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, upzoned parcel prices increased by 11%-38% more than untreated parcels.
- Results further imply heterogeneous effects across market segments.
- Low-end upzoned parcels increased in price, while high-end parcel prices decreased.

Upzoning and Residential Transaction Price in Nashville

Nicholas Forster-Benson[a], Karim Nchare[a]

[a]*Department of Economics, Vanderbilt University, Calhoun Hall, 2201 West End Ave, Nashville, 37240, Tennessee, United States*

Abstract

The impact of upzoning policies on housing affordability remains controversial, as targeted investment, migration, and amenity patterns lead to 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 suggest that house price declines 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 results highlight the importance of heterogeneity in the design and evaluation of upzoning policies.

Keywords: Upzoning, Housing Prices, Natural Experiment

1. Introduction

To date, empirical research on the relationship between changing zoning regimes, levels of housing production and prices has produced mixed results. Coming from an era in which zoning regimes in the United States functioned as a form of both economic and racial discrimination (Maantay, 2002; Rothwell and Massey, 2009; Shertzer et al., 2016; Whittemore, 2017, 2021), much of the early economic analysis of zoning policies tended to focus on the relation between strict zoning regimes and increased housing prices (Glaeser et al., 2005; Quigley and Raphael, 2005; Ihlanfeldt, 2007; Zabel and Dalton, 2011; Gyourko and Molloy, 2015). More recently, however, there has been an increasing focus on upzoning in relation to emerging patterns of urban growth and displacement (Angotti and Morse, 2016; Rodríguez-Pose and Storper, 2020; Lowe and Richards, 2022).

Freemark (2023)'s in-depth literature review highlights the lack of consensus on the relationship between upzoning and housing affordability, importantly drawing attention to the diversity of policy outcomes depending on different spatial, temporal, and regulatory contexts. The potentially path dependent causal chain between long-term house prices and changes in zoning regimes (including potential and varying effects on housing supply in different market segments, neighborhood investments, amenity effects, and migration flows) makes it challenging to isolate a causal determination regarding the promotion of successful zoning policy. In particular, it can be difficult, if not impossible, to disentangle the relationship between up-zoning and the development of amenity structures (such as proximity to employment and leisure activities, as well as *'sense of place'* which can be endogenous to urban density) that drive both urban growth and the demand for housing (Clark et al., 2002). Nevertheless, recent empirical efforts in a variety of geographical and political configurations have exploited heterogeneity within various zoning policies to assess the impact of zoning changes on both housing construction (supply) and housing prices.

Table 1 summarizes the literature on upzoning policies. Studies that examine 1-4 years after upzonings find increases in house prices, in the case of both single-family (in Minneapolis, Kuhlmann (2021) and Auckland, Fernandez et al. (2021)) and multi-family (in Chicago, Freemark (2020)) upzonings. Initial price increases are believed to result from investments driven by the anticipated rise in potential utility per unit of land. Studies examining the effect of adding accessory dwelling units (ADUs) to single-family zoning in the context of Los Angeles Liu et al. (2024) and Vancouver Davidoff et al. (2022) find heterogeneous effects. In general, house price increases due to ADUs were associated with low-value areas where investment effects could be observed, while price decreases were associated with high-value areas

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)
10-13 years	A majority of 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 scholarship. Detailed table located in the appendix.

where a combination of supply effects and negative amenity effects (such as increased traffic or negative aesthetics) may have occurred.

Studies of which examine 5-9 years after the upzonings have produced a variety of results. Findings include property values decreases (São Paulo, Anagol et al. (2021)), increases (Phoenix, Atkinson-Palombo (2010)), and no effect (San Jose, Gabbe et al. (2021)). Mixed results may reflect variance in the market segment distribution of additional housing supply that may result from upzonings. Over a longer period, the structure of both housing supply and demand may be path dependent on varied forms of investment and migration, potentially leading to the variety of observed policy outcomes.

To date, the longest studies on the effects of upzoning have examined 10-13 years after implementation. Research at both neighborhood level (Zurich, Büchler and Lutz (2021)) and state level (Brisbane, Murray and Limb (2023)) have found higher prices as the result of upzoning. However, Büchler and Lutz (2024)'s recent examination floor-to-area ratio (FAR) increases in Zurich Switzerland found no effect on rent prices, while demonstrating supply induction, potentially decreasing equilibrium prices. Similarly, Anagol et al. (2021)'s paper on block level floor-to-area (FAR) increases in São Paulo utilized an equilibrial model to estimate a potential decrease in equilibrium housing price by 0.5% due to upzoning. Only one paper has examined zoning in relation to prices over this time horizon in North America. Gnagey et al. (2023)'s 20 year repeated cross-sectional analysis of ADUs in Ogden, Utah found no effect on property values. Our paper extends this literature by providing the first empirical study of the effect of upzoning on house prices in the Southern United States and for the longest time period. We examine the effect of Nashville's transformative 2010 downtown upzoning on housing parcel transaction prices using repeated cross-sectional data from Davidson County between 2000 and 2023. In the absence of rental data, we use residential transaction prices as a proxy for housing prices and affordability, similar to Freemark (2020).

Our analysis attempts to capture price variation among upzoned multifamily units in which density and height limits were increased and 'by-type' zoning was suspended as a result of BL2009-586. Our quasi-experimental design utilizes both geographic control groups and synthetic control groups. Geographic control groups utilize proximity to treatment for control section, while our synthetic controls are created using Propensity Score Matching (PSM), Generalized Boosted Matching (GBM), and Random Forest Matching (RFM). The utilization of matching methods greatly improves covariate balance between our treatment and control groups. To estimate price effects of BL2009-586, we combine a hedonic price model with a difference-in-differences approach. First we average treatment effect (ATE) through a standard DiD approach. Next, to account for housing market price segmentation, we apply quantile difference-in-differences to estimate the quantile treatment effects (QTE).

