# Highlights

**Upzoning and Residential Transaction Price in Nashville**

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- We analyze the effects of Nashville's 2010 upzoning on housing prices from 2000-2023.
- The study uses matching methods and quantile difference-in-differences for estimation.
- On average, the prices of the upzoned parcels increased by 11%-38% more than the untreated parcels.
- Quantile results show heterogeneous effects in different market price segments.
- The price of the upzoned parcels at the lower end of the distribution increased, while the price of the high-end parcels decreased.

# Upzoning and Residential Transaction Price in Nashville

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## Abstract

Empirical research on the impact of upzoning policies on housing affordability has produced mixed results. This paper uses difference-in-differences and matching methods to analyze the effects of the 2010 upzoning of downtown Nashville over the period 2000-2023. We find a significant increase in the average price of the treated parcels relative to similar untreated parcels. Estimated quantile treatment effects reveal that price decreases are concentrated at the upper end of the house price distribution, while upzoned parcels at the lower end experience price increases due to positive amenities and retained investment. Our findings underscore the importance of considering heterogeneity when designing and evaluating upzoning policies.

*Keywords:* Upzoning, Housing Prices, Natural Experiment

# 1. Introduction

Coming from an era in which zoning regimes in the United States functioned as a form of economic and racial discrimination (Maantay, 2002; Rothwell and Massey, 2009; Shertzer et al., 2016; Whittemore, 2017, 2021), there has been an increasing focus on zoning policies in relation to emerging patterns of urban growth and displacement (Angotti and Morse, 2016; Rodríguez-Pose and Storper, 2020; Lowe and Richards, 2022). In the context of the housing affordability crisis, economic analysis of zoning policies has focused on the relation between strict zoning regimes and housing prices (Glaeser et al., 2005; Quigley and Raphael, 2005; Ihlanfeldt, 2007; Zabel and Dalton, 2011; Gyourko and Molloy, 2015). However, empirical research on the relationship between changing zoning regimes, levels of housing construction, and prices has produced mixed results. Unlike zoning policies that restrict use, mandate affordability, or regulate design without increasing housing availability, upzoning directly aims to increase housing density. Its effectiveness often depends on local market conditions and complementary policies, such as antidisplacement measures.

Freemark (2023)'s in-depth literature review highlights the lack of consensus on the relationship between upzoning and housing affordability due to the diversity of policy outcomes depending on different spatial, temporal, and regulatory contexts. The path-dependent relationship between changes in upzoning regimes and long-term housing prices makes it challenging to identify the causal effects of upzoning policies. Challenges include varying effects on housing supply in different market segments, neighborhood investments, amenity effects, and migration flows. In particular, it can be difficult to disentangle the relationship between upzoning and the development of amenities, such as proximity to employment and leisure activities, as well as a *"sense of place"* which result from urban density and can drive both urban growth and housing demand (Clark et al., 2002). Nevertheless, recent empirical studies in various geographical and political contexts have examined the impact of upzoning policy on housing construction (supply) and prices.

Table 1 summarizes the recent literature on upzoning policies. Studies examining one to four years after upzoning have found increases in housing prices, for both single-family units (Kuhlmann (2021) in Minneapolis, Fernandez et al. (2021) in Auckland) and multi-family units( Freemark (2020) in Chicago). As discussed by Büchler and Lutz (2021), rising housing prices may indicate increasing land values due to upzoning, as investors anticipate building more units per square foot. Studies examining the effect of adding accessory dwelling units (ADUs) to single-family zoning such as Liu et al. (2024) in Los Angeles and Davidoff et al. (2022) in Vancouver find heterogeneous effects. Generally, house price increases due to ADUs were asso-

Table 1: Summary of Recent Research on Upzoning and Housing Price

| **Study period** (post-treatment) | **Summary of findings** | **Recent studies** |
|---|---|---|
| **1-4 years** | Most studies conclude that upzoning increased housing costs as compared to non-upzoned areas. Studies focusing on heterogeneous trends tend to find this effect is largest among low-value units and small or even negative among higher market housing prices. | Freemark (2020); Fernandez et al. (2021); Greenaway-McGrevy et al. (2021); Kuhlmann (2021); Davidoff et al. (2022); Stacy et al. (2023); Liu et al. (2024); Ortiz-Villavicencio et al. (2024) |
| **5-9 years** | Mixed results, including property value decreases, no effect, and price increases. | Atkinson-Palombo (2010); Anagol et al. (2021); Gabbe et al. (2021); Stacy et al. (2023) |
| **10-13 years** | Most estimates show that upzoning resulted in housing price increases or no effect. | Büchler and Lutz (2021); Gnagey et al. (2023); Murray and Limb (2023); Büchler and Lutz (2024) |

*Source: Adapted from Freemark (2023)'s review of the literature. A detailed version of this table is located in the Appendix (Table A.21).*

ciated with low-value areas where investment effects could be observed. Meanwhile, price decreases were associated with high-value areas where a combination of supply effects and negative amenity effects (such as increased traffic) may have occurred.

Studies investigating the effects of upzoning changes, 5-9 years after their implementation, have found mixed results. These results include a decrease in housing prices in São Paulo, as estimated by Anagol et al. (2021); an increase in Phoenix, as reported by Atkinson-Palombo (2010); and no effect on prices in San Jose, as reported by Gabbe et al. (2021). These mixed results may reflect heterogeneous market segment effects playing out over time as a result the particular form of supply induction produced by changing zoning regimes. Over time, housing prices can be affected not only through supply induction but also through changes in investment and migration patterns influenced by land use policy.

Fewer papers have investigated the long-term effects of upzoning policies (a decade or more). These articles examined periods ranging from 10 to 13 years after the implementation of upzoning policies. Studies in the Canton of Zurich, Switzerland, (Büchler and Lutz, 2021) and the city of Brisbane, Australia, (Murray and Limb, 2023) have found that upzoning changes are associated with higher housing prices. However, Büchler and Lutz (2024)'s recent examination of floor-to-area ratio (FAR) increases in Zurich, Switzerland, found no effect on rent prices. The study did demonstrate supply induction, which could potentially decrease prices. Likewise, Gnagey et al. (2023) performed a repeated cross-sectional analysis of the increase in accessory dwelling units (ADUs) in Ogden, Utah, and found no effect on property values.

Our paper contributes to this body of literature by presenting the first empirical study examining the impact of upzoning on house prices in the Southern United States over the longest time period, spanning 24 years. Using repeated cross-sectional data from Davidson County from 2000 to 2023, we examine the effects of Nashville's 2010 downtown upzoning, Ordinance BL2009-586.

We attempt to capture the effects of increased density and height limits and the elimination of "by-type" zoning that came as a result of BL2009-586. Our quasi-experimental design compares variation in the prices of upzoned multifamily housing with geographic control groups and matched control groups. We select geographic control groups based on proximity to the upzoned parcels. We create matched control groups using Propensity Score Matching (PSM), Generalized Boosted Matching (GBM), and Random Forest Matching (RFM), respectively. These matching methods greatly improve the balance of covariates between our treatment and control parcels. Estimates of price effects of are obtained through a hedonic price model combined with a difference-in-differences (DiD) approach. First, we estimate the average treatment effect on the treated (ATT) using the standard DiD approach. Next, to account for housing market price segmentation, we estimate quantile treatment effects on the treated (QTT) using quantile difference-in-differences.

Our analysis yields two main findings. First, we present evidence showing that prices increased among upzoned parcels compared to similar control parcels in Davidson County. These results are robust across control group selection approaches. Second, and more importantly, we present evidence of the heterogeneous treatment effects of BL2009-586 on housing prices. Specifically, we found that prices increased for housing units at the lower end of the price distribution, while prices decreased at the high end. These findings align with the growing supply of luxury apartments within the treatment zone. This growth could contribute to supply-side effects for high-end parcels while simultaneously exerting positive amenity effects on low-end parcels.

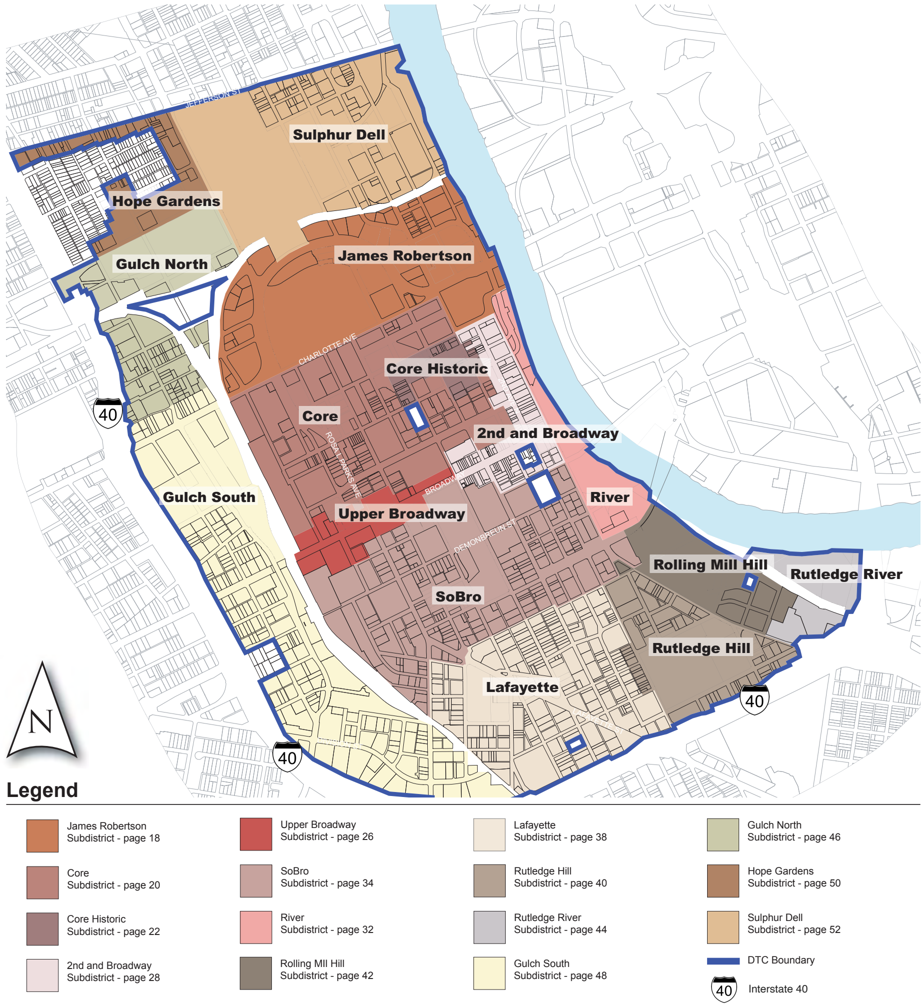
Our findings have significant implications for policymakers regarding land use and housing affordability. We present evidence showing the limitations of using density upzoning to increase affordability in upzoned areas. The substantial price increase among housing units at the lower end of the price distribution demonstrates the potentially regressive price effects of upzoning in Nashville's downtown core. These heterogeneous treatment effects underscore the necessity for the housing economics literature to further recognize the potentially segmented nature of housing supply and demand. Our results emphasize the path-dependent nature of the outcomes of upzoning policies and acknowledge the variety of factors, including zoning regimes, migration patterns, mortgage rates, and amenity structures, that contribute to specific forms of housing production and consumption across space and time. The remainder of the paper is organized as follows: Section 2 discusses the background of the Downtown Code Zoning District (DTC) upzoning in Nashville, Section 3 describes our data and empirical strategies, Section 5 presents our empirical results and Section 6 concludes the paper.

