and Southeast corridor properties (control group). The estimated impact of LRT is about 5.4% of the average single-family home in this model or \$9,288. The amenity coefficients differ between models by 0.0023, which indicates a 4.5% bias. The increase in bias with the use of a improved research design is due to a smaller amenity estimate as well as better controls for neighborhood characteristics, which limits bias to unobserved structural characteristics and the influence of renovations. The experimental model generates a capitalization rate of 60.7% for renovations.

5.3 Repeat Sales Models Results

Here, we estimate the models given by Equation 6 for a repeat sales models with a couple of additional variables to highlight the impact of LRT. Specifically, we estimate a difference-in-difference model comparing parcels within 1 mile of LRT stations with those parcels within 1 mile of proposed LRT stations and compare these neighborhoods before and after the announcement of LRT in 2000. We simply focus on the bias in the amenity coefficient due to omitted renovations given that most repeat sales estimators assume unchanged structural attributes. Our coefficient of interest in given

as ($LRTAnn * SouthLine$) where identification is given by homes that sold prior to the announcement of LRT and then sold again after the announcement of LRT.

Some scholars address concerns regarding omitted renovations by removing properties that sell multiple times in a short time period²¹ or dropping observations subject to renovations.²² An additional correction for repeat sales models would be to classify renovations as a non-temporal component of property appreciation and include intercepts based on properties grouped by initial purchase prices. These intercepts, developed by [Goetzmann and Spiegel \(1995\)](#), provide mean property appreciation irrespective of holding time for broad groups of repeat sales properties.²³ These intercepts are based on the premise that one can classify property appreciation into two components: temporal and non-temporal. The temporal component of property appreciation represents housing price appreciation due to increases in land values and structural depreciation while the non-temporal component captures other elements of appreciation (e.g. renovations, deferred maintenance) that may occur in preparation or as part of a property transaction. One can use these intercepts to control for the likelihood that a property is subject to renovations between its purchase and later sale in a repeat sales framework. Properties that have a relatively lower (higher) price, given structural and neighborhood attributes, are more likely to have lower (higher) quality or older (newer) structural attributes and thus have a greater (lower) likelihood of being subject to renovations. Therefore, one can include these intercepts as a way to address omitted renovations. For one set of repeat sales models, we include intercepts based on quintile of purchase price, which should provide a basic measure of the likelihood of structural improvement that is unrelated to land appreciation, but is related to purchase prices.

We present repeat sales result in [Table 4](#) along with the hedonic results from [Table 3](#). We simultaneously present all of our hedonic models for valuing LRT in the same table to highlight which models present the smallest bias under omitted renovations as well as the sensitivity of estimates of the value of LRT across a range of specifications. [Table 4](#) includes six specifications of the basic model of all sold single-family homes as well as six specifications of the quasi-experimental models

²¹[Billings and Thibodeau \(2011\)](#), [Billings \(2011\)](#) and [Harding et al. \(2009\)](#)

²²[McMillen and Thorsnes \(2006\)](#), [Goetzmann and Spiegel \(1995\)](#), [Case and Shiller \(1987\)](#)

²³Purchase price intercepts also help control for the finding of [Gyourko and Saiz \(2004\)](#), where homes that have low value relative to their replacement costs may underinvest in renovations.

that incorporate only parcels in neighborhoods that received LRT or along proposed alignments (Northeast and Southeast).

We include four repeat sales models to highlight potential methods that may address omitted renovations through controls for purchase price, renovation potential or the exclusion of properties that were most likely to have been subject to renovations. Our specifications include a standard repeats sales model, a repeat sales model with a series of five intercepts determined by quintiles of purchase prices and two models that incorporate common data cleaning techniques to remove likely renovated properties: 1) the removal of any repeat sales observation with holding time less than one year and 2) the inclusion of only observations with less than 50% annual appreciation.

Table 4 sorts results for the basic and experimental models by the percent bias for coefficients on the announcement of LRT. We also provide dollar valuations of the value of LRT and any bias due to omitted renovations for an average sold property in our dataset. The dollar quantification of these estimates allows a better sense of the scale of concern about omitting renovation in hedonic estimates. Results indicate a range of estimates across these models with the purchase price intercepts generating lower bias than standard repeat sales models. Additionally, results appear to be sensitive to specification with estimates ranging from \$1,858 to \$35,777 for the announcement of LRT in basic models and a more narrow range of \$1,858 to \$8,875 for the quasi-experimental models. Across all ten models, capitalization rates vary from 13.3% to 60.7% with the quasi-experimental hedonic model generating the highest capitalization rate.