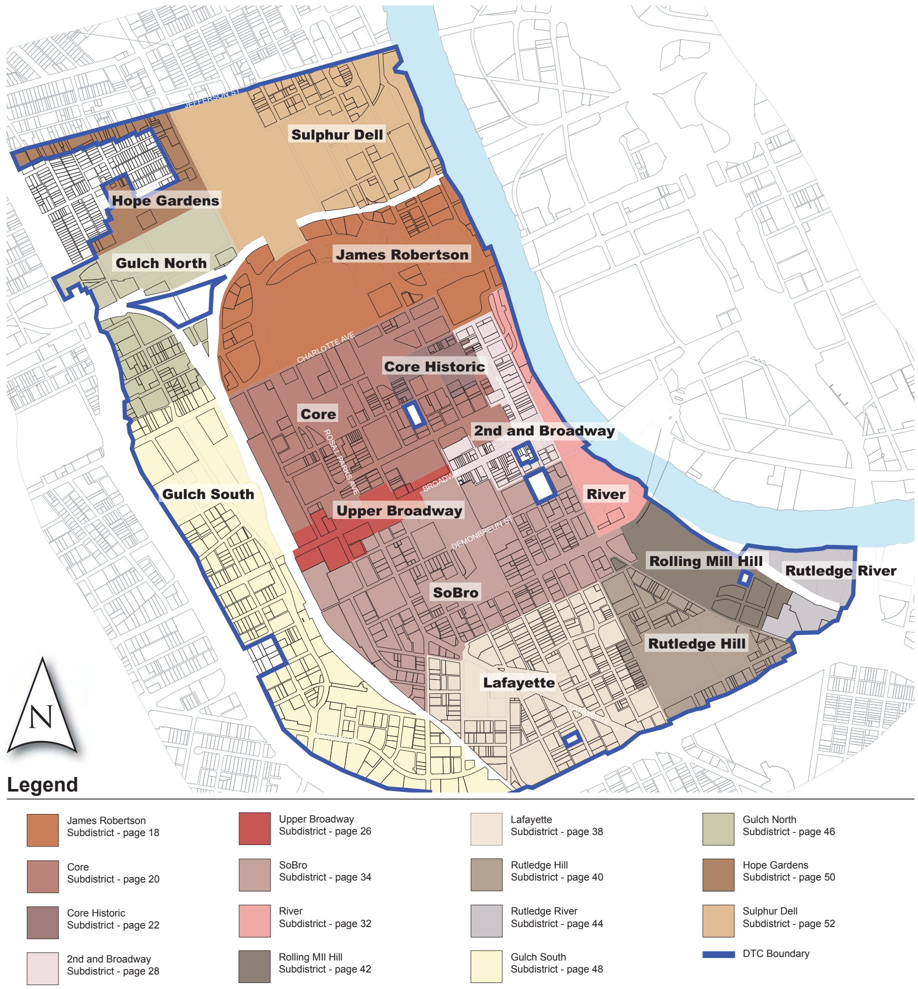
Our results yield two primary findings. Firstly, we present evidence of increased prices among upzoned parcels, as compared to the most similar control parcels in Davidson County. These results are robust to changes in sample size and protracted DiD analysis. Secondly, we present evidence for heterogeneous treatment effects among quantiles of the housing price distribution. In particular, we observe increased prices for low-end housing in conjunction with decreasing prices on the high-end of the market. Our findings are consistent with the growing supply of luxury apartments within the treatment zone, potentially contributing towards supply side effects for high-end parcels while simultaneously exerting positive amenity effects on low-end parcels.

These results have important implications for urban practitioners with relation to land use and housing affordability. We provide evidence for the potential limitations of density upzoning as a tool to increase affordability within upzoned districts. This finding is particularly import in relation to large price increases among low-price market segments, which demonstrates the potentially regressive price effects in the DTC. These heterogeneous treatment effects, including price decreases for high-end sales, necessarily draws attention to the need for further recognition of the segmented nature of both housing supply and demand in economics's housing literature. Throughout this paper, we continue to draw attention to the path-dependent nature of upzoning policies, acknowledging the constellation of factors, including zoning regimes, migration patterns, mortgage rates, and amenities structures which contribute to specific forms of housing production and consumption in a given place at a given time. The remainder of the paper is organized as follows: Section 2 discusses the background of the DTC policy in Nashville, Section 3 presents our data and empirical strategies, Section 5 provides our empirical results and Section 6 concludes.

2. Background

Over the past twenty 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). As recently as the 1990s, however, downtown Nashville was facing 40 years of decline, lacking a centralized business core or residential areas (Lloyd and Christens, 2012). Fuelling 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 Downtown Code Zoning District (DTC), shown in Figure 1. Though the implementation of DTC zoning varied slightly due to historic overlays and aesthetic subdistricts, the policy had three major implications: elimination of 'by-type' zoning (allowing mixed-use development), removal of building height

Figure 1: Downtown Code Zoning District and Subdistrict Boundaries



Notes: This map is sourced from City of Nashville (2011), an attachment to Ordinance No. BL2009-586 as adopted on February 02, 2010.

limitations, and removal of minimum parking requirements.[1] Since February 2010, when BL2009-586 was passed, the DTC has been amended fifteen times, primarily

[1] While mixed use zoning and the elimination of parking requirements are universal throughout the DTC, height and residential density limits do vary among sub-districts. 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).

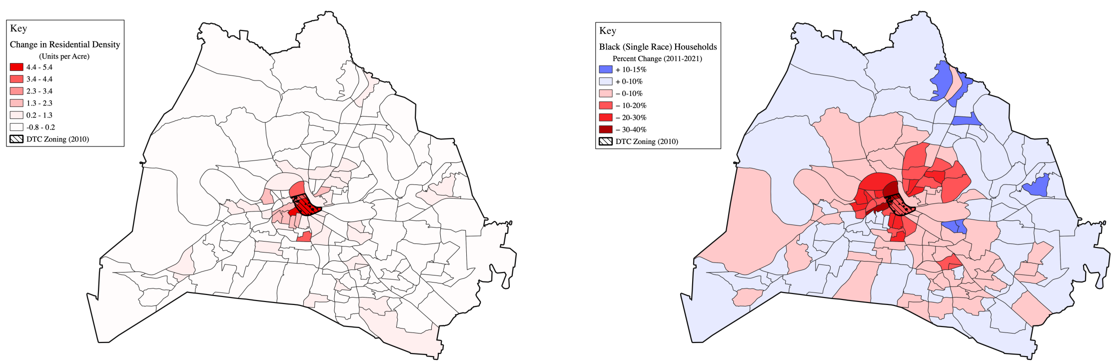
with slight modifications to ensure that the land can be utilized to its maximum capacity. These amendments have meant that since 2010 there has not been a single 'on-spot' zoning within the DTC, implying that DTC has been flexible enough to not require individual deviations, making the downtown a central node for investment and economic development.