# 2. Background

During the past 20 years, Nashville has undergone a remarkable transformation, earning the title of 'Best Real Estate Prospect in the U.S.' for the past three years (Luis Quintero, 2021; Lawson, 2023). However, in the 1990s, downtown Nashville was facing 40 years of decline, lacking a central business center or residential areas (Lloyd and Christens, 2012). Boosting Nashville's urban growth, the intensification of urban density has coincided with a dynamic zoning regime, providing a new model for the city as a hub of urban prosperity and attracting the attention of urban planners across the country (Luis Quintero, 2021).

As a critical component of capital investment and residential development, in 2009, the Nashville Metro Council unanimously passed BL2009-586, rezoning all land north of I-40 and south of Jefferson Street to the DTC. Seen in Figure 1, the DTC occupies roughly two square miles and lies in the heart of downtown Nashville, surrounding the Broadway *'honky-tonk'* strip. The policy had three major implications: elimination of the "by type" zoning (allowing mixed-use development), removal of

Figure 1: Downtown Code Zoning District and Subdistrict Boundaries




*Notes: This map shows the Downtown Code Zoning District and Subdistrict boundaries. To see the DTC in the context of the entirety of Nashville (Davidson County), see see Figure 3*. This map is sourced from City of Nashville (2011), an attachment to Ordinance No. BL2009-586 as adopted on February 02, 2010.

building height limitations, and removal of minimum parking requirements.[1] The

[1]While mixed-use zoning and the elimination of parking requirements are universal throughout the DTC, height and residential density limits do vary among the historic and aesthetic sub-districts presented in Figure 1. Height limits range from 6 stories to unlimited, but the DTC now predominantly consists of limits above 20 stories. For more information, see City of Nashville (2024).

primary intention of the bill was to transform the downtown area from a scattering of parking lots, industrial, commercial, and residential land into a multi-use urban environment that could support investment and tourism in the downtown area. Since February 2010, when BL2009-586 was passed, the DTC has been amended 15 times, primarily with slight modifications to ensure that the land can be used to its maximum capacity. These amendments have meant that there has been no spot-zoning within the DTC since its enactment. The DTC was an essential element in turing Nashville's downtown into a central node for real estate investment and economic development instituting the production of entirely new residential neighborhoods such as the Gulch and SoBro (previously industrial parking lots) which have become hotspots for upscale living and dining for Nashville's affluent.

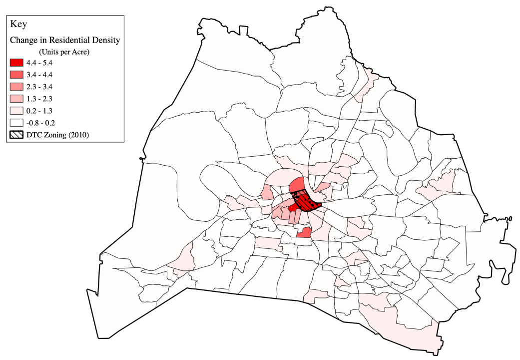
BL2009-586 was the only major, multi-parcel rezoning in Nashville over the period 2000-2023 and remains the only special district zoning area in Nashville. However, between 2000-2023 the city has passed roughly 800 'spot-zoning' amendments to individual parcels (both residential and commercial). There remains large heterogeneity in the type and form of spot-zoning changes that occurred, so due to the imprecision with which these changes were recorded and their staggard implementation, these parcels are excluded from our analysis.

Since the creation of the DTC in 2010, Nashville's downtown has undergone a dramatic transformation, evolving into a hub of economic, cultural, and residential activity. The city's population boom, coupled with a surge in tourism and business investment, has driven the development of high-rise residential towers, mixed-use spaces, and entertainment venues. The DTC has played a crucial role in guiding Nashville's urban growth towards a densification never before seen in Nashville, sharply contrasting decades of urban blight and sprawl. Residential density data from the US Census (Figure 2a) reflects this relatively rapid intensification of urban residential density in the downtown core of Nashville.

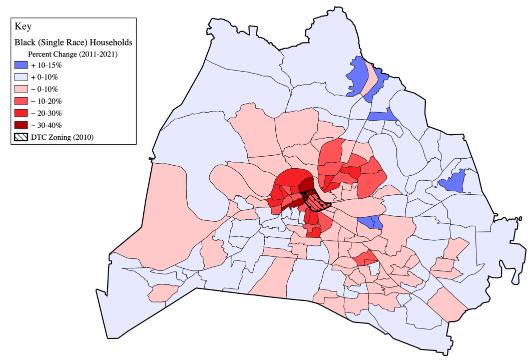
The recent infill of luxury apartments and entirely new neighborhoods in downtown Nashville has coincided with ongoing patterns of displacement and peripheralization. Similar to other contemporary urban growth stories, the stunning transformation of Nashville's built environment over the past 15 years has coincided with a consistent and growing affordable housing crisis. (Thurber et al., 2014; Open Table, 2017; Florida, 2017; Johnson, 2018; DCMO, 2021; Commission, 2018a,b, 2019; Carrier, 2021; Tatian et al., 2023). In particular, Nashville's historically black semi-periphery of single-family homes, once considered an area of low amenity, affordable housing, has become some of the hottest real estate on the market, leading to well-documented processes of gentrification and displacement Lockman (2019); Thurber et al. (2021). The displacement of black communities in urban Nashville

Figure 2: Residential Density and Racial Change in Davidson County

(a) Residential Density (2010-2020)




(b) Racial Change (2011-2021)




*Notes: Residential density data sourced from U.S. Census Bureau (2010a, 2021a). Demographic data sourced from U.S. Census Bureau (2010b, 2021b). Map produced by author using QGIS.*

has been well documented throughout the city in neighborhoods immediately north (Hightower and Fraser, 2020), south/west (Hatfield, 2018; Lockman, 2019), and east (Lloyd, 2011; Miller, 2015) of Nashville's urban core. Peripheralization of Nashville's Black households can be seen in Figure 2b. These patterns of displacement are by no means unique to Nashville, as the resurgence of housing prices in urban cores and the corresponding displacement have been a consistent pattern across American cities in the 21$^{st}$ century (Orfield, 2019).

Given these displacement trends and the continued use of land deregulation as a tool to create affordable housing, our analysis has particular relevance for policymakers considering major upzonings as a tool for increasing housing affordability.[2] To this end, this paper uses BL2009-586 as a quasi-experimental land-use reform to analyze the effects of increased density on housing prices.

[2]This policy tool continues to gain relevance in the context of Nashville, as the Metro Council has continued to focus on land deregulation as a tool to create affordable housing, passing BL2024-187, which allows for adaptive housing developments, effectively eliminating 'by-type' zoning.

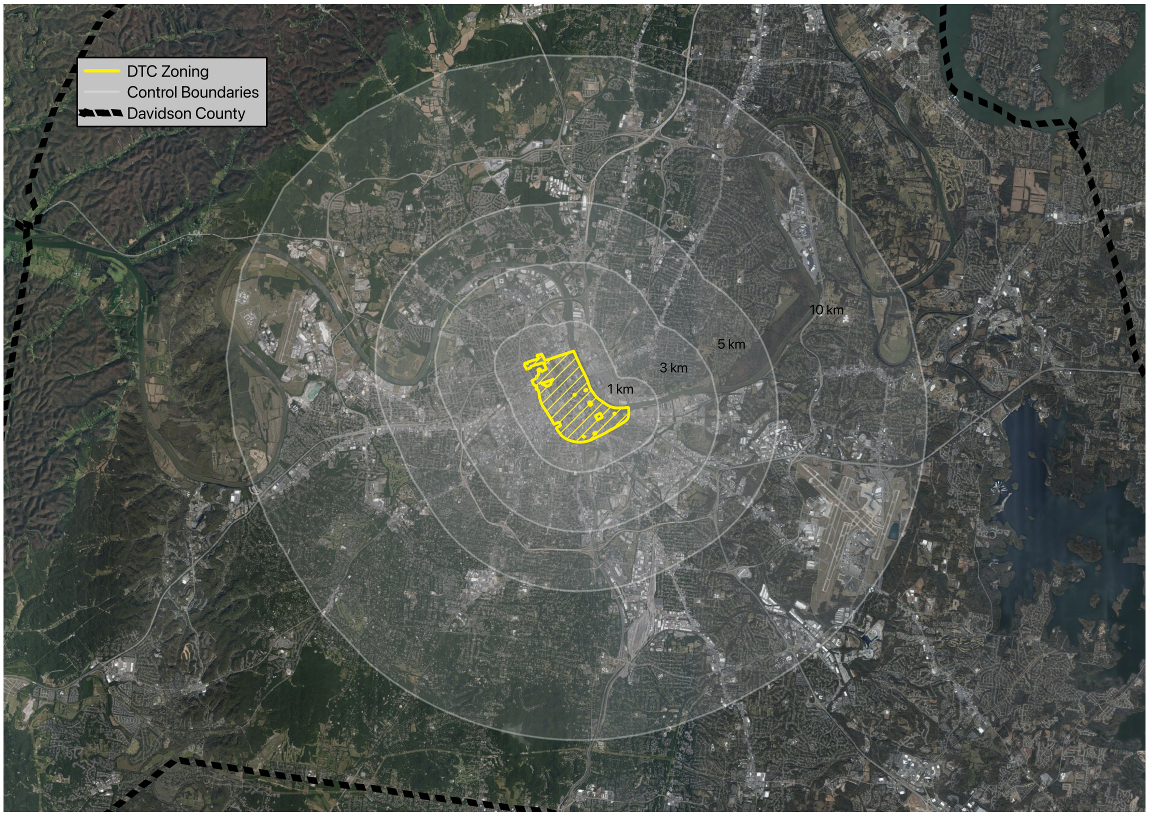
# 3. Data and Control Group Selection

## 3.1. Data

Our empirical analysis focuses on estimating the effects of residential density increases, removal of height regulations, and removal of "by-type" zoning associated with BL2009-586 on housing prices. To accomplish this, we use residential parcel transaction data from the Metropolitan Planning Commission in Davidson County.[3] The data includes 156,632 multi-family housing sales that occurred between 2000 and 2023.[4] This data is recorded upon the instance of each parcel transaction (allowing for repeated sales), giving us information on the sale price, sale date, square footage, building age, census tract, and address. We compare upzoned parcels in the DTC with control parcels which did not undergo any zoning change over the period 2000-2023.[5] Given the lack of single-family housings in the treatment area before policy implementation, we exclude single family housing sales from our analysis.

To construct matched control groups (described further in Section 3.3) we utilize additional housing demand characteristics based a parcel's census tract. Demographic data includes both the percent White residents and percent of residents 25 years or older with a bachelor's degree or higher in a parcel's census tract. Demographic data is sourced from U.S. Census Bureau (2010b). Using data from Davidson County Planning, we recorded the number of building and renovation permits granted in each census tract during the pre-treatment period (2000-2009). Following (Shakro, 2013), we utilize building permit frequency as a proxy for prior neighborhood investment. Balance tables with housing demand characteristics can be found in Tables A.9 – A.16 of the Appendix. The process by which control parcels were selected is described below.