Basic models generate larger marginal impacts of between \$273 and \$595 due to omitted renovations. For the quasi-experimental research design, models generate a bias in marginal impacts of between \$214 and \$402 due to omitted renovations. Since quasi-experimental models have smaller marginal impacts of LRT, the magnitude of bias under omitted renovations is smaller for most quasi-experimental models. The removal of observations with holding times less than 1 year appears to worsen bias in both models, while the removal of observations with greater than 50% appreciation worsens bias in the basic models and removes bias in the quasi-experimental model. Since these censored observation models have smaller marginal impacts due to LRT, the magnitude of their bias is relatively small. The benefits of LRT likely occur in the form of residential (re)development

and associated sorting to LRT neighborhoods. Therefore, censoring properties that may be the result of housing 'flips' or speculative investment due to LRT may understate amenity benefits as well as the effect of omitted renovations. In essence, the broad removal of properties for different property transaction criteria may generate biases in amenity valuation beyond omitted renovations.

Furthermore, the ordering of bias reverses for repeat sales with purchase price intercepts, with models generating smaller percent bias in basic models to the largest percent bias in quasi-experimental models. These results are informative for showing that bias due to renovations is not exclusive to neighborhood characteristics or structural attributes. If omitted renovations are perfectly explained by unobserved neighborhood attributes, quasi-experimental models should be uniformly lower in bias than their basic model counterpart. If renovations were exclusive to homes of certain structural characteristics, we would expect repeat sales models to provide lower bias than hedonic models. The presence of different magnitudes and ordering of results by bias across specifications highlight that multiple factors impact the decision to renovate which corresponds to multiple sources of bias with the exclusion of information on renovations.

6 Conclusions

In summary, results for standard as well as repeat sales models to value access to transit indicate a range of estimated coefficients with models generating omitted renovation biases of between 1.6% and 19.9%. The magnitude of these effects are small, with models estimating biases of between \$214 and \$595 per home for the announcement of LRT. Our research provides two notable suggestions for applied researchers. First, bias due to omitted renovations is a second order concern to research design and model specification in amenity valuation. Second, data cleaning techniques to deal with renovations such as the removal of renovated parcels, parcels with short holding times (< 1 year) or parcels with high annual appreciation rates ($> 50\%$) may increase bias in estimated amenity coefficients.

Our results generate some important conclusions regarding the role of renovations in hedonic amenity valuation. We find that almost all models have a positive bias in amenity coefficients as well as positive bias in a number of structural characteristics suggesting a positive relationship between

renovations and higher valued structural characteristics and neighborhood amenities. Improved research designs that better control for neighborhood attributes do not always decrease this positive bias. Unless detailed information on renovations is included in estimation, hedonic estimates will assign renovations to land and other structural attributes, which may overstate the benefits of neighborhood amenities. Additionally, the positive bias in amenity coefficients and the fact that renovations are positively correlated with the announcement of LRT disputes that results are due to substitution between structural and neighborhood quality. Finally, the finding that approximately the same portion of renovated and non-renovated homes sold throughout most of our study period shows that renovations occur both prior to the sale of a home, as well as after purchasing a home. Only during the housing downturn that began in 2007 for Charlotte do we see a larger portion of renovated homes selling relative to non-renovated homes.

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Table 1: Summary Statistics by Quintile of Neighborhood Income 1996-2008