Since 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 Broadway corridor has solidified its reputation as a national destination for live music and nightlife, while areas like the Gulch and SoBro (previously industrial parking lots and never before areas of downtown living) have become hotspots for upscale living and dining for Nashville's affluent. 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.

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

US Census data on residential density (Figure 2a) reflects this relatively rapid intensification of urban residential density in Nashville's core. The recent infill of luxury apartments and even entirely new neighborhoods, such as the Gulch 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 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.

To assess the impact of DTC zoning on housing prices, our analysis used records of residential transaction prices from 2000-2023, obtained from Davidson County Planning.[3] Transaction price data is complemented by additional property-level covariates such as parcel area and unit size. We also rely on time-dependent tract-level demographic data from the US Census.

3. Data and Control Selection

3.1. Data

The focus of our empirical analysis is to estimate the effect of the 2010 implementation of DTC upzoning on housing prices. To achieve this, we use data on residential parcel transactions in Davidson county between 2000 and 2023 from the Metropoli-

[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]For the average treatment effect (ATE) estimates, we drop observations with zero price and prices above 2.5 million. However, all observations are utilized for quantile treatment effect (QTE) estimates, as quantile regression is able to provide accurate estimates utilizing the entirety of the price distribution.

tan Planning Commission. Parcel transaction data includes sale price, sale date, square footage, address (census tract/neighborhood), and building age. To derive additional housing demand covariates used for matching, we rely on both demographic data (percent White and percent with BA or higher) sourced from U.S. Census Bureau (2010a) and building permit frequency data from Davidson county as a proxy for prior neighborhood investment.[4] Balance tables with housing demand characteristics can be found in Tables A.9 – A.16 of the appendix.

Given that the prior residential zoning of the DTC consisted of primarily lower density multi-family housing, we seek to capture housing price variation caused by increased density limits on multi-family housing and the removal of 'by-type' zoning.[5] In addition, our analysis excludes approximately 800 parcels that underwent spot zoning changes during the same period.[6] In an attempt to estimate the treatment effect of the policy, our analysis attempts to capture the effects of increased land utility, in the form of residential density increases, removal of height regulations and removal of by-type zoning.

3.2. Geographic Control Selection

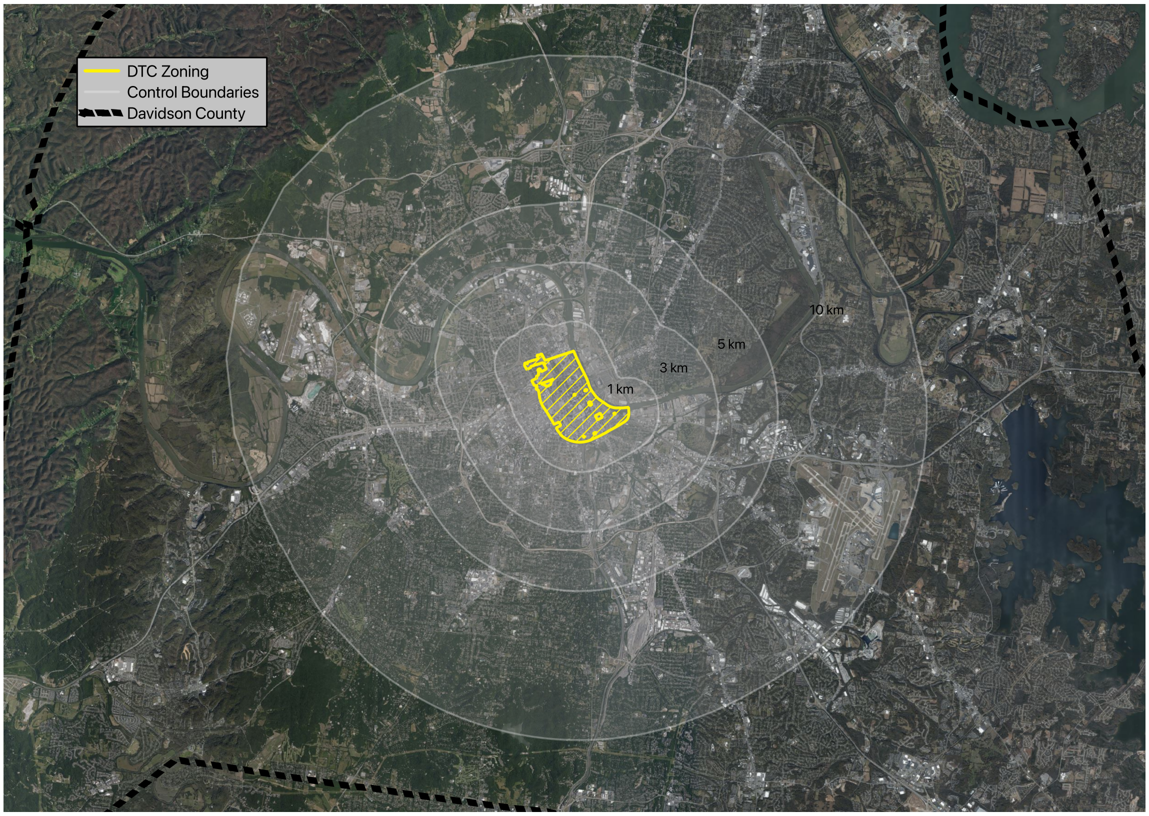
To capture potential variation in house prices, our initial analysis compares the DTC (treatment area) with different geographically defined control areas: 1 km, 3 km, 5 km, and 10 km (see Figure 3). The control areas are broadly representative of Nashville's semi-periphery, both because of their separation 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 of 3km and less (areas generally within Nashville's Interstate 440 loop) are traditionally defined by single-family housing and racial segregation. Many of the historically black neighborhoods lie directly east and north of the core, while the west and south are

[4]We aggregate building permit data by census tract, giving each census tract a point value based on the number of building permits awarded by Davidson county Planning in the pre-treatment period (2000-2009). This acts as a pre-treatment investment proxy, providing information on the number of buildings being built in each census tract in the pre-treatment period.

[5]Due to the lack of single-family housing in the core prior to the policy intervention, the common trend assumption does not hold when comparing the core to single-family housing.