Figure 3: Downtown Code (DTC) Zoning and Control Boundaries




*Notes: Satellite image comparing the Downtown Code Zoning district (in yellow) with 1 km, 3 km, 5 km, and 10 km control boundaries in gray. Zoning shapefiles provided by Davidson County planning. Map produced by author using QGIS.*

## 3.2. Geographic Control Selection

To estimate the effect of the DTC upzoning on housing prices, we first compare parcels sold within the DTC with parcels sold in four control areas based on their

[3]Due to the absence of rental data, we use residential transaction prices as a measure for housing prices and affordability, similar to Freemark (2020).

[4]For the ATT estimates, we excluded outliers consisting of observations with prices of zero or above $2.5 million. However, all observations are used for the QTT estimates, as quantile regression is robust to the presence of outliers.

[5]Our analysis excludes approximately 800 parcels that underwent spot-zoning changes in Davidson County between 2000-2023 to ensure that the only zoning change being captured directly by our data is changes in DTC zoning.

proximity to the treatment area: 1 km, 3 km, 5 km, and 10 km (see Figure 3). These control areas broadly represent Nashville's semi-periphery, both because of their separation from the core (they are outside the Interstate 40 loop that surrounds the DTC) and because of their proximity to urban development over the past 20 years. Control areas within 3 km are generally inside Nashville's Interstate 440 loop and are traditionally defined by single-family housing. Control areas farther away (5 and 10 km) contain a larger sample of Nashville's residential housing stock, especially multifamily units. The covariate balance analyses presented in Tables A.9, A.10, A.11, and A.12 illustrate the similarity between the DTC core and control areas farther away (5 and 10 km). On average, control areas farther away (5 and 10 km) from the DTC have similar observable characteristics to treated areas.

One potential limitation of selecting control areas based on geography is the possibility of capturing spillover effects. Both investments and amenities associated with densification may have spilled over into Nashville's adjacent neighborhoods within the 1 km, 2 km, and 3km boundaries. These adjacent neighborhoods may have received amenity benefits despite their location outside of the treatment zone due to their complementary nature, proximate location, and long histories as residential urban environments. Potential positive spillover effects on housing prices in nearby control areas may result in an underestimation price effect estimates. Conversely, the concentration of investments in the core, as opposed to comparable parcels in the control area, could lead to an overestimation of the treatment effects.

## 3.3. Control Group Selection with Matching Methods

Since electing control parcels on distance may be subject to spillover effects, we supplement our analysis with alternative control groups selected using matching methods. This allows us to create a control group that is similar to the treatment group based on observable characteristics of the parcels. This approach has been used in the empirical literature on zoning policies (Büchler and Lutz, 2021; Dong, 2024) and housing policies more generally (Thomschke, 2016; Peklak, 2020; D'Lima et al., 2023). Using R's "Matchit" package (Stuart et al., 2011) through the Olmos and Govindasamy (2019)'s methodological approach, we attempt to achieve covariate balance between control and treatment parcels for five key characteristics. The building age, square footage, racial composition (percentage of white residents in a parcel's census tract), educational attainment (percentage of residents with a bachelor's degree or higher in a parcel's census tract), and prior neighborhood investment (census tract building permit frequency in the pre-treatment period).

We apply covariate matching using three different matching algorithms: Propensity Score Matching, Generalized Boosted Matching, and Random Forest Matching. Full balance tables can be seen in Tables A.14, A.15, and A.16. The sample sizes shown were selected to maximize the balance of covariates while yielding large enough power for interpretable results. The *Distance* variable provides an overall diagnostic balance measure in all covariate balance tables. Based on the results, the Propensity Score Matching algorithm achieves the best balance of covariates reducing the difference between the treated and control parcels to within one standard deviation for all characteristics.

Table 2: Mean Sale Price by Group and Period (Geographic and Matched Controls)

| Group | Pre-Treatment | Post-Treatment | % Increase |
|---|---|---|---|
| Treatment (DTC) | 233,529 | 593,536 | 154% |
| 1 km Control | 202,242 | 539,621 | 167% |
| 3 km Control | 215,191 | 523,991 | 143% |
| 5 km Control | 207,624 | 512,616 | 147% |
| 10 km Control | 192,719 | 495,268 | 157% |
| All Davidson County | 188,527 | 394,055 | 109% |
| Propensity Score Control | 282,522 | 499,498 | 76% |
| Generalized Boosted Control | 180,926 | 379,471 | 110% |
| Random Forest Control | 161,439 | 332,192 | 106% |

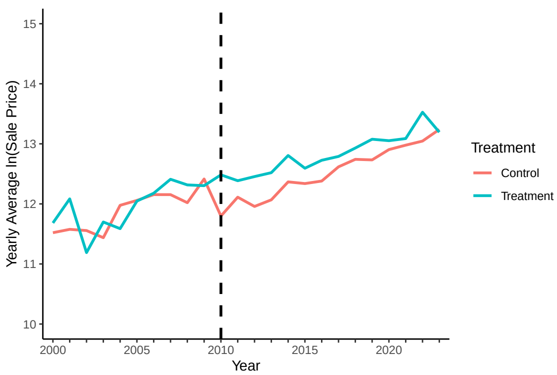
*Notes: Pre-Treatment and Post-Treatment represent whether the parcel was transacted before or policy implementation (February of 2010). Geographic control boundaries can be seen in Figure 3. Complete descriptive tables on sale price (Table A.7) and price per square foot (Table A.8) can be found in the Appendix.*

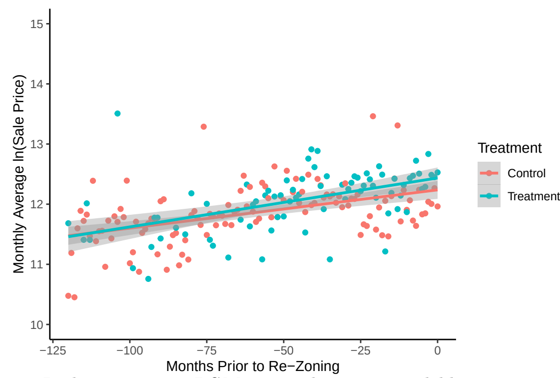
## 3.4. Pre-Treatment Trends

Our difference-in-differences (DiD) empirical strategy relies on the common trend assumption that, in the absence of direct-to-consumer (DTC) upzoning, the prices of control parcels would trend similarly to those of treatment parcels. We assess the plausibility of this assumption by examining parallel trends in pre-treatment prices using four methods: visual inspection of annual transaction prices, monthly comparison of pre-treatment trends, pre-treatment placebo regression analysis, and event studies.

Figure 4a provides a basic visual comparison of the trend changes in the annual average prices of the control and treatment parcels. For the propensity score matched control, the trends are broadly similar with minimal deviation pre-treatment years.

Figure 4: Average Sale Price Trends Sale Price By Treatment (Propensity Score Matching)




*Notes: Left, average yearly ln sale prices by treatment status. Red represents PSM control group, and blue represents DTC zoning. Dotted line denotes time of treatment. Right, depicts ln sale price averages by month in the pre-treatment period, by treatment. OLS regression lines are fitted, with 95% CIs depicted in gray.*

Year and treatment graphs for all other control group trends can be found in Figures A.6 and A.8 of the Appendix. Our visual inspection of average annual price trends is further supported by pre-treatment linear trends at the monthly level, as shown in Figure 4b.[6] This plot allows us to see the congruence of the trendline fit between treatment and control monthly price averages in the pre-treatment period. The overlap in plotted standard error of our trend lines (shaded in the gray area) further supports the similarity of trends between upzoned and control parcels in the pre-treatment period.

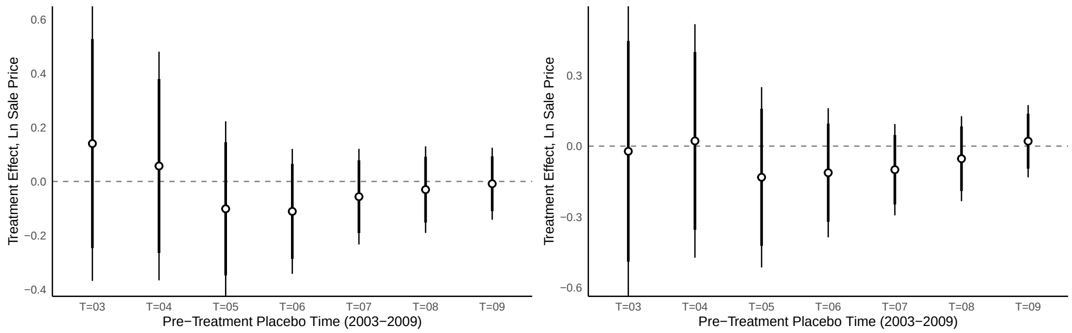
Next, we apply pre-treatment placebo regression analysis to identify possible discontinuities in pre-treatment trends. Using only pre-treatment data, we interact placebo treatment times with our treatment group.[7] The results are shown in Figure 5a and 5b. Using 95% and 99% confidence intervals, we find no statistical significance in any of our pre-treatment placebo DiD estimators, regardless of the year chosen. Finally, we applied sequential event studies to evaluate potential inconsistencies in pretreatment trends. Using each individual year as a placebo treatment provided us with a more granular sense of the pre-treatment trends but resulted in higher variation in our estimates. Event studies are presented in Figure A.10 and A.11. The results generally show no statistically significant pre-treatment ef-

[6]Pre-treatment trends for the 3 km geographic control group can be found in Figure A.9 of the Appendix.

[7]Pre-treatment trends for the 3 km geographic control group can be found in Figure A.9 of the Appendix.

Figure 5: Pre-Treatment Placebos (2003-2009)

(a) 3 km Control Group (b) PSM Control Group




*Notes: Plain lines represent 99% confidence interval, and bold lines, 95% confidence intervals. Pre-treatment placebo time values represent theoretical treatment times, meaning all observations after treatment times are considered treated. Estimates in event study (Figure A.10 and A.11) only count each particular year as treated, leading to larger variation in estimates.*

fects, which supports the common trends assumption. Taken together, our visual inspection of annual transaction prices, our comparison of pre-treatment trends on a monthly basis, our pre-treatment placebo regression analysis, and our event studies are consistent with the parallel trends assumption.