	<i>All CBGs</i>	<i>\$ < 40,400</i>	<i>\$40,400 - \$52,400</i>	<i>\$52,401 - \$66,000</i>	<i>\$66,001 - \$82,000</i>	<i>\$ > 82,000</i>
Sales Price (\$)	200,784 (186,078)	104,067 (87,908)	136,754 (95,298)	167,940 (104,178)	235,452 (198,133)	316,884 (257,466)
Number Sales per Parcel	0.94 (0.91)	0.63 (0.81)	0.81 (0.84)	0.98 (0.90)	1.10 (0.90)	1.17 (0.98)
Ever Sold	0.64 (0.48)	0.46 (0.50)	0.59 (0.49)	0.66 (0.47)	0.73 (0.44)	0.74 (0.44)
Ever Renovated	0.18 (0.39)	0.17 (0.37)	0.14 (0.34)	0.18 (0.38)	0.19 (0.39)	0.26 (0.49)
Renovation Value per Parcel (\$)	6,696 (32,835)	3,476 (16,332)	3,372 (18,205)	4,992 (22,460)	7,946 (38,586)	13,768 (52,298)
Year Built	1981.0 (22.0)	1964.6 (22.5)	1978.6 (22.8)	1984.0 (18.6)	1989.8 (17.3)	1988.4 (17.8)
Heated Area (sqft)	2,052 (959)	1,355 (466)	1,684 (634.6)	1,949 (696.6)	2,428 (954)	2,860 (1,077)
Lot Size (acres)	0.39 (0.41)	0.31 (0.31)	0.37 (0.40)	0.41 (0.42)	0.43 (0.46)	0.44 (0.41)
Full Bathrooms	1.98 (0.69)	1.47 (0.56)	1.79 (0.55)	2.00 (0.49)	2.21 (0.63)	2.43 (0.75)
Bedrooms	3.23 (0.83)	2.71 (0.83)	3.05 (0.68)	3.25 (0.69)	3.48 (0.78)	3.70 (0.79)
Pop Density (per sq mile)	1,962 (1,429)	3,088 (1,779)	2,106 (1,479)	1,794 (1,045)	1,227 (974)	1,579 (871)
Within 1 mile of Light Rail-Transit Station	0.05 (0.21)	0.09 (0.29)	0.09 (0.28)	0.02 (0.14)	0.01 (0.11)	0.02 (0.13)
Math and Reading End-of-Grade Test Scores	-0.008 (0.41)	-0.423 (0.23)	-0.209 (0.27)	-0.004 (0.30)	0.177 (0.31)	0.426 (0.30)
Single-Family Parcels	226,240	45,706	46,005	44,020	45,426	45,044

Cells contain means with standard deviations in parentheses for non-missing parcel attributes given by row headings. Number of Sales indicates the number of times a parcel sold between 1996-2008, while Ever Sold and Ever Renovated indicate if a parcel was ever sold or ever renovated. Renovation value is based on aggregate building permits over this time period for each parcel. End-of-Grade test scores are for 3rd-5th grade math and reading and given a mean of zero and standard deviation of one relative to the state. Test score are assigned to parcels based on school attendance zones.

Table 2: Hedonic Indices and Renovations

	All Properties	High Appreciation Quarters	Low Appreciation Quarters	Rich Neighborhoods	Poor Neighborhoods
<i>Single Sale Hedonic Index</i>					
Index	3.31%	4.81%	1.66%	3.33%	4.28%
Index with renovations	3.26%	4.75%	1.63%	3.25%	4.20%
Difference	0.05%***	0.06%***	0.03%	0.08%***	0.08%***
<i>Repeat Sales Index</i>					
Index	3.65%	5.19%	1.80%	4.23%	4.49%
Index with renovations	3.54%	5.04%	1.71%	4.09%	4.29%
Difference	0.11%***	0.015%***	0.09%**	0.15%***	0.19%***

Each cell contains annual appreciation rates for sample of properties given in row headings. Define High (Low) Appreciation Quarters as those year-quarter observations for which annual appreciation is above (below) the median value for the 1996-2008 time period. Define Rich (Poor) Neighborhoods based on Census Block Group 2000 neighborhoods that are above (below) median household income. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 3: Light Rail-Transit (LRT) - Hedonic