[6]There remains large heterogeneity in the type and form of on-spot zoning changes that occurred in Nashville between 2000 and 2023. Due to the imprecision with which these zonings were recorded, it can be difficult to determine which zoning changes are upzonings or downzonings. Furthermore, the sequential nature of their implementation leads us to exclude all on-spot zonings from our analysis.

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



Notes: Satellite image comparing the Downtown Code Zoning district (in yellow) with various control boundaries in gray. Zoning shapefiles provided by Davidson County planning. Map produced by author using QGIS.

predominantly majority white neighborhoods. The spurious and temporally dependent nature of Nashville's residential segregation pose a challenge to inner geographic controls, which is why they are supplemented by larger (5 km and 10 km) control boundaries, representing a larger sample of Nashville residential housing stock.

Counter-intuitive to intuition, covariate balance (as seen in Tables A.9, A.10, A.11, and A.12) between the core and control groups gradually improves as boundaries grow larger (distance from the DTC increases). An additional limitation of our geographic control boundaries is the potential of capturing spill-over effects from both investments and amenities associated with densification. Due to the lack of historical housing stock in the downtown as compared to Nashville's adjacent neighborhoods in the 1 km, 2 km, and 3km boundaries, investments induced by the concentration of employment and housing downtown may have spilled over into nearby areas with already established housing stock. Particularly, due to adjacent neighborhoods potentially complementary nature, proximate location, and long histories of residential urban environments they may have received investments and amenity benefits caused by their proximity to the DTC, despite their location outside of the treatment zone. Positive spillover effects, particularly in close-by control boundaries may result in an under-estimation of the policy's true effect on housing prices within the core. Alternatively, negative investment spillovers due to a potential concentration of investments in the core, as opposed to comparable percales in the control, could result in an over-estimation of treatment effects.

3.3. Synthetic Control Selection with Matching Methods

To address issues of spatial heterogeneity and spillover effects, we use covariate matching methods to formulate synthetic control groups. This allows us to create a control group that is similar to the treatment group based on physical and social characteristics of the parcels. This approach is has been used before in the empirical literature on zoning regimes (Büchler and Lutz, 2021; Dong, 2024) and housing more generally (Thomschke, 2016; Peklak, 2020; D'Lima et al., 2023). Using R's "Matchit" package (Stuart et al., 2011) through Olmos and Govindasamy (2019)'s methodological approach, we attempt to achieve covariate balance between the control and treatment for five key variables: property age, square footage, racial composition (percentage of white residents in a parcel's census tract), educational attainment (percentage of college educated residents 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 techniques: Propensity Score Matching, Generalized Boosted Matching, and Random Forest Matching. Covariate balance is greatly improved, with the most similar control sample provided by Propensity Score Matching which reduces sample and treatment differences under a standard deviation within every covoriate. 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.

3.4. Pre-Treatment Trends

Our DiD estimation relies on the common trend assumption, that in the absence of the DTC policy prices of control parcels would follow a similar trend to those of treatment parcels. While this counterfactual remains unobservable, we attempt to assess its potential validity using parallel trends in pre-treatment prices through four

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

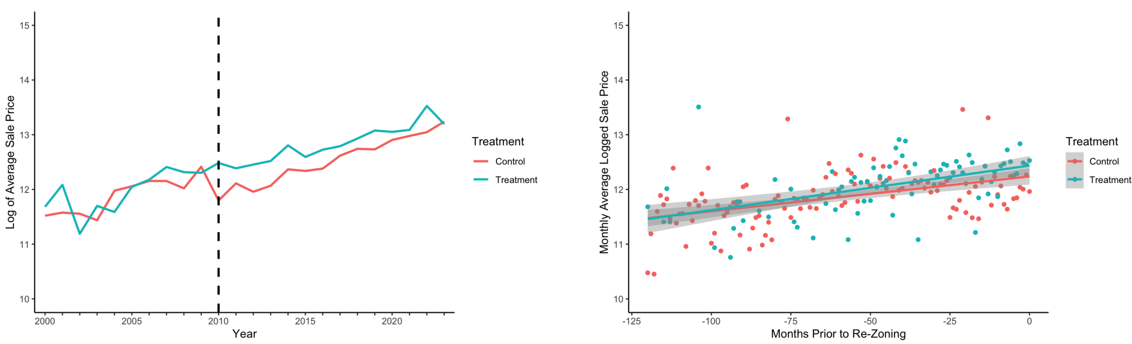
Group	Pre-Treatment	Post-Treatment	% Increase
Treatment (DTC)	233,529	593,536	154%
1 km Control	202,242	539,621	167%
3 km Control	215,191	523,991	143%
5 km Control	207,624	512,616	147%
10 km Control	192,719	495,268	157%
All Davidson County	188,527	394,055	109%
Propensity Score Control	282,522	499,498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

Notes: Before and after represent whether the parcel was transacted before or after treatment time (February of 2010). 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.

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

(a) Log of Sale Price (2000-2023)

(b) Log of Sale Price (2000-2010)



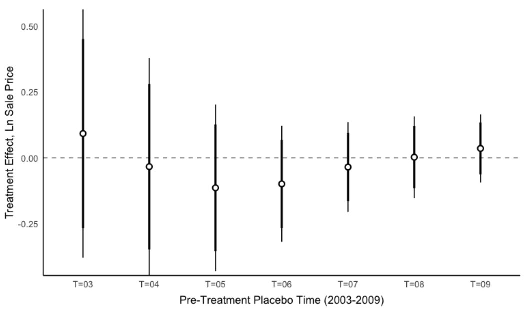
Notes: Left, average yearly ln sale prices, by treatment status. Red represents PSM control group, and blue represents DTC zoning. Dotted line denotes time of treatment. Right, depicts ln sale price averages by month in the pre-treatment period, by treatment. OLS regression lines are fitted, with 95%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

primary methods: a visual inspection of annual transaction prices, a comparison of pre-treatment trends on a monthly basis, a pre-treatment placebo regression analysis, and event studies.

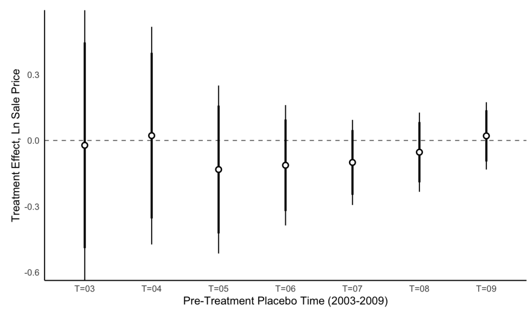
Figure 4a provides a basic visual comparison of the trend changes in the annual average prices of the control and treatment parcels. For the propensity score matched control, the trends are broadly similar with minimal deviation pre-treatment years. Year and treatment graphs for all other control group trends can be found in Figures A.6 and A.7 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.[7] 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 demonstrates the similarity of trends between upzoned and control parcels in the pre-treatment period.