# 4. Empirical Strategy

## 4.1. Standard Difference-in-Differences

To assess the impact of Nashville's upzoning (BL2009-586) on house prices, we use a hedonic price difference-in-differences analysis common in the empirical literature (Freemark, 2020; Kuhlmann, 2021; Gnagey et al., 2023). Our two outcome variables are sale price and sale price per square foot of residential parcels. Studying the impact of DTC upzoning on these two outcomes provides complementary insights that address different aspects of market behavior, valuation, and buyer preferences. Sale prices reflect total market value, while sale prices per square foot reflect space utilization efficiency. For example, higher sale prices per square foot in downtown signal a willingness to pay for proximity due to shorter commutes or amenities. We combine available parcel characteristics data with neighborhood-level fixed effects (FE) to reduce endogeneity issues. Applying the Hausman specification test confirms the preference for the fixed effects model over the random effects model, which is in line with the existing empirical literature. The FE DiD model estimates the ATT of the DTC upzoning through the following equation:

$$\ln(Y_{pnt}) = \beta_0 + \beta_1 U_p + \beta_2 A_t + \beta_3 U_p A_t + \gamma X_p + \eta_n + \tau_t + \epsilon_{pnt} \tag{1}$$

where $Y_{pnt}$ measures the sale price (resp. sale price per square foot) of a residential parcel $p$ in $n$ neighborhood (census tract) and year $t$. $A_t$ is a dummy variable indicating whether the transaction happened before or after the zoning change, and $U_p$ is a dummy variable indicating whether the transaction happened in the DTC (treatment area). $X_p$ represents property level covariates (unit size ft$^2$, age). $\eta_n$ is a neighborhood fixed effect (as represented by the census tract of the parcels), $\tau_t$ is a time fixed effect (the year of the transaction), and $\epsilon_{pnt}$ is the error term. $\beta_3$ is the main parameter of interest and estimates the ATT of the DTC upzoning.

## 4.2. Quantile Difference-in-Differences

To capture potential heterogeneous price responses to the DTC upzoning, we estimate quantile treatment effects using quantile difference-in-differences (QDiD). Examining treatment effects beyond the mean is particularly useful for identifying heterogeneous treatment effects that may arise due to the segmented nature of housing markets (Thomschke, 2016; Peklak, 2020; D'Lima et al., 2023; Ortiz-Villavicencio et al., 2024). Following Ortiz-Villavicencio et al. (2024), we estimate QDiD using a quantile version of Equation 1:

$$\ln(Y_{pnt})^q = \beta_0^q + \beta_1^q U_p + \beta_2^q A_t + \beta_3^q U_p A_t + \gamma^q X_p + \eta_n^q + \tau_t^q + \epsilon_{pnt}^q. \tag{2}$$

The outcome variables $\ln(Y_{pnt})^q$ are the logarithm of parcel sale price and price per square foot at the $q$-th quantile. This model enables us to estimate the quantile treatment effect on the treated (QTT) parcels, which is the difference in the $q$-th quantile of potential outcome distributions for the treated parcels, and is represented by the parameter $\beta_3^q$. In addition to assuming parallel trends at each quantile $q$, this model assumes that the ranking of parcels based on sale price and sale price per square foot (both in logarithm) will not change after the DTC upzoning is implemented. We estimate the QTT for the first quartile ($q = .25$), median ($q = .5$), and third quartile ($q = .75$) parcel transactions. These estimations assign different weights to low, medium, and high market value transactions, providing insights into treatment effects among different housing market segments. An alternative approach to estimating QDiD is the Change in Changes (CIC) method of Athey and Imbens (2006). However, CIC relies on strong distributional and support assumptions that are unlikely to hold for our limited sample size.

# 5. Results

## 5.1. Average Treatment Effects on the Treated

Tables 3a and 3b provide ATT estimates using four geometric control areas. The ATT estimate for sale price using the nearest control group (1 km) is negative but not statistically significant. Using control groups farther away (3 km and 5 km), the ATT estimates become positive and increase with distance, though they remain statistically insignificant. However, the average sale price of upzoned parcels increased significantly by 13% when using 10 km control parcels. Overall, we find that Nashville's DTC upzoning did not significantly reduce the average price of treated parcels relative to those in the 1 km, 3 km, and 5 km control groups. In some cases, such as the 10 km control group, it resulted in a price increase. A similar pattern is observed when considering the sale price per square foot. The ATT is negative but not statistically significant at the 5% level when using the 1 km control parcels. When using control parcels farther away, the ATT estimates are positive and increase with distance. The average sale price per square foot of treated parcels increased by 11.5% using 5 km controls and by 14.3% using 10 km controls, respectively. These results are consistent with the description of the geographic control areas in Table 2. Control parcels closer to the Nashville DTC are more expensive due to reduced commuting time and access to urban amenities, whereas control parcels farther away (10 km) have sustained low prices over time. Additionally, the same pattern is observed when using sale price per square foot to capture efficient land and space use. Control parcels farther from Nashville DTC have on average a low valuation per square foot.

To evaluate the reliability of the ATT estimates presented above, we employed alternative matched control parcels. On average, these control parcels have the same observable characteristics as the upzoned parcels. The associated ATT estimates are presented in Tables 4a and 4b. For all three matching algorithms, the direction and significance of the effects are consistent. On average, upzoned parcels are more expensive in terms of both sale price and sale price per square foot. The sale price increase ranges from 17% to 32%, and the sale price per square foot increase ranges from 11% to 20%. These results are aligned with the event studies presented in Figure A.11, which revealed an upward trend in sale price and sale price per square foot during the five years after Nashville's DTC upzoning. Afterward, the trend remains positive but declines progressively. We explore this temporal heterogeneity by estimating ATT in two post-treatment periods: 2010–2015 and 2016–2023. The results, shown in Tables A.17 through A.20, demonstrate that increases in sale prices among treated parcels are larger during 2010–2015 as compared to 2016–2023. Nonetheless,

Table 3: Fixed Effects Difference-in-Differences with Geographic Control Groups

a Sale Price

| | *Dependent variable: log(Sale Price)* | | | |
|---|---|---|---|---|
| Control Boundary: | (1 km) | (3 km) | (5 km) | (10 km) |
| DTC*Time Period | −0.088 | 0.029 | 0.055 | 0.131*** |
| | (0.057) | (0.043) | (0.035) | (0.034) |
| DTC | 0.168*** | 0.041 | −0.003 | −0.058 |
| | (0.056) | (0.045) | (0.038) | (0.037) |
| Time Period | 0.097 | 0.006 | −0.093 | 0.032 |
| | (0.150) | (0.111) | (0.082) | (0.064) |
| Finished Area | 0.00004*** | 0.00004*** | 0.0001*** | 0.00001*** |
| | (0.00000) | (0.00000) | (0.00000) | (0.00000) |
| Age | −0.016*** | −0.009*** | −0.010*** | −0.013*** |
| | (0.001) | (0.0004) | (0.0003) | (0.0002) |
| Tract FE | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES |
| Observations | 4,448 | 9,989 | 17,145 | 27,684 |
| $R^2$ | 0.496 | 0.436 | 0.483 | 0.557 |
| Adjusted $R^2$ | 0.491 | 0.432 | 0.480 | 0.554 |

b Sale Price Per Square Foot

| | *Dependent variable: log(Sale Price Per Sqr. ft)* | | | |
|---|---|---|---|---|
| Control Boundary: | (1 km) | (3 km) | (5 km) | (10 km) |
| DTC*Time Period | −0.078* | 0.046 | 0.115*** | 0.143*** |
| | (0.046) | (0.038) | (0.030) | (0.027) |
| DTC | 0.246*** | 0.176*** | 0.094*** | 0.079*** |
| | (0.045) | (0.039) | (0.032) | (0.029) |
| Time Period | −0.106 | −0.105 | −0.232*** | −0.169*** |
| | (0.122) | (0.097) | (0.070) | (0.051) |
| Age | −0.013*** | −0.009*** | −0.006*** | −0.007*** |
| | (0.001) | (0.0004) | (0.0002) | (0.0002) |
| Tract FE | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES |
| Observations | 4,448 | 9,989 | 17,145 | 27,684 |
| $R^2$ | 0.628 | 0.544 | 0.551 | 0.609 |
| Adjusted $R^2$ | 0.625 | 0.541 | 0.548 | 0.608 |

*Note: This table uses fixed effects ordinary least squares to estimate the effect of upzoning (DTC) on logged housing prices. Each column represents a different geographic control area (as depicted in Figure 3). The variable of interest, capturing the impact of the DTC upzoning, is DTC*Time Period. *p<0.1; **p<0.05; ***p<0.01.*

there remains a positive and significant treatment effect in the 2016–2023 period. These results potentially capture the delayed effect of the increased supply of multi-family housing in Nashville's DTC.

## 5.2. Quantile Treatment Effects

The QDiD estimates, shown in Tables 5 and 6, provide strong evidence of heterogeneous effects on housing affordability as a result of Nashville's DTC upzoning. Focusing first on sale prices, the estimates display similar patterns whether the geographic or matched control parcels are used. There is a positive and significant effect on upzoned parcels at the lower end of price distribution ($\tau = .25$), ranging from 2% to 28% price increase and a negative and significant effect on upzoned parcels at the upper end of price distribution ($\tau = .75$), ranging from 4% to 25% price decrease. A price increase in the first quartile of price distribution is consistent with the findings of Freemark (2020) and Kuhlmann (2021) who argue that increased land utility could boost the speculative value of residential parcels. Investment effects, combined with potential amenity effects associated with increased density, can reduce affordability within upzoned areas, particularly at the lower end of the market. Ortiz-Villavicencio

Table 4: Fixed Effects Difference-in-Differences with Matched Control Groups

a Sale Price

| | *Dependent variable: log(Sale Price)* | | |
|---|---|---|---|
| Matching Method: | (PSM) | (GBM) | (RFM) |
| DTC*Time Period | 0.319*** | 0.267*** | 0.169*** |
| | (0.045) | (0.038) | (0.034) |
| DTC | 0.003 | 0.025 | 0.075* |
| | (0.051) | (0.048) | (0.038) |
| Time Period | −0.137 | −0.005 | −0.090 |
| | (0.092) | (0.075) | (0.066) |
| Finished Area | 0.0002*** | 0.00005*** | 0.0001*** |
| | (0.00001) | (0.00000) | (0.00000) |
| Age | −0.029*** | −0.003*** | −0.003*** |
| | (0.001) | (0.0003) | (0.0003) |
| Tract FE | YES | YES | YES |
| Year FE | YES | YES | YES |
| Observations | 12,637 | 12,637 | 12,637 |
| $R^2$ | 0.464 | 0.490 | 0.518 |
| Adjusted $R^2$ | 0.457 | 0.488 | 0.514 |

b Sale Price Per Square Foot

| | *Dependent variable: log(Sale Price / $ft^2$)* | | |
|---|---|---|---|
| Matching Method: | (PSM) | (GBM) | (RFM) |
| DTC*Time Period | 0.108** | 0.203*** | 0.121*** |
| | (0.047) | (0.031) | (0.032) |
| DTC | 0.039 | 0.039 | 0.121*** |
| | (0.053) | (0.039) | (0.036) |
| Time Period | −0.095 | −0.107* | −0.068 |
| | (0.096) | (0.062) | (0.062) |
| Age | −0.020*** | −0.003*** | −0.003*** |
| | (0.001) | (0.0003) | (0.0002) |
| Tract FE | YES | YES | YES |
| Year FE | YES | YES | YES |
| Observations | 12,637 | 12,637 | 12,637 |
| $R^2$ | 0.532 | 0.660 | 0.646 |
| Adjusted $R^2$ | 0.526 | 0.659 | 0.643 |

*Note: This table uses fixed effects ordinary least squares to estimate the effect of upzoning (DTC) on logged housing prices in Davidson County. Each column denotes the matching methodology used to produce matched control groups. The variable of interest, capturing the impact of the DTC upzoning, is DTC*Time Period.* $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

et al. (2024) argue that price increase in the first quartile could reflect an increase in demand for larger multifamily parcels. We evaluate this hypothesis later using sale price per square foot as the outcome variable.