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	<i>No RenoValue</i>	<u>Basic Model</u> <i>w/ RenoValue</i>	<i>Bias %</i>	<i>No RenoValue</i>	<u>Quasi-Experimental Model</u> <i>w/ RenoValue</i>	<i>Bias %</i>
LRTAnn*SouthLine	0.1553*** (0.014)	0.1528*** (0.014)	1.6%**	0.0530*** (0.017)	0.0507*** (0.017)	4.5%
RenoValue		0.0018*** (0.001)			0.0028*** (0.001)	
SouthLine	0.0165 (0.013)	0.0188 (0.013)	-12.2%	0.0886*** (0.017)	0.0912*** (0.016)	-2.9%
acres	0.1270*** (0.006)	0.1270*** (0.006)	0.0%	0.1627*** (0.024)	0.1681*** (0.027)	-3.2%
fullbaths	0.0871*** (0.002)	0.0824*** (0.002)	5.7%***	0.0146** (0.007)	0.0051 (0.006)	186.3%***
bedrooms	0.0144*** (0.002)	0.0140*** (0.002)	2.9%**	0.0287*** (0.004)	0.0254*** (0.004)	13.0%***
sqft (000s)	0.4213*** (0.006)	0.4233*** (0.006)	-0.5%	0.4911*** (0.023)	0.4998*** (0.029)	-1.7%
<i>sqft</i> ²	-0.0215*** (0.001)	-0.0228*** (0.001)	5.7%***	-0.0387*** (0.005)	-0.0449*** (0.007)	13.8%**
age	-0.0131*** (0.00)	-0.0131*** (0.001)	0.0%	-0.0196*** (0.001)	-0.0194*** (0.001)	1.0%
<i>age</i> ²	0.2162*** (0.009)	0.2109*** (0.009)	2.5%***	0.3800*** (0.026)	0.3679*** (0.025)	3.3%
<i>age</i> ³	-0.0007*** (0.001)	-0.0007*** (0.001)	-0.5%***	-0.0019*** (0.001)	-0.0018*** (0.001)	5.6%
fireplace	0.1202*** (0.003)	0.1206*** (0.003)	-0.3%	0.1145*** (0.006)	0.1176*** (0.006)	-2.6%***
Test Scores (t-1)	0.1769*** (0.003)	0.1730*** (0.003)	2.3%***	0.0191* (0.011)	0.0086 (0.011)	122.1%***
Distance to CBD (miles)	-0.1140*** (0.002)	-0.1108*** (0.002)	-2.9%***	-0.2233*** (0.008)	-0.2225*** (0.008)	-0.4%
Distance to CBD (miles) squared	0.0059*** (0.001)	0.0058*** (0.001)	1.7%***	0.0164*** (0.001)	0.0166*** (0.001)	-1.2%*
Distance to Interstate (miles)	-0.0047*** (0.001)	-0.0042*** (0.001)	-11.9%***	-0.0059*** (0.002)	-0.0058*** (0.002)	-1.7%
Pop Density	0.0059*** (0.001)	0.0066*** (0.001)	-10.6%***	0.0126*** (0.002)	0.0124*** (0.002)	1.6%
Ownership Units (%)	-0.1191*** (0.006)	-0.1208*** (0.005)	1.4%***	-0.1044*** (0.026)	-0.1115*** (0.026)	6.4%
Median HH Income	0.0027*** (0.000)	0.0027*** (0.000)	0.4%	0.0030*** (0.000)	0.0030*** (0.000)	0.0%
age 65 and older (%)	1.0039*** (0.024)	1.0025*** (0.024)	0.1%	1.6533*** (0.100)	1.6598*** (0.098)	0.4%
age < 18 years old (%)	-0.6881*** (0.023)	-0.6724*** (0.023)	-2.3%***	-1.2598*** (0.059)	-1.2443*** (0.059)	-1.2%**
within 1/4 mile of bus-transit (%)	0.1117*** (0.005)	0.1069*** (0.005)	4.5%***	0.1887*** (0.020)	0.1824*** (0.020)	3.5%**
total crime index	-0.0603*** (0.001)	-0.0590*** (0.001)	-2.2%***	-0.0607*** (0.003)	-0.0605*** (0.003)	-0.3%
Observations	102,863	102,863		11,575	11,575	
R-squared	0.85	0.85		0.78	0.79	

Robust standard errors in parentheses. All regressions include indicators for building attributes and year by quarter of sale dummies.

Dependent variable is equal to $\log(\text{Sale Price})$ in all models. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Indicators for building attributes contain 55 unique measures of foundation type, stories, exterior wall, heating, air-conditioning.

Bias % is based on the difference in coefficient between No RenoValue and w/ RenoValue models divided by the coefficient from the w/ RenoValue model.

Significance for Bias % based on chi-squared test across the No RenoValue and w/ RenoValue models.