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

(a) 3 km Control Group



(b) PSM Control Group



Note: *Plain lines represent 99% confidence interval, and Bold lines signify 95% confidence intervals. Pre-treatment placebo T values represent theoretical treatment times, meaning that all data after treatment is considered treated. Estimates on in event study (Figure A.9 and A.10) only count each particular year as treated, leading to larger variation in estimates.*

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.[8] 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 indicators regardless of year chosen. Following a similar logic, our TWFE sequential treatment event studies provide intuitions into potential violation of pretreatment trends. By using each individual year as a placebo treatment, these provide us with a more granular sense of the pre-treatment trends, but at the cost of higher variation in our estimates. Event studies are presented in Figure A.9 and A.10. These results generally demonstrate minimal variation from pre-treatment trends, leading us to verify the common trends assump-

[7] Pre-treatment trends for the 3 km geographic control group can be found in Figure A.8 of the appendix.

[8] Pre-treatment trends for the 3 km geographic control group can be found in Figure A.8 of the appendix.

tion. Taken together, our visual inspection of annual transaction prices, comparison of pre-treatment trends on a monthly basis, a pre-treatment placebo regression analysis, and event studies support 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 differences-in-differences analysis that is commonly used in the empirical literature (Freemark, 2020; Kuhlmann, 2021; Gnagey et al., 2023). Our two outcome variables are sale prices and sale prices per square foot. We combine available parcel characteristics data with neighborhood level fixed effects (FE) to limit omitted variable bias.[9] The FE DiD model attempts estimate the ATE of the upzoning while addressing omitted variable bias over time as well as heterogeneity in housing stock across space though the following equation:

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

where K_{pnt} measures the sale price of a residential parcel p in n neighborhood (census tract) and year t. A_t is a dummy variable indicating whether the transaction took place before or after the zoning change, and U_p is a dummy variable indicating whether the transaction took place in the DTC (treatment area). X_p represents property level covariates (unit size ft^2, age). In addition to these covariates, η_n is a fixed effect variable for neighborhood effects (as represented by the census tract of the parcels) and τ_t is a fixed effect variable for time (the year of the transaction). β_3 is the main parameter of interest and captures the average effect of the DTC policy. We additionally estimate price per square foot, providing additional information on relative cost per area.[10] However, these estimates obscure information regarding entry cost and overall affordability which are provided by the basic hedonic model.

[9] Applying the Hausman specification test confirms the superior performance of fixed effects models over random effects which is consistent with the existing empirical literature on the topic.

[10] Estimates for sale price per square foot rely upon a manipulation of the hedonic model, moving unit size (ft^2) to the left hand side, making the response variable $\ln(K_{pnt}/Sqr.ft_p)$, and removing $Sqr.ft_p$ from the property level covariates X_p.

4.2. Quantile Difference-in-Differences

To account for heterogeneous price responses to the DTC policy, we estimate quantile treatment effects of upzoning using quantile difference-in-differences (QDiD), results presented in Section 5.2. Examining treatment effects beyond the mean is particularly useful for identifying potentially 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). Similar to Ortiz-Villavicencio et al. (2024), we estimate QDiD using a quantile version of Equation 1. By weighting observations relative to their proximity to value τ in the housing price distribution, QDiD allows us to estimate treatment effects among different cost segments. Our QDiD specification is used to estimate treatment effects among first quartile ($\tau = .25$), median ($\tau = .5$) and third quartile ($\tau = .25$) parcel transactions. Respectively, these estimations provide different weights to low, medium, and high market value transactions, providing insights into treatment effects among different housing market segments. Another approach to estimating QDiD is the Change in Changes (CIC) method of Athey and Imbens (2006). However, CIC relies on strong distributional assumptions that are unlikely to hold for our limited sample sizes.

5. Findings

5.1. Average Treatment Effects

Tables 3a and 3b provide estimates for the average treatment effect (ATE) using the four control areas (1 km, 3 km, 5 km, and 10 km) on both price and price per square foot. Starting with the comparison of sales prices of upzoned parcels and the 1 km control group, our estimates for the effect of upzoning (the interaction term) suggest a small negative effect, which is significant in the case of price per square foot. However, these results are not robust to changes in distance from the core, as neither the 3 km nor the 5 km controls yield negative estimates. Interestingly, for sale price, comparing treated parcels to a 10 km diameter control group leads to positive and significant estimates of the treatment effect. These results suggest that, on average, upzoned parcels became more expensive as compared to parcels that were farther away from the core and perhaps more isolated from the potential spillover effects of densification.

The observed difference in ATE estimates may be related to the distribution of market segments present in each of the control groups (consistent with the descriptive statistics across control groups presented in Table 2). We observe that when the

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, representing the effect of the policy, is DTC*Time Period. *p<0.1; **p<0.05; ***p<0.01.*

treatment is compared to areas of the city closer to the core (and closer to the urban amenities that drive up house prices), the effect appears to be negative. This contrasts with the 10 km control, which includes a greater variety of housing, particularly housing without amenities, where prices have remained lower over time. Overall, our estimates show different impacts of the DTC policy depending on the control group considered. In the following section, we use covariate matching techniques to assess their robustness.

Tables 4a and 4b present DiD regression results comparing upzoned parcels with our synthetic matched samples. For all three matching methods, the ATE estimates are positive and significant. Average treatment effect estimates range from 11%-38% more expensive (roughly \$55k-\$209k) than the most similar non-treated parcels. These results are robust to changes in sample size for all three matching methods. We believe that our synthetic controls provide strong evidence that, relative to the most similar counterfactual control units, upzoned parcels were more expensive in terms of both parcel price and parcel price per square foot.