Table 5: Quantile Difference-in-Difference, Geographic Controls (2000-2023)

a Treatment Effect, Sale Price

| | *Dependent variable: log(Sale Price)* | | | |
|---|---|---|---|---|
| tau | (1 km) | (3 km) | (5 km) | (10 km) |
| $\tau$=0.25 | 9.056*** | 0.896 | 0.535** | 0.655*** |
| | (1.521) | (1.095) | (0.252) | (0.092) |
| $\tau$=0.50 | −0.180** | −0.083 | -0.040 | -0.092** |
| | (0.080) | (0.058) | (0.036) | (0.038) |
| $\tau$=0.75 | −2.70*** | -2.639*** | −0.036 | -2.585** |
| | (0.615) | (0.751) | (0.068) | (1.267) |
| Observations | 4,358 | 6,918 | 9,860 | 17,125 |

b Treatment Effect, Price Per Square Ft

| | *Dependent variable: log(Sale Price / $ft^2$)* | | | |
|---|---|---|---|---|
| tau | (1 km) | (3 km) | (5 km) | (10 km) |
| $\tau$=0.25 | 2.334*** | 0.634*** | 0.127 | 1.22*** |
| | (0.506) | (0.218) | (0.276) | (0.222) |
| $\tau$=0.50 | 0.068 | 0.051 | 0.032 | -0.061 |
| | (0.096) | (0.055) | (0.030) | (0.054) |
| $\tau$=0.75 | −2.59** | -2.556** | 0.087*** | -2.546*** |
| | (0.796) | (1.027) | (0.027) | (1.267) |
| Observations | 4,358 | 6,918 | 9,860 | 17,125 |

*Notes: Reported regressions include property covariates and quarter-by-year fixed effects.* $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 6: Quantile Difference-in-Difference, Matched Controls (2000-2023)

a Treatment Effect, Sale Price

| | *Dependent variable: log(Sale Price)* | | |
|---|---|---|---|
| Matching Method: | (PSM) | (GBM) | (RFM) |
| $\tau$=0.25 | 0.079*** | 0.245*** | 0.134*** |
| | (0.024) | (0.027) | (0.023) |
| $\tau$=0.50 | −0.015 | 0.009 | -0.090*** |
| | (0.028) | (0.036) | (0.034) |
| $\tau$=0.75 | 0.172*** | −0.043* | −0.147*** |
| | (0.058) | (0.023) | (0.021) |
| Observations | 12,637 | 12,637 | 12,637 |

b Treatment Effect, Price Per Square Ft

| | *Dependent variable: log(Sale Price / $ft^2$)* | | |
|---|---|---|---|
| Matching Method: | (PSM) | (GBM) | (RFM) |
| $\tau$=0.25 | −0.058 | 0.209*** | 0.103** |
| | (0.048) | (0.039) | (0.032) |
| $\tau$=0.50 | −0.229*** | 0.005 | −0.097*** |
| | (0.021) | (0.017) | (0.018) |
| $\tau$=0.75 | −0.077** | −0.134*** | −0.227*** |
| | (0.032) | (0.022) | (0.021) |
| Observations | 12,637 | 12,637 | 12,637 |

*Notes: Reported regressions include property covariates and quarter-by-year fixed effects.* $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

The prices of upzoned parcels in the third quartile have decreased compared to control parcels. This finding aligns with the results of Anagol et al. (2021), who attribute this decrease to a price reduction resulting from an increase in supply relative to demand. Nashville's downtown transformation supports this hypothesis, as the construction of several multifamily luxury apartment buildings has flooded the downtown housing market, leading to downward price pressures. We observe similar patterns when turning to sale price per square foot. There is a positive and significant effect at the lower end of the distribution, which challenges the parcel size hypothesis because upzoned parcels cost more per square foot. However, upzoned parcels at the upper end of the distribution have seen their prices per square foot decrease significantly due to the upzoning policy. This could be explained by the fact that, although they are more expensive, newly built multifamily units in Downtown Nashville are also bigger in size. Overall, the QTT estimates suggest that BL2005-586 did not improve housing affordability.

# 6. Conclusion

Housing affordability is a key issue throughout the United States. Upzoning, the relaxation of zoning laws to allow for denser and more diverse housing types, has been implemented as a supply-side solution, yielding mixed results. This study contributes to the existing body of research on the impact of upzoning policies in the U.S. by examining the long-term effects of Nashville's 2010 downtown upzoning using residential transaction prices from 2000 to 2023. The upzoning change increased density requirements and building height limits while eliminating by-type zoning. Our paper is the first to rigorously assess the effects of Nashville's DTC upzoning on housing. Due to data restrictions, our analysis focuses solely on multifamily parcels. We employ a difference-in-differences approach, combined with matching methods, to estimate the average and heterogeneous treatment effects of upzoning on sale prices and prices per square foot.

We find that, across all specifications, Nashville DTC upzoning failed to reduce the average sale price of upzoned parcels. On average, treated multifamily parcels cost 11% to 38% more (approximately $55,000 to $209,000 USD) than similar untreated parcels. Our analyses also revealed a waning effect: higher price increases (18% to 46%) in the short term (2010–2015) and lower price increases (4% to 28%) in the long term (2016–2023). Our results are consistent with those of Freemark (2020) and Kuhlmann (2021), who also found that upzoning changes did not result in reduced prices, but rather the opposite. One possible reason for the price increase is the increase in the size of new property developments. However, our finding that transaction prices per square foot of treated parcels have significantly increased challenges this idea. Importantly, we found evidence of heterogeneous treatment effects across market price segments. Prices increased by 2% to 28% for upzoned parcels in the first quartile and decreased by 4% to 25% for upzoned parcels in the third quartile. There is upward pressure at the lower end of the market due to proximity and amenities. The decrease in prices at the higher end of the market, as reported by Anagol et al. (2021), could reflect the rapid development of large multifamily units recently built in Nashville's core. This development could explain a decrease in the price of high-end housing through supply-side mediation.

Overall, our findings tell a cautionary tale about the effectiveness of upzoning policies. Providing zoning incentives to increase housing supply without an enforcement mechanism can fail to deliver affordable housing, and this failure can be especially detrimental in areas where housing density functions as an amenity such as in the case of downtown Nashville. Considering our findings on heterogeneous treatment effects, policies aimed at increasing housing affordability should stimulate housing supply across the price distribution spectrum to achieve a balanced distribution among diverse income levels (Ortiz-Villavicencio et al., 2024). When combined with additional policy actions, upzoning can address housing affordability issues. One example suggested by Tatian et al. (2023) is leveraging underutilized land owned by institutions (faith-based, academic, and healthcare) for low-income housing development. This can be achieved through rezoning commercial parcels for multifamily use, permitting small-scale multifamily units such as fourplexes, and enabling subdivisions to maximize land use. They also emphasize the importance of partnerships between institutions and developers. These partnerships are supported by technical assistance and funding, as well as demand-side mechanisms such as tax credits and grants. Additionally, they emphasize the need for Metro Nashville to establish an organizing entity to facilitate these collaborations and ensure they align with community affordability needs. Overall, we acknowledge that a constellation of factors; including migration patterns, financial incentives, speculation, and amenity structures; may shape the outcomes of upzoning policies across space and time. Therefore, more empirical research is needed to identify and define the ideal configuration of a successful upzoning policy.

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# Appendix A. Tables and Figures

Table A.7: Sale Price by Group and Period

| Statistic: | N | | Mean | | SD | | P25 | | P50 | | P75 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group | Before | After | Before | After | Before | After | Before | After | Before | After | Before | After |
| Treatment (DTC) | 320 | 2,317 | 233,529 | 593,536 | 131,997 | 465,481 | 146,150 | 320,000 | 207,347 | 425,000 | 297,750 | 670,000 |
| 1k Control | 156 | 1,659 | 202,242 | 539,621 | 160,538 | 321,390 | 102,900 | 310,000 | 180,100 | 459,000 | 243,725 | 699,900 |
| 3k Control | 650 | 6,706 | 215,191 | 523,991 | 170,981 | 311,220 | 119,225 | 320,000 | 187,847 | 459,000 | 258,302 | 659,900 |
| 5k Control | 1,413 | 13,182 | 207,624 | 512,616 | 161,172 | 301,522 | 117,300 | 308,000 | 178,000 | 443,500 | 248,000 | 649,999 |
| 10k Control | 2,690 | 22,365 | 192,719 | 495,268 | 174,820 | 333,208 | 90,000 | 274,900 | 150,000 | 421,250 | 229,375 | 634,900 |
| All Davidson County | 30,983 | 125,649 | 188,527 | 394,055 | 199,624 | 320,367 | 100,967 | 205,000 | 140,266 | 312,000 | 209,900 | 465,000 |
| Propensity Score | 1,937 | 8,063 | 282,522 | 499,498 | 405,366 | 442,597 | 103,850 | 225,000 | 150,000 | 353,000 | 240,000 | 576,000 |
| Generalized Boosted | 2,909 | 9,591 | 180,926 | 379,471 | 153,766 | 333,413 | 108,500 | 185,000 | 134,000 | 284,000 | 201,750 | 427,500 |
| Random Forest | 3,655 | 13,345 | 161,439 | 332,192 | 229,194 | 290,762 | 89,900 | 170,000 | 119,000 | 264,000 | 154,975 | 390,000 |

Table A.8: Sale Price Per Square Foot by Group and Period

| Statistic: | N | | Mean | | SD | | P25 | | P50 | | P75 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group | Before | After | Before | After | Before | After | Before | After | Before | After | Before | After |
| Treatment (DTC) | 320 | 2,317 | 239 | 548 | 85 | 297 | 183 | 376 | 243 | 486 | 302 | 622 |
| 1k Control | 156 | 1,659 | 170 | 340 | 127 | 160 | 51 | 251 | 184 | 325 | 245 | 422 |
| 3k Control | 650 | 6,706 | 158 | 328 | 98 | 202 | 80 | 226 | 160 | 293 | 217 | 384 |
| 5k Control | 1,413 | 13,182 | 149 | 298 | 122 | 161 | 89 | 213 | 138 | 270 | 189 | 344 |
| 10k Control | 2,690 | 22,365 | 129 | 277 | 108 | 173 | 65 | 193 | 110 | 252 | 166 | 321 |
| All Davidson County | 30,983 | 125,649 | 114 | 245 | 210 | 322 | 69 | 128 | 87 | 188 | 107 | 264 |
| Propensity Score | 1,937 | 8,063 | 399 | 732 | 732 | 921 | 99 | 245 | 144 | 371 | 255 | 737 |
| Generalized Boosted | 2,909 | 9,591 | 106 | 223 | 91 | 256 | 74 | 121 | 90 | 180 | 109 | 257 |
| Random Forest | 3,647 | 13,353 | 99 | 218 | 115 | 205 | 65 | 120 | 80 | 181 | 98 | 258 |

Table A.9: Covariate Balance (1km Control)

| Variable | Treated Mean | Control Mean | Std. Mean Diff. |
|---|---|---|---|
| Distance | 0.7781 | 0.3220 | 2.5288 |
| Age | 9.2814 | 9.5499 | -0.0333 |
| Finished Area | 1088.47 | 1888.72 | -0.5711 |
| % White | 61.08 | 37.76 | 2.4706 |
| % Bachelors Degree | 0.4334 | 0.3061 | 3.2326 |
| Building Permits | 45.50 | 53.29 | -0.3457 |