Table 4: Summary of Bias - LRT

	(1) <i>No Reno Value</i>	(2) <i>w/ Reno Value</i>	(3) Difference [(1) - (2)]	(4) Bias %	(5) Marginal Impact (\$) of Announcement of LRT	(6) Marginal Impact (\$) in (5) Due to Omitted Renovations
Basic Models						
Hedonic, structural/neighborhood variables	0.1553***	0.1528***	0.0025	1.6%***	\$ 35,777	\$ 542
Repeat Sales, purchase price intercepts	0.1708***	0.1601***	0.0107	6.7%	\$ 9,257	\$ 574
Repeat Sales, no intercepts	0.1518***	0.1417***	0.0101	7.1%**	\$ 8,116	\$ 541
Repeat Sales, annual appreciation < 50%	0.0599***	0.0548***	0.0051	9.3%***	\$ 3,003	\$ 273
Repeat Sales, holding time > 1 year	0.0875***	0.0764***	0.0111	14.5%***	\$ 4,233	\$ 595
Quasi-Experimental Models						
Hedonic, structural/neighborhood variables	0.0530***	0.0507***	0.0023	4.5%***	\$ 8,875	\$ 393
Repeat Sales, annual appreciation < 50%	0.0507***	0.0467***	0.004	8.6%*	\$ 2,553	\$ 214
Repeat Sales, no intercepts	0.0472*	0.0408	0.0064	15.7%	\$ 2,224	\$ 343
Repeat Sales, holding time > 1 year	0.0484**	0.0409*	0.0075	18.3%***	\$ 2,230	\$ 402
Repeat Sales, purchase price intercepts	0.0410*	0.0342	0.0068	19.9%	\$ 1,858	\$ 364

Each cell in columns (1) and (2) represents the coefficient on LRTAnn*SouthLine for the models in corresponding row headings.

Repeat sales basic models contain 67,048 observations and decrease by 7,855 and 5,912 for holding time > 1 yr and annual appreciation < 50% models.

Quasi-experimental models contain 7,138 observations and decrease by 1,110 and 973 for holding time > 1 yr and annual appreciation < 50% models.

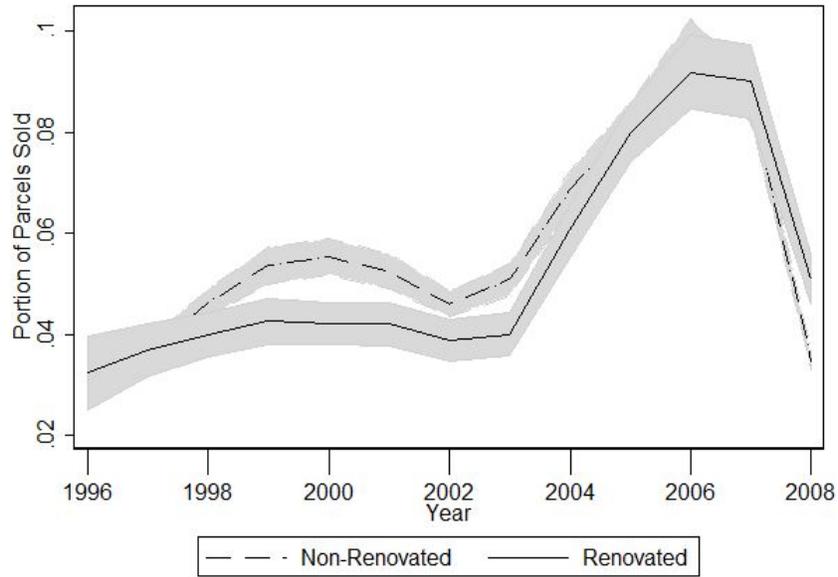
Bias % is based on the difference in coefficient between No RenoValue and w/ RenoValue models divided by the coefficient from the w/ RenoValue model and stars indicate significant difference between renovations and no renovations models.