ATE results are furthered by our TWFE event studies found in Figure A.9 and A.10. Event studies demonstrate an upward trend in housing prices concentrated most strongly in the five years after policy implementation, with waning increases

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 synthetic control groups. The variable of interest, representing the effect of the policy, is DTC*Time Period. *p<0.1; **p<0.05; ***p<0.01.*

as the years following. To further explore this temporal heterogeneity in ATE estimates, we employ segmented regressions, comparing effects over the 2010-2015 and 2016-2023 periods. These estimates, shown in Tables A.17 through A.20, reveal that the ATE was higher in the first 5 years after implementation (2010-2015) but remained positive and significant in the next 7 years (2016-2023). Price increases, as compared to matched control groups, ranged 18%-46% between (2010-2015) and 4%-28% between (2016-2023). This temporal variation in ATE could represent a leveling off of investment effects, or perhaps the delayed effect of supply induction within the DTC.

5.2. Quantile Treatment Effects

QDiD estimate results shown in Tables 5 and 6 provide strong evidence of a heterogeneous treatment effect across the housing price distribution. Generally, our results demonstrate evidence of increased price prices for first quartile ($\tau = .25$) upzoned parcels in conjunction with price decreases for third quartile ($\tau = .75$) upzoned parcels.

For estimates using both geographic controls and matched controls, we observe that the first quartile treatment effect is primarily positive and significant. While estimates using geographic control groups vary greatly, estimates using matched control groups observe price increases among upzoned first quartile parcels ranging from 2%-28%. This implies that after upzoning, less expensive parcels tended to become more expensive than control parcels. This finding is similar to the results of Freemark (2020) and Kuhlmann (2021), who find that increased land utility has the potential to increase the speculative value of residential parcels, particularly over shorter time periods. Importantly, our results show that over longer periods, 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.

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)
τ=0.25	9.056***	0.896	0.535**	0.655***
	(1.521)	(1.095)	(0.252)	(0.092)
τ=0.50	−0.180**	−0.083	-0.040	-0.092**
	(0.080)	(0.058)	(0.036)	(0.038)
τ=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)
τ=0.25	2.334***	0.634***	0.127	1.22***
	(0.506)	(0.218)	(0.276)	(0.222)
τ=0.50	0.068	0.051	0.032	-0.061
	(0.096)	(0.055)	(0.030)	(0.054)
τ=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. Due to multicollinearity, we are unable to apply neighborhood fixed effects, as in the ATE DiD. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Secondly, we generally observe price decreases for third quartile upzoned parcels as compared to both geographic and matched control groups. For our matched controls, price decreases in range from 4%-25%. This finding is consistent with Anagol et al. (2021), who find potential price reductions as a result of supply induction through upzoning. An on the ground perspective of Nashville's downtown transformation supports the supply induction theory, as a many potentially substitute large luxury apartment buildings have flooded downtown market, potentially leading to a negative effect on the price of high-end housing through supply-side mediation. Furthermore, the concentration of investments could potentially induce an upward pressure on low-value transactions through spillover amenity effects.

Overall, these results are consistent with previous observations regarding the

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)
τ=0.25	0.079***	0.245***	0.134***
	(0.024)	(0.027)	(0.023)
τ=0.50	−0.015	0.009	-0.090***
	(0.028)	(0.036)	(0.034)
τ=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)
τ=0.25	−0.058	0.209***	0.103**
	(0.048)	(0.039)	(0.032)
τ=0.50	−0.229***	0.005	−0.097***
	(0.021)	(0.017)	(0.018)
τ=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. Due to multicollinearity, we are unable to apply neighborhood fixed effects, as in the ATE DiD. *p<0.1; **p<0.05; ***p<0.01

differential distribution of market segmentation across our geographic control groups. As reflected in our descriptive data from Table 2, parcels closer to Nashville's core are more likely to be high value units due to their proximity to urban amenities, while the largest control contains a higher proportion of low amenity housing on Nashville's periphery. Distribution of market segments could be a leading factor in the differences of ATE estimates found among geographic controls in Section 5.1.

6. Discussion and Conclusions

This study examines the effects of Nashville's 2010 downtown upzoning on residential transaction prices between 2000 and 2023. To date, little research has examined the effects of upzoning over long term time horizons. Our estimations yield two key findings with implications for the relationship between upzoning and housing affordability. Firstly we present average treatment effect estimates ranging from 11%-38% more expensive (roughly \$55k-\$209k) than the most similar non-treated parcels, finding sustained price increases more than 10 years after treatment. Secondly, we find evidence of heterogeneous treatment effect by market segment, with price increases for low-end ($\tau = .25$) parcels ranging from 2%-28% and price decreases for high-end ($\tau = .75$) treated parcels ranging from 4%-25%.

Our analysis solely focuses on the effects of increased density and building height limits in combination with the effects of eliminating 'by-type' zoning and does not compare single-family to multifamily as in Kuhlmann (2021). Estimating average treatment effect, we present evidence that multifamily transaction prices increased among upzoned parcels as compared to non-treated parcels over the period 2000-

2023. This finding is in line with Freemark (2020) and Kuhlmann (2021), demonstrating the potentially resilient effects of upzoning-induced investment and associated amenity structures. As revealed through both event studies and segment regression, these effects were not evenly distributed across time, as the ATE was higher (18%-46%) in the first 5 years after implementation (2010-2015) but remained positive and significant (4%-28%) in the next 7 years (2016-2023). This finding is critical for policy makers, as it demonstrates the sustained effect of upzoning on housing prices over a decade beyond policy implementation.

Furthermore, our finding of heterogeneous quantile treatment effect has particular relevance to the distributional welfare effects of downtown upzoning on housing prices in Nashville. Our observation of price decreases among high-end ($\tau = .75$) treated parcels is consistent with Anagol et al. (2021)'s finding of price reduction through supply induction finding. However, the simultaneous price increases for low-end ($\tau = .25$) treated parcels and overall price increases for ATE, our results imply that a potential upward price concentration occurred, increasing the average price while decreasing prices of high end parcels. These findings reflect the rapid development of large luxury apartments recently built in Nashville's core, potentially leading to a negative effect on the price of high-end housing through supply-side mediation, combined with upward pressure on lower-value transactions through amenity effects. For policy makers, may provide insight into the potential trade off among market segment affordability made when upzoning without particular building affordability mandates.