Table A.10: Covariate Balance (3km Control)

| Variable | Treated Mean | Control Mean | Std. Mean Diff. |
|---|---|---|---|
| Distance | 0.4274 | 0.2050 | 1.9214 |
| Age | 9.2814 | 10.6540 | -0.1702 |
| Finished Area | 1088.47 | 1883.47 | -0.5674 |
| % White | 61.08 | 47.99 | 1.3869 |
| % Bachelors Degree | 0.4334 | 0.3687 | 1.6435 |
| Building Permits | 45.50 | 35.03 | 0.4641 |

Table A.11: Covariate Balance (5km Control)

| Variable | Treated Mean | Control Mean | Std. Mean Diff. |
|---|---|---|---|
| Distance | 0.2931 | 0.1235 | 1.4160 |
| Age | 9.3835 | 13.2968 | -0.5253 |
| Finished Area | 1066.47 | 1886.53 | -0.5856 |
| % White | 60.95 | 60.55 | 0.0418 |
| % Bachelors Degree | 0.4329 | 0.4288 | 0.1026 |
| Building Permits | 45.81 | 32.12 | 0.5992 |

Table A.12: Covariate Balance (10km Control)

| Variable | Treated Mean | Control Mean | Std. Mean Diff. |
|---|---|---|---|
| Distance | 0.2406 | 0.0797 | 1.3133 |
| Age | 9.2613 | 15.5191 | -0.7794 |
| Finished Area | 1088.62 | 1943.53 | -0.6097 |
| % White | 61.08 | 66.48 | -0.5720 |
| % Bachelors Degree | 0.4334 | 0.4140 | 0.4915 |
| Building Permits | 45.51 | 28.35 | 0.7606 |

Table A.13: Covariate Balance (All Davidson County)

| Variable | Treated Mean | Control Mean | Std. Mean Diff. |
|---|---|---|---|
| Distance | 0.0837 | 0.0154 | 1.4434 |
| Age | 9.3239 | 28.5614 | -2.3596 |
| Finished Area | 1090.40 | 1895.91 | -0.5744 |
| % White | 61.08 | 67.22 | -0.6498 |
| % Bachelors Degree | 0.4334 | 0.3690 | 1.6356 |
| Building Permits | 45.51 | 68.41 | -1.0154 |

Table A.14: Covariate Balance (Propensity Score Matching)

| Variable | Treated Mean | Control Mean | Std. Mean Diff. |
|---|---|---|---|
| Distance | 0.3182 | 0.1798 | 0.6843 |
| Age | 9.3239 | 6.3989 | 0.3588 |
| Finished Area | 1090.40 | 905.19 | 0.1321 |
| % White | 61.08 | 59.67 | 0.1492 |
| % Bachelors Degree | 0.4334 | 0.4531 | -0.5000 |
| Building Permits | 45.51 | 35.93 | 0.4247 |

Table A.15: Covariate Balance (Generalized Boosted Matching)

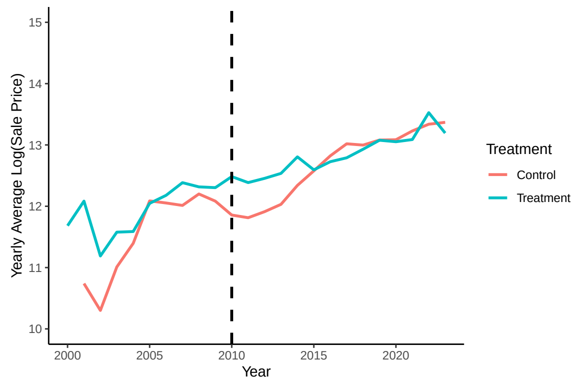
| Variable | Treated Mean | Control Mean | Std. Mean Diff. |
|---|---|---|---|
| Distance | 0.4885 | 0.1079 | 1.7667 |
| Age | 9.3239 | 28.5317 | -2.3559 |
| Finished Area | 1090.40 | 1889.97 | -0.5702 |
| % White | 61.08 | 69.14 | -0.8537 |
| % Bachelors Degree | 0.4334 | 0.4243 | 0.2311 |
| Building Permits | 45.51 | 40.52 | 0.2212 |

Table A.16: Covariate Balance (Random Forest Matching)

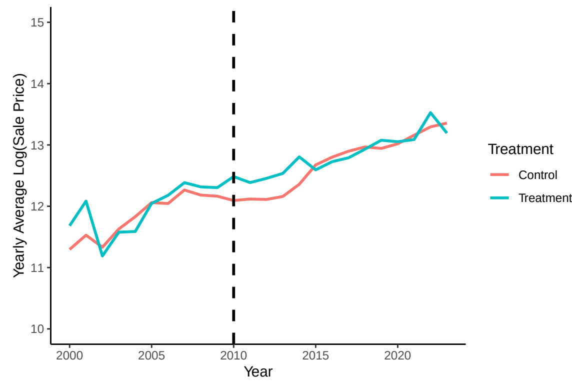
| Variable | Treated Mean | Control Mean | Std. Mean Diff. |
|---|---|---|---|
| Distance | 0.5477 | 0.0702 | 2.8495 |
| Age | 9.3239 | 35.4352 | -3.2027 |
| Finished Area | 1090.40 | 1669.00 | -0.4126 |
| % White | 61.08 | 69.05 | -0.8440 |
| % Bachelors Degree | 0.4334 | 0.2957 | 3.4973 |
| Building Permits | 45.51 | 7.48 | 1.6858 |

Figure A.6: Average Sale Price By Year and Treatment (Geographic Controls)

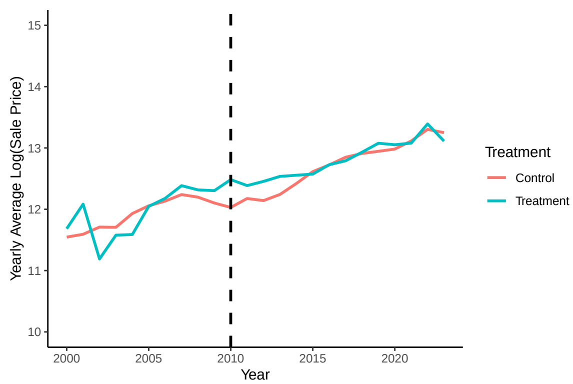
(a) 1km Control



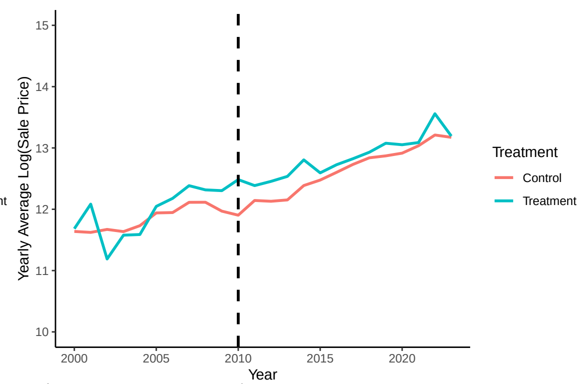

(b) 3km Control




(c) 5km Control



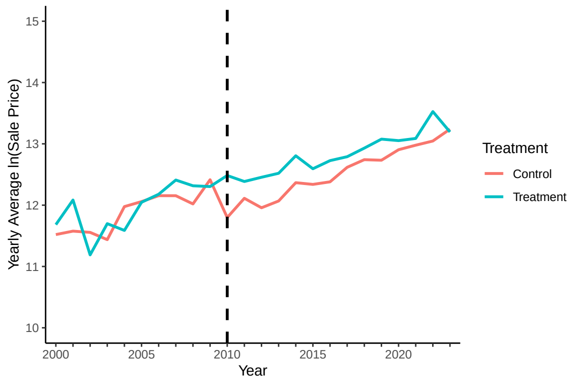

(d) 10km Control



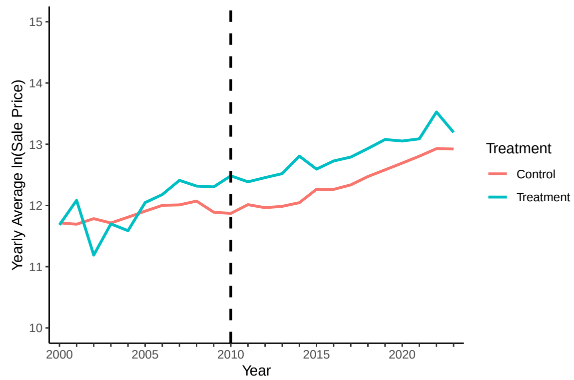

*Note: Average sale price by year. Geographic control bands (1km, 3km, and 10k) are compared to the DTC.*

Figure A.7: Average Sale Price By Year and Treatment (Matched Controls)

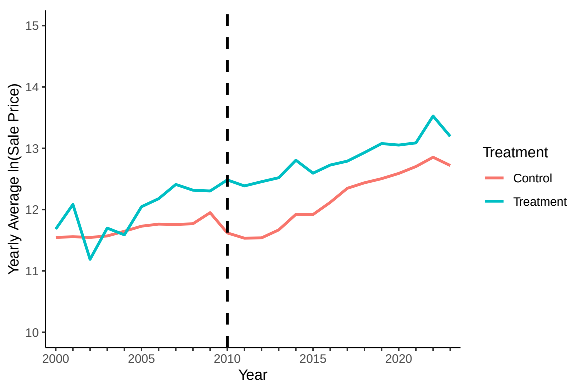
(a) Propensity Score Matching




(b) Generalized Boosted Matching



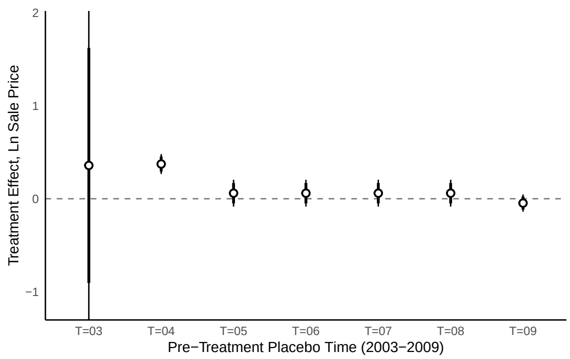

(c) Random Forrest Control



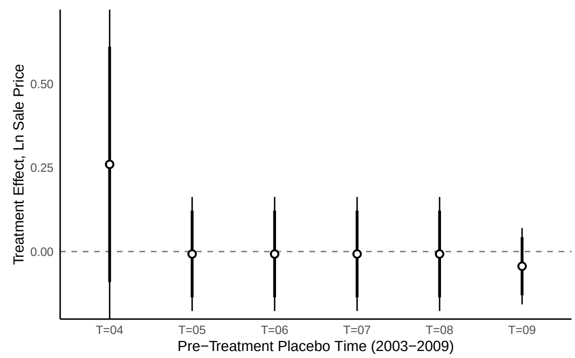

*Note: Average sale price by year. Matched Control groups are compared to the DTC.*

Figure A.8: Pre-Treatment Placebos, Quantile Effect (2003-2009)