Marginal Impact (\$) of the Announcement of LRT and Marginal Impact Due to Omitted Renovations are based on columns (2) and (3) respectively

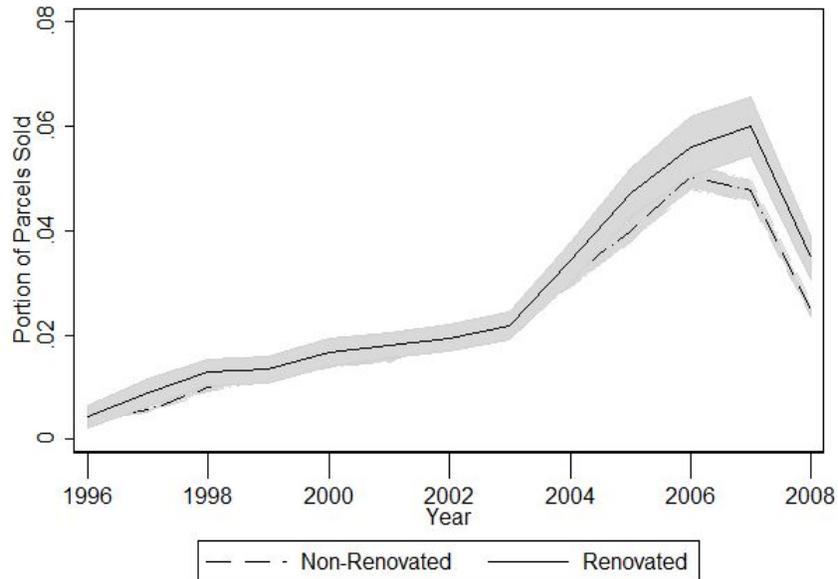
and use the mean sales price and mean repeat sales prices for samples that correspond to row headings.

Robust standard errors are clustered by individual parcel. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Figure 1: Are Renovated Homes Sold More Often?