Overall, our focus on both temporal and market segment heterogeneity bring to light the continued necessity for nuanced research on the relation between housing prices and policy. We acknowledge that beyond zoning, there remains a constellation of factors, including migration patterns, financial incentives, speculation, and amenities structures which may be conducive to specific forms of housing production and consumption in a given place at a given time. Such discrepancies are important to take into account, as policy outcomes remain contingent on the contextual and temporal specificity within which zoning regimes are enacted. Specifically, our finding of heterogeneous treatment effects within housing market segments remains of particular interest for future housing research. The potentially segmented nature of not only housing prices, but potential price mechanisms, such as migration induction, investments, densification, and urban amenities presents a juncture for further research. Critically, as upzoning continues to be cited as a mechanism for housing affordability, further research is needed to clarify its contextually embedded relation with housing production and consumption.

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Data Availability: The data and R code used to produce the Tables and Figures in this article can be found here: https://github.com/nfb77/ZoningNashville. Usage directions are available in the README.md file. For any additional questions please reach out to the first author.

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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.
OLS 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.
OLS 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.
OLS 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.
OLS 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.
OLS 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.
OLS 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)

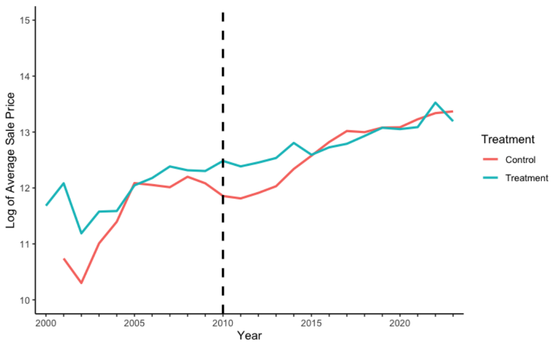
Variable	Treated Mean	Control Mean	Std. Mean Diff.
OLS Distance	0.4885	0.1079	1.7667
Age	9.3239	28.5317	-2.3559
Finished Area	1090.40	1889.97	-0.5702
% White	61.08	69.14	-0.8537
% Bachelors Degree	0.4334	0.4243	0.2311
Building Permits	45.51	40.52	0.2212

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

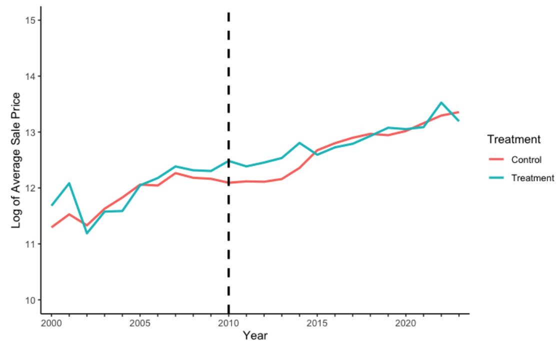
Variable	Treated Mean	Control Mean	Std. Mean Diff.
OLS Distance	0.5477	0.0702	2.8495
Age	9.3239	35.4352	-3.2027
Finished Area	1090.40	1669.00	-0.4126
% White	61.08	69.05	-0.8440
% Bachelors Degree	0.4334	0.2957	3.4973
Building Permits	45.51	7.48	1.6858

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

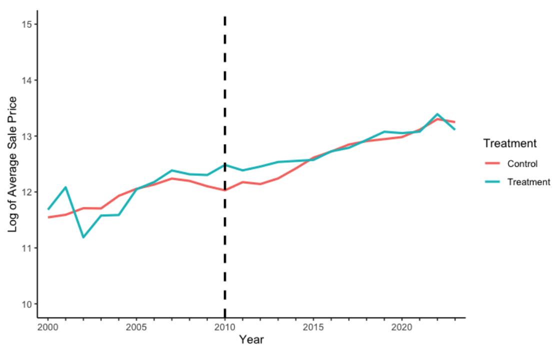
(a) 1km Control



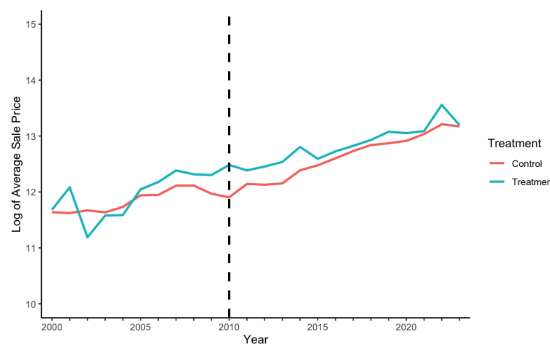
(b) 3km Control



(c) 5km Control



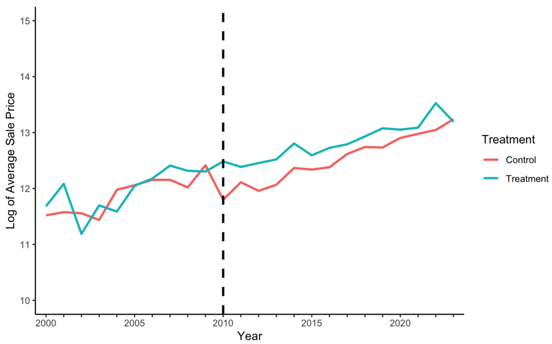
(d) 10km Control



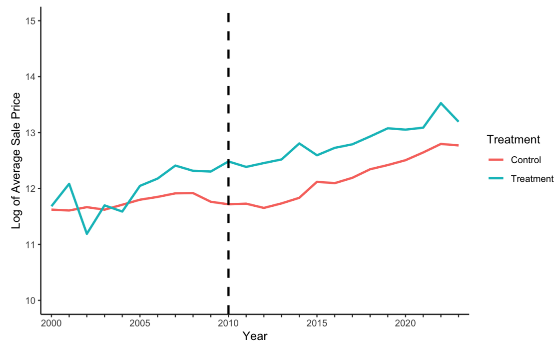
Note: Average sale price by year. Geographic control bands (1km, 3km, and 10k) are compared to the DTC.