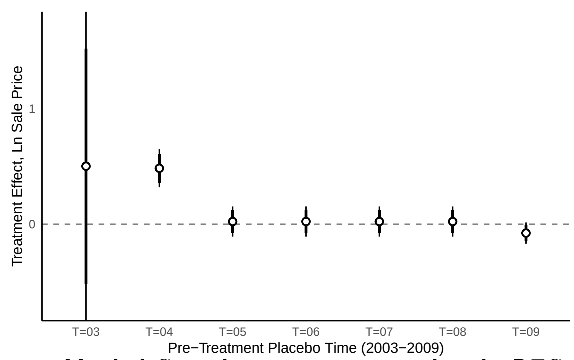
(a) Propensity Score Matching $\tau = .25$




(b) Propensity Score Matching $\tau = .50$

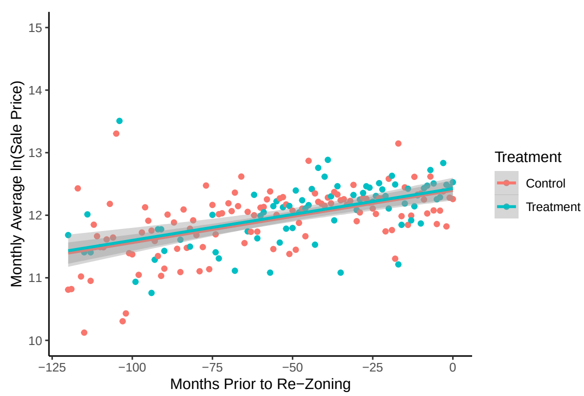



(c) Propensity Score Matching $\tau = .75$



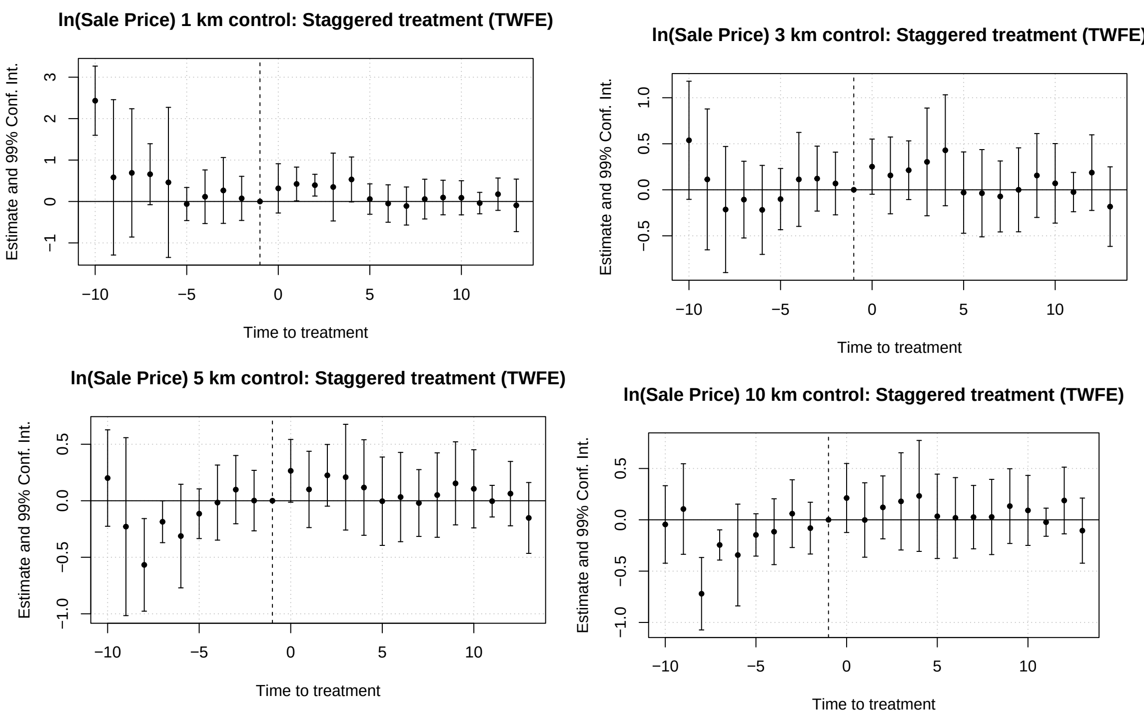

*Note: Average sale price by year. Matched Control groups are compared to the DTC.*

Figure A.9: Pre-treatment Trends by Month (3km Control)



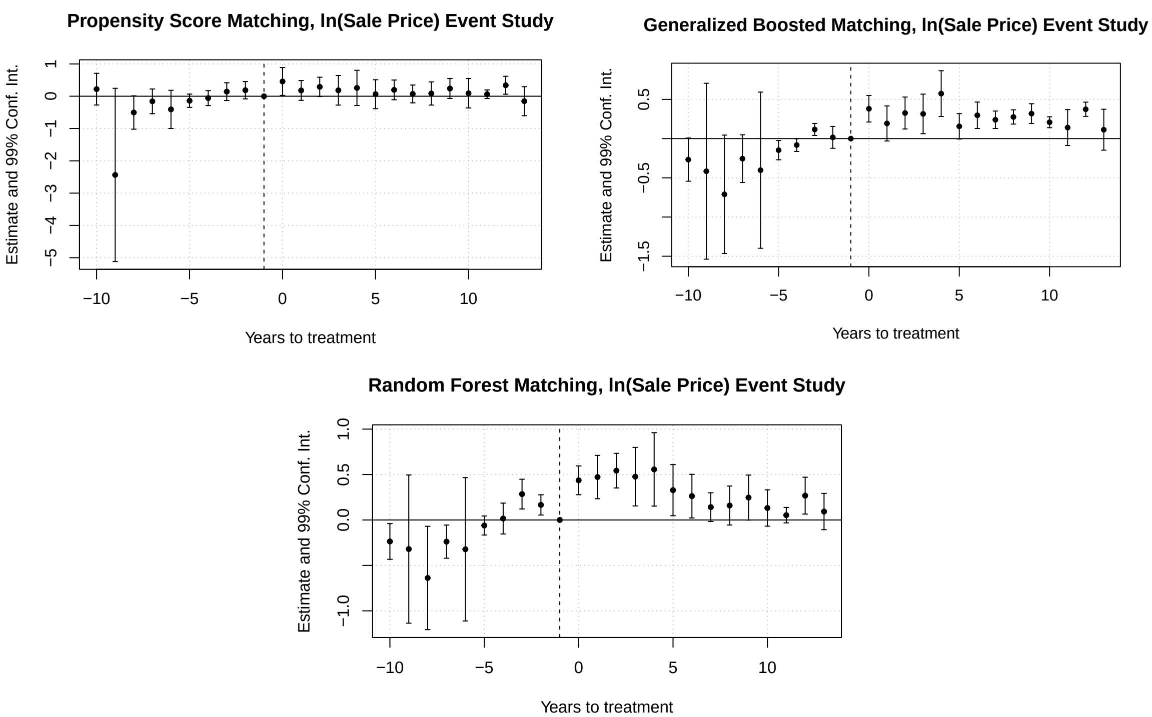

*Notes: Depicts ln sale price averages by month in the pre-treatment period, by treatment. OLS regression lines are fitted, with 95% CIs depicted in gray.*

Figure A.10: Event Studies with Geographic Controls:




*Note: Event studies are presented with 95% confidence intervals.*

Figure A.11: Event Studies with Matched Controls:




*Note: Event studies are presented with 95% confidence intervals.*

Table A.17: Ln(Sale Price) Fixed Effects Difference-in-Differences with Geographic Control Groups

a (2010-2015)

| | *Dependent variable: log(Sale Price)* | | | |
|---|---|---|---|---|
| Control Boundary: | (1 km) | (3 km) | (5 km) | (10 km) |
| DTC*Time Period | 0.049 | 0.047 | 0.072 | 0.147*** |
| | (0.067) | (0.056) | (0.046) | (0.047) |
| DTC | −0.036 | −0.040 | −0.083 | −0.139** |
| | (0.061) | (0.059) | (0.051) | (0.055) |
| Time Period | −0.056 | 0.057 | −0.022 | 0.037 |
| | (0.153) | (0.124) | (0.091) | (0.075) |
| Finished Area | 0.0001*** | 0.00003*** | 0.00004*** | 0.00001*** |
| | (0.00000) | (0.00000) | (0.00000) | (0.00000) |
| Age | −0.013*** | −0.005*** | −0.009*** | −0.011*** |
| | (0.001) | (0.001) | (0.001) | (0.0005) |
| Tract FE | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES |
| Observations | 1,305 | 2,696 | 4,622 | 7,644 |
| $R^2$ | 0.464 | 0.375 | 0.413 | 0.459 |
| Adjusted $R^2$ | 0.451 | 0.362 | 0.403 | 0.451 |

b (2016-2023)

| | *Dependent variable: log(Sale Price)* | | | |
|---|---|---|---|---|
| Control Boundary: | (1 km) | (3 km) | (5 km) | (10 km) |
| DTC*Time Period | −0.117** | 0.022 | 0.061* | 0.153*** |
| | (0.058) | (0.043) | (0.035) | (0.033) |
| DTC | 0.185*** | 0.043 | −0.008 | −0.074** |
| | (0.057) | (0.045) | (0.038) | (0.036) |
| Time Period | 2.789*** | 2.168*** | 1.770*** | 1.555*** |
| | (0.375) | (0.118) | (0.071) | (0.048) |
| Finished Area | 0.00004*** | 0.00004*** | 0.0001*** | 0.0001*** |
| | (0.00000) | (0.00000) | (0.00000) | (0.00000) |
| Age | −0.015*** | −0.009*** | −0.010*** | −0.012*** |
| | (0.001) | (0.0005) | (0.0003) | (0.0002) |
| Tract FE | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES |
| Observations | 3,933 | 8,990 | 15,557 | 25,065 |
| $R^2$ | 0.476 | 0.427 | 0.474 | 0.584 |
| Adjusted $R^2$ | 0.471 | 0.423 | 0.471 | 0.582 |

*Note: This table uses fixed effects ordinary least squares to estimate the effect of upzoning (DTC) on logged housing prices in Davidson County. Each column represents a different geographic control area (as depicted in Figure 3). The variable of interest, capturing the impact of the DTC upzoning, DTC*Time Period.* $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