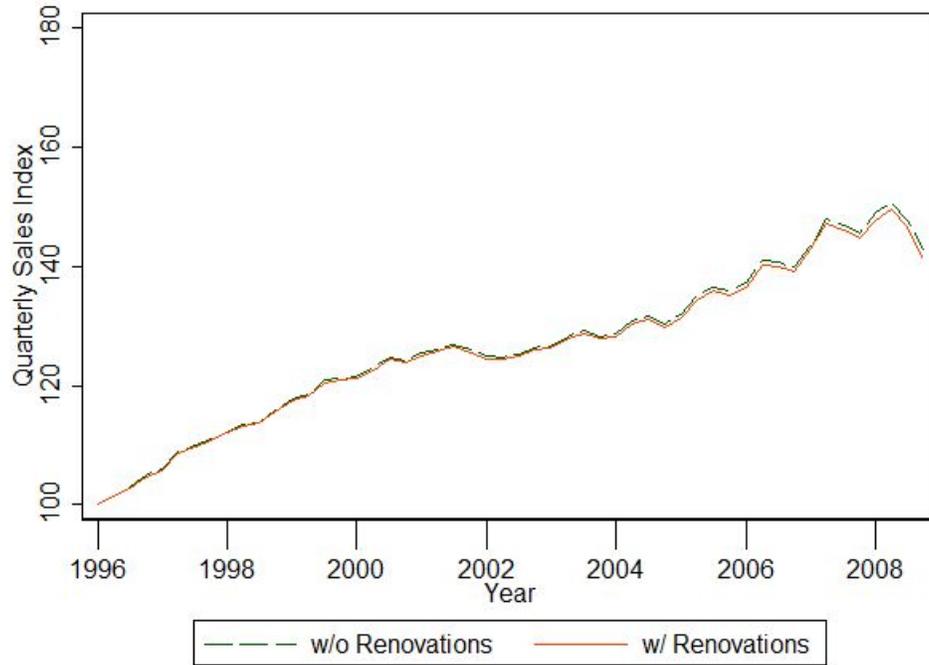
(a) Sold Once



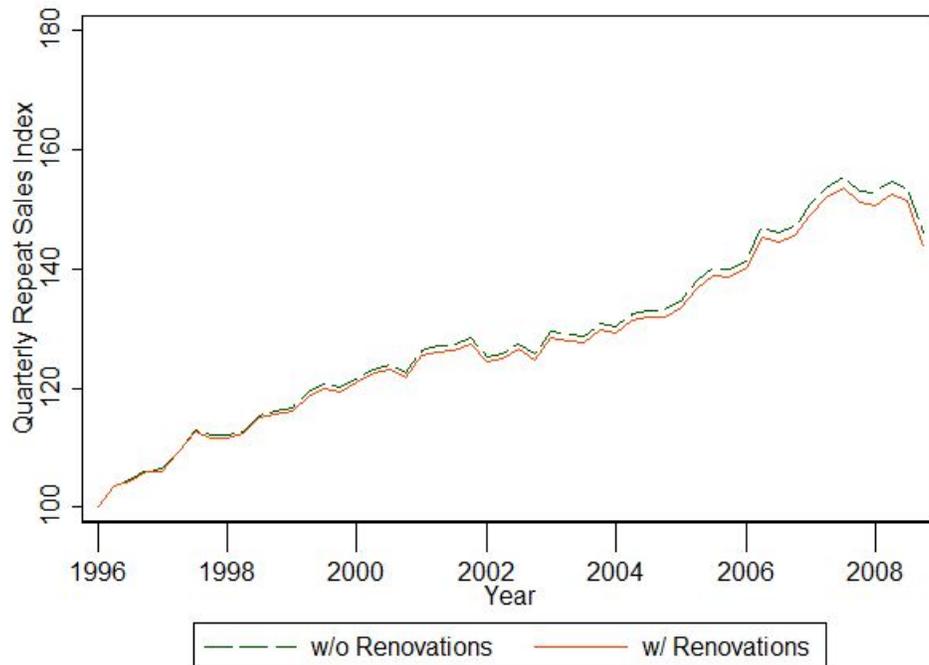
(b) Sold More Than Once

Note: y-values indicate the portion of all renovated and non-renovated existing single-family parcels sold in a given year. We define renovated as those parcels and years for which a building permit was issued within a given year or previous 3 years. The number of parcels is updated on an annual basis based on the new construction of single-family homes. Shaded areas indicate 95% confidence bands based on portion of renovated and non-renovated single-family parcels sold in a given year for each Census Block Group.

Figure 2: Prices Indices - Single-Family Properties

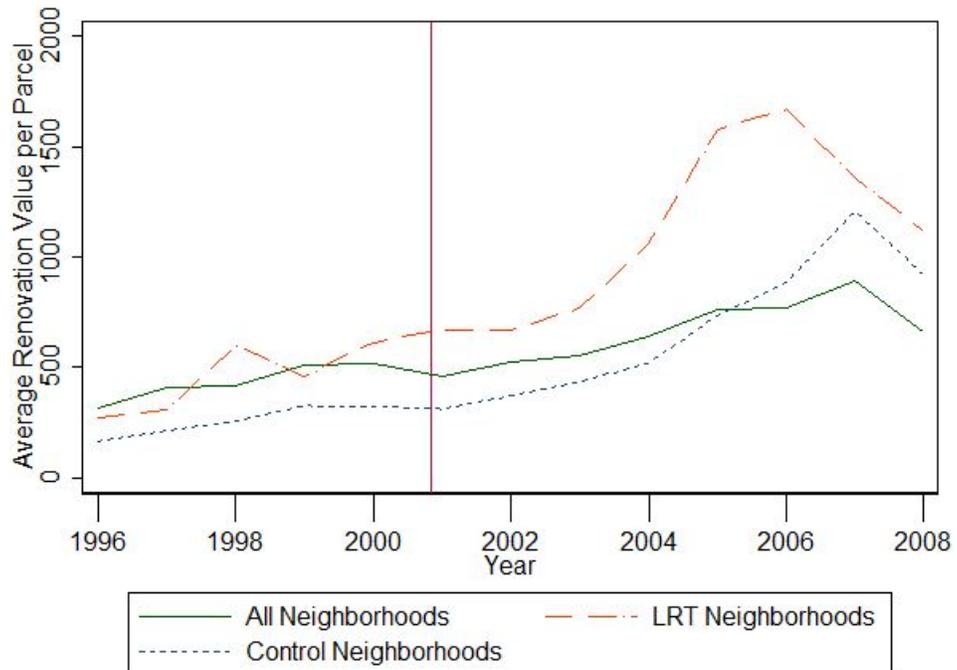


(a) Hedonic Price Index



(b) Repeat Sales Price Index

Figure 3: Light Rail-Transit and Renovations



Note: All Neighborhoods includes all single-family parcels in Mecklenburg County; LRT Neighborhoods include just single-family parcels within 1 mile of SouthLine LRT stations; Control Neighborhoods include single-family parcels within 1 mile of proposed LRT stations along the Northeast and Southeast proposed LRT alignments. Y-axis indicates the average renovation value per parcel for each year and corresponding group.