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

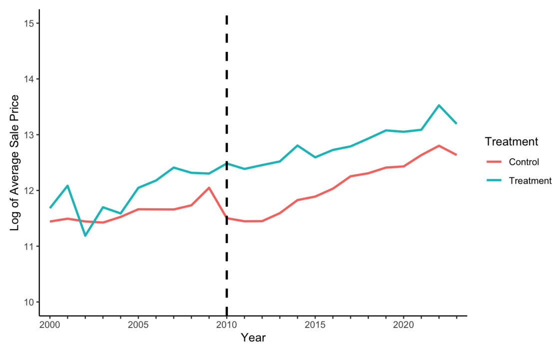
(a) Propensity Score Matching



(b) Generalized Boosted Matching

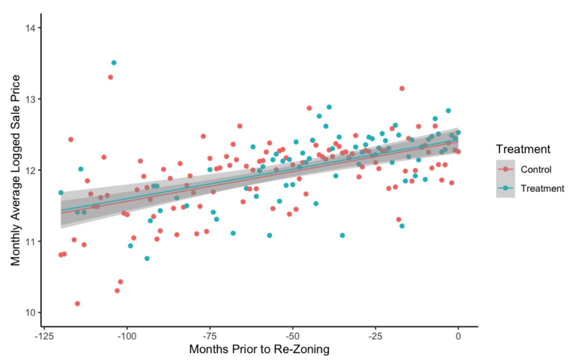


(c) Random Forrest Control



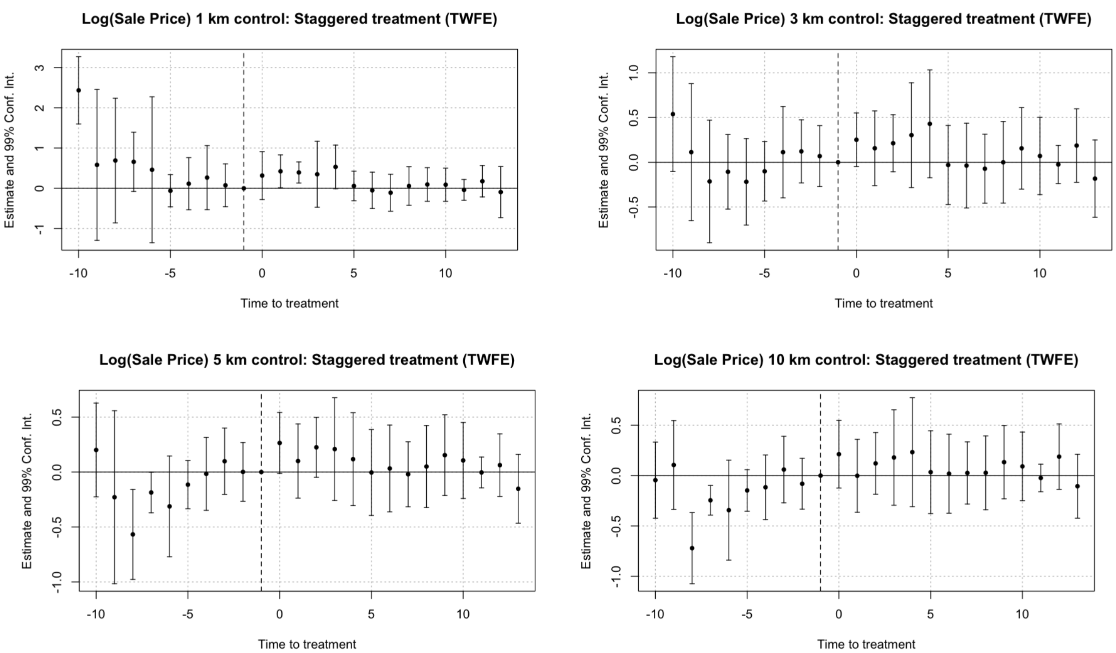
Note: Average sale price by year. Synthetically Matched Control groups are compared to the DTC.

Figure A.8: Pre-treatment Trends by Month (3km Control)



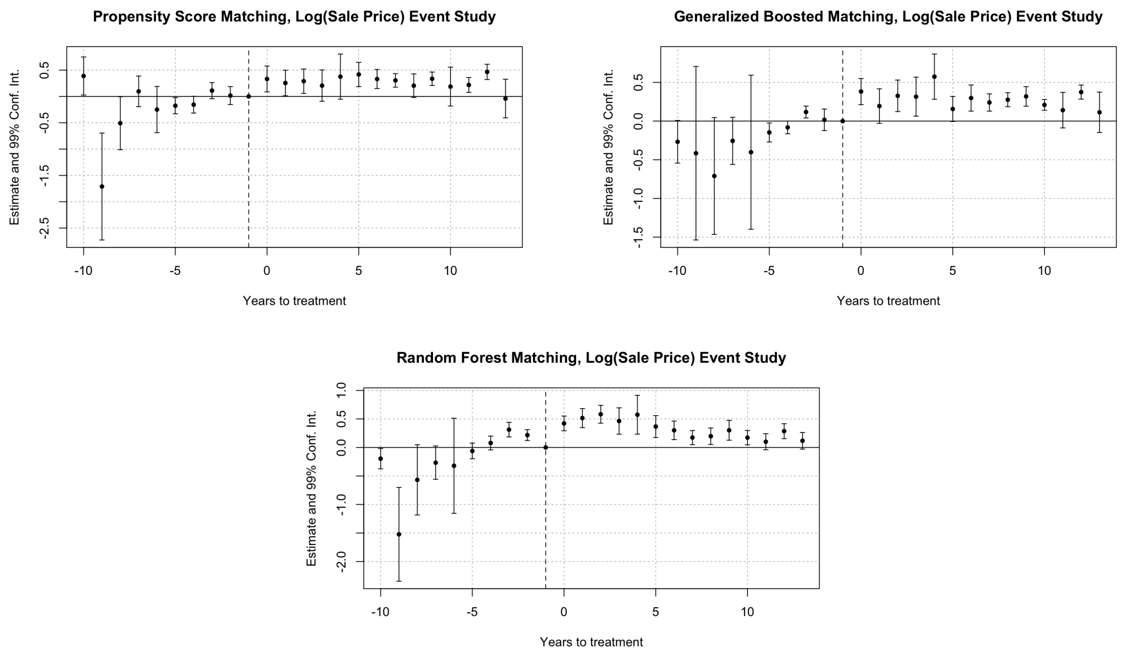
Notes: Depicts ln sale price averages by month in the pre-treatment period, by treatment. OLS regression lines are fitted, with 95% CIs depicted in gray.

Figure A.9: Event Studies with Geographic Controls:



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

Figure A.10: 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, representing the effect of the policy, 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, representing the effect of the policy, 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 synthetic control groups. The variable of interest, representing the effect of the policy, 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 synthetic control groups. The variable of interest, representing the effect of the policy, 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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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 scholarship.