Table A.18: Ln(Sale Price / $ft^2$) Fixed Effects Difference-in-Differences with Geographic Control Groups

a (2010-2015)

| | *Dependent variable: log(Sale Price Per Sqr. ft)* | | | |
|---|---|---|---|---|
| Control Boundary: | (1 km) | (3 km) | (5 km) | (10 km) |
| DTC*Time Period | 0.057 | 0.090* | 0.139*** | 0.164*** |
| | (0.057) | (0.051) | (0.041) | (0.039) |
| DTC | 0.043 | 0.071 | 0.013 | −0.012 |
| | (0.051) | (0.054) | (0.046) | (0.046) |
| Time Period | −0.184 | −0.047 | −0.147* | −0.160** |
| | (0.129) | (0.113) | (0.082) | (0.064) |
| Age | −0.017*** | −0.010*** | −0.009*** | −0.009*** |
| | (0.001) | (0.001) | (0.001) | (0.0004) |
| Tract FE | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES |
| Observations | 1,305 | 2,696 | 4,622 | 7,644 |
| $R^2$ | 0.683 | 0.553 | 0.538 | 0.550 |
| Adjusted $R^2$ | 0.675 | 0.544 | 0.531 | 0.543 |

b (2016-2023)

| | *Dependent variable: log(Sale Price Per Sqr. ft)* | | | |
|---|---|---|---|---|
| Control Boundary: | (1 km) | (3 km) | (5 km) | (10 km) |
| DTC*Time Period | −0.117** | 0.035 | 0.117*** | 0.157*** |
| | (0.047) | (0.037) | (0.029) | (0.026) |
| DTC | 0.282*** | 0.190*** | 0.102*** | 0.074*** |
| | (0.046) | (0.038) | (0.031) | (0.028) |
| Time Period | 3.450*** | 2.160*** | 1.715*** | 1.434*** |
| | (0.299) | (0.101) | (0.059) | (0.038) |
| Age | −0.011*** | −0.008*** | −0.005*** | −0.006*** |
| | (0.001) | (0.0004) | (0.0002) | (0.0002) |
| Tract FE | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES |
| Observations | 3,933 | 8,990 | 15,557 | 25,065 |
| $R^2$ | 0.610 | 0.543 | 0.550 | 0.633 |
| Adjusted $R^2$ | 0.606 | 0.540 | 0.548 | 0.631 |

*Note: This table uses fixed effects ordinary least squares to estimate the effect of upzoning (DTC) on logged housing prices in Davidson County. Each column represents a different geographic control area (as depicted in Figure 3). TThe variable of interest, capturing the impact of the DTC upzoning, is DTC*Time Period.* $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

Table A.19: Ln(Sale Price) Fixed Effects Difference-in-Differences with Matched Control Groups

a (2010-2015)

| | *Dependent variable: log(Sale Price)* | | |
|---|---|---|---|
| Matching Method: | (PSM) | (GBM) | (RFM) |
| DTC*Time Period | 0.251*** | 0.358*** | 0.377*** |
| | (0.062) | (0.047) | (0.050) |
| DTC | −0.139* | −0.091 | −0.068 |
| | (0.073) | (0.068) | (0.057) |
| Time Period | −0.201* | −0.005 | −0.017 |
| | (0.112) | (0.080) | (0.097) |
| Finished Area | 0.0001*** | 0.00002*** | 0.00002*** |
| | (0.00001) | (0.00000) | (0.00000) |
| Age | −0.007*** | −0.006*** | −0.007*** |
| | (0.002) | (0.001) | (0.001) |
| Tract FE | YES | YES | YES |
| Year FE | YES | YES | YES |
| Observations | 4,361 | 5,324 | 4,911 |
| $R^2$ | 0.423 | 0.312 | 0.334 |
| Adjusted $R^2$ | 0.404 | 0.307 | 0.325 |

b (2016-2023)

| | *Dependent variable: log(Sale Price)* | | |
|---|---|---|---|
| Matching Method: | (PSM) | (GBM) | (RFM) |
| DTC*Time Period | 0.186*** | 0.243*** | 0.159*** |
| | (0.047) | (0.038) | (0.039) |
| DTC | −0.032 | 0.030 | 0.032 |
| | (0.052) | (0.047) | (0.042) |
| Time Period | 1.878*** | 1.180*** | 1.210*** |
| | (0.078) | (0.062) | (0.064) |
| Finished Area | 0.0003*** | 0.0001*** | 0.00001*** |
| | (0.00001) | (0.00000) | (0.00000) |
| Age | −0.003*** | −0.005*** | −0.005*** |
| | (0.001) | (0.0004) | (0.0004) |
| Tract FE | YES | YES | YES |
| Year FE | YES | YES | YES |
| Observations | 11,277 | 11,066 | 11,079 |
| $R^2$ | 0.486 | 0.496 | 0.519 |
| Adjusted $R^2$ | 0.479 | 0.494 | 0.515 |

*Note: This table uses fixed effects ordinary least squares to estimate the effect of upzoning (DTC) on logged housing prices in Davidson County. Each column denotes the matching methodology used to produce matched control groups. The variable of interest, capturing the impact of the DTC upzoning, is DTC*Time Period.* $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

Table A.20: Ln(Sale Price / $ft^2$) Fixed Effects Difference-in-Differences with Matched Control Groups

a (2010-2015)

| | *Dependent variable: log(Sale Price Per Sqr. ft)* | | |
|---|---|---|---|
| Matching Method: | (PSM) | (GBM) | (RFM) |
| DTC*Time Period | 0.168*** | 0.354*** | 0.338*** |
| | (0.060) | (0.040) | (0.045) |
| DTC | −0.176** | −0.085 | −0.029 |
| | (0.071) | (0.059) | (0.051) |
| Time Period | −0.192* | −0.070 | −0.072 |
| | (0.108) | (0.070) | (0.087) |
| Age | 0.005*** | −0.006*** | −0.009*** |
| | (0.002) | (0.0005) | (0.001) |
| Tract FE | YES | YES | YES |
| Year FE | YES | YES | YES |
| Observations | 4,361 | 5,324 | 4,911 |
| $R^2$ | 0.479 | 0.501 | 0.512 |
| Adjusted $R^2$ | 0.463 | 0.497 | 0.506 |

b (2016-2023)

| | *Dependent variable: log(Sale Price Per Sqr. ft)* | | |
|---|---|---|---|
| Matching Method: | (PSM) | (GBM) | (RFM) |
| DTC*Time Period | 0.042 | 0.161*** | 0.137*** |
| | (0.047) | (0.033) | (0.034) |
| DTC | 0.016 | 0.067* | 0.079** |
| | (0.053) | (0.041) | (0.037) |
| TimeBin | 1.965*** | 1.249*** | 1.220*** |
| | (0.079) | (0.054) | (0.057) |
| Age | 0.004*** | −0.004*** | −0.003*** |
| | (0.001) | (0.0003) | (0.0003) |
| Tract FE | YES | YES | YES |
| Year FE | YES | YES | YES |
| Observations | 11,277 | 11,066 | 11,079 |
| $R^2$ | 0.547 | 0.659 | 0.654 |
| Adjusted $R^2$ | 0.541 | 0.658 | 0.651 |

*Note: This table uses fixed effects ordinary least squares to estimate the effect of upzoning (DTC) on logged housing prices in Davidson County. Each column denotes the matching methodology used to produce matched control groups. The variable of interest, capturing the impact of the DTC upzoning, is DTC*Time Period.* *$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.*

Table A.21: Summary of Recent Research on Upzoning and Housing Price

| Years examined | Scale/Intensity | Effects | Study |
|---|---|---|---|
| **2010-20** | Block–level upzoning, São Paulo, Brazil. Average increase of 36% floor-to-area (FAR) ratio on blocks in city. | Translated into 1.9% increase in citywide housing stock. 0.5% reduction in citywide prices in resulting equilibrium model. | Anagol et al. (2021) |
| **1995-2007** | Upzoning overlay, Phoenix, Arizona. Ordinance allowed transit–oriented, mixed uses in areas near stations. | Overlay increases condo costs in mixed–use neighborhoods by 37%. In residential neighborhoods, single–family homes, condos lost value by 11–12%; single–family homes in mixed–use neighborhoods had no change. | Atkinson-Palombo (2010) |
| **1995–2020** | Numerous neighborhood–level upzonings in the Canton of Zurich, Switzerland. | Upzoning of 20% or more is associated with a 9.6–15.5% increase in supply, No significant differences in rents in upzoned versus other areas. | Büchler and Lutz (2021) |
| **1995-2020** | Examination of incrementally implemented floor-to-area ratio (FAR) increases in Zurich, Switzerland | Found no effect on rent prices, while demonstrating supply induction of approximately 9%, potentially decreasing equilibrium prices. | Büchler and Lutz (2024) |

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| Years examined | Scale/Intensity | Effects | Study |
|---|---|---|---|
| **2012-17** | Adding ADUs to single-family homes, Vancouver, Canada. | Find that ADUs negatively effect neighboring properties. This negative spillover is strongest for higher-valued properties and non-existent for median and lower-valued homes. | Davidoff et al. (2022) |
| **2011-16** | Upzoning throughout much of inner–suburban land in Auckland, New Zealand. Eliminated single–family zoning, increased overall development capacity by 300%. | Results indicate that the SHAs caused an average price increase of approximately 5% and did not contribute to increases in the likelihood of affordable transactions. | Fernandez et al. (2021) |
| **2010–15, 2013-18** | Multi-family homes, Chicago, Illinois. Building heights increases, parking requirement decrease on 6 percent of city land area. | Density upzoning led to 15–23.3% increase in transaction values compared to non–upzoned parcels. | Freemark (2020) |
| **2005–19** | Zoning map change, San Jose, California. Urban villages allowed different zoning frameworks to be applied to certain areas. | Finds no significant treatment effects on permits, transactions, and assessed values. | Gabbe et al. (2021) |
| **1999–2019** | ADU ordinance, citywide in Ogden, Utah in most but not all single–family neighborhoods. | No impact of allowing ADUs on property values in areas effected by change versus other neighborhoods. | Gnagey et al. (2023) |

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(Continued)

| Years examined | Scale/Intensity | Effects | Study |
|---|---|---|---|
| **2010–17** | Upzoning throughout much of inner–suburban land in Auckland, New Zealand. Eliminated single–family zoning, increased overall development capacity by 300%. | Increases property value of upzoned parcels by 1.5–4.2% depending on the model and area. Underdeveloped properties see larger price appreciation than already–developed properties, which decrease in value. | Greenaway-McGrevy et al. (2021) |
| **2017-2019** | Single-family homes, Minneapolis, Minnesota. Allows for up to three times the housing unit density. | Plan change associated with a 3–5 percent increase in price of properties. Price increases larger in inexpensive neighborhoods and underdeveloped properties. | Kuhlmann (2021) |
| **2017-21** | Adding ADUs to single-family homes, Los Angeles, California. | Find heterogeneous effects across zip codes, with price increases concentrated in areas with lower property values (in the range of 2 to 4%) and price decreases concentrated in areas with higher property (approximately -2%). | Liu et al. (2024) |
| **1996–2016** | State-level rezoning, Brisbane, Australia. Zoned capacity doubled over the 20–year study period. | Additional housing supply is associated with higher prices of about 2%. | Murray and Limb (2023) |

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| **Years examined** | **Scale/Intensity** | **Effects** | **Study** |
|---|---|---|---|
| **2011-16** | Upzoning throughout much of inner–suburban land in Auckland, New Zealand. Eliminated single–family zoning, increased overall development capacity by 300%. | The results show that the SHAs program failed to reduce housing prices across the distribution; and, even in some cases, prices increased. For new dwellings, the program decreased prices at the lower end of the distribution while increasing them at the upper end. | Ortiz-Villavicencio et al. (2024) |
| **2008-17** | 180 upzoning and downzoning policies implemented in a sample of more than 1,000 municipalities in eight U.S. metropolitan regions. | Reforms loosening restrictions associated with a significant, 0.8% increase in citywide housing supply at least 3 years post–reform; found no statistically significant evidence that additional lower-cost units became available or moderated in cost in the years following reforms. | Stacy et al. (2023) |

*Source: Adapted from Freemark (2023)'s review of the literature.*