Upzoning, Density, and Housing Affordability in Nashville

A thesis to be submitted in fulfillment of the requirements for the degree of Bachelor of Arts with Honors

by

Nicholas Forster-Benson

Department of Economics

Vanderbilt University College of Arts and Science

April 2025

Abstract

Name of the student: **Nicholas Forster-Benson**

Degree for which submitted: ***Bachelor of Arts with Honors***

Department: **Economics**

Thesis title: **Upzoning, Density, and Housing Affordability in Nashville**

Thesis Advisor: **Dr. Karim Nchare**

Thesis Committee: **Dr. Karim Nchare**, **Dr. Michelle Marcus**, **Dr. Brian Beach**

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.

Acknowledgements

I would like to express my deepest gratitude to my advisor and mentor, Dr. Karim Nchare, whose guidance, encouragement, and intellectual generosity have shaped me as both academically and personally. His insights, patience, and unwavering support -even from 5000 miles away at times- have been instrumental in my growth as a scholar, and I am truly fortunate to have learned from him.

I am also immensely grateful to Dr. Michelle Marcus, the director of the thesis program, for her leadership and invaluable feedback throughout this process. Her commitment to fostering rigorous scholarship and her thoughtful advice have helped me refine my ideas and navigate the challenges of academic research. Her dedication to this program is unmatched, and she will be thoroughly missed as she embarks on her much needed sabbatical! Furthermore, I would like to thank Dr. Brian Beach, my secondary reviewer, for his keen insights and strongly felt encouragement, which will fuel these works into my graduate years.

Additionally, I am thankful to Dr. Richard Lloyd and Dr. Brandon Underwood for their near constant mentorship throughout my time at Vanderbilt. Our conversation, were always not only insightful but entertaining, spanning everything from backgammon and Pokemon cards to local politics and economic analysis.

Beyond my formal mentors, I am thankful for the support of my cohort peers, Aidan Caplan, Tristan Caplan, Nandika Chirala, Leyton Xing, Saayili Budhiraja, Vivi Ma, and Jacob Katz for their encouragement, feedback, and conversations that helped me along the way.

Lastly, I would like to express my heartfelt gratitude to Jayce Pollard and my entire family (mom, dad, Eliot and Tim) for their unwavering support and encouragement throughout the entirety of my undergraduate years. Their guidance and love has been invaluable, and my work is but merely a reflection of the intellectual and personal community that has shaped it throughout my years at Vanderbilt.

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

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

Post-Treatment Study Period	Summary of recent research 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. In the case of ADUs, there was no effect on housing prices.	Büchler and Lutz (2021); Gnagey et al. (2023); Murray and Limb (2023)

Source: Adapted from Freemark (2023)'s review of the scholarship. Detailed table located in the appendix.

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 amount and market segment 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. 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 (BL2009-586 allowed for unrestricted -by unit density, height, and parkin- mixed use development), on housing parcel transaction prices using repeated cross-sectional data from Davidson County between 2000 and 2023. As in Freemark (2020), in the absence of rent data, we use residential transaction prices as a proxy for housing prices and affordability.

Our analysis attempts to isolate variation among upzoned multifamily units in which density and height limits were increased and 'by-type' zoning was suspended. 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 utilizing Propensity Score Matching, Generalized Boosted Matching, and Random Forest Matching. The utilization of matching methods greatly improves covariate balance between our treatment and control groups. To estimate price effects of 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 finding 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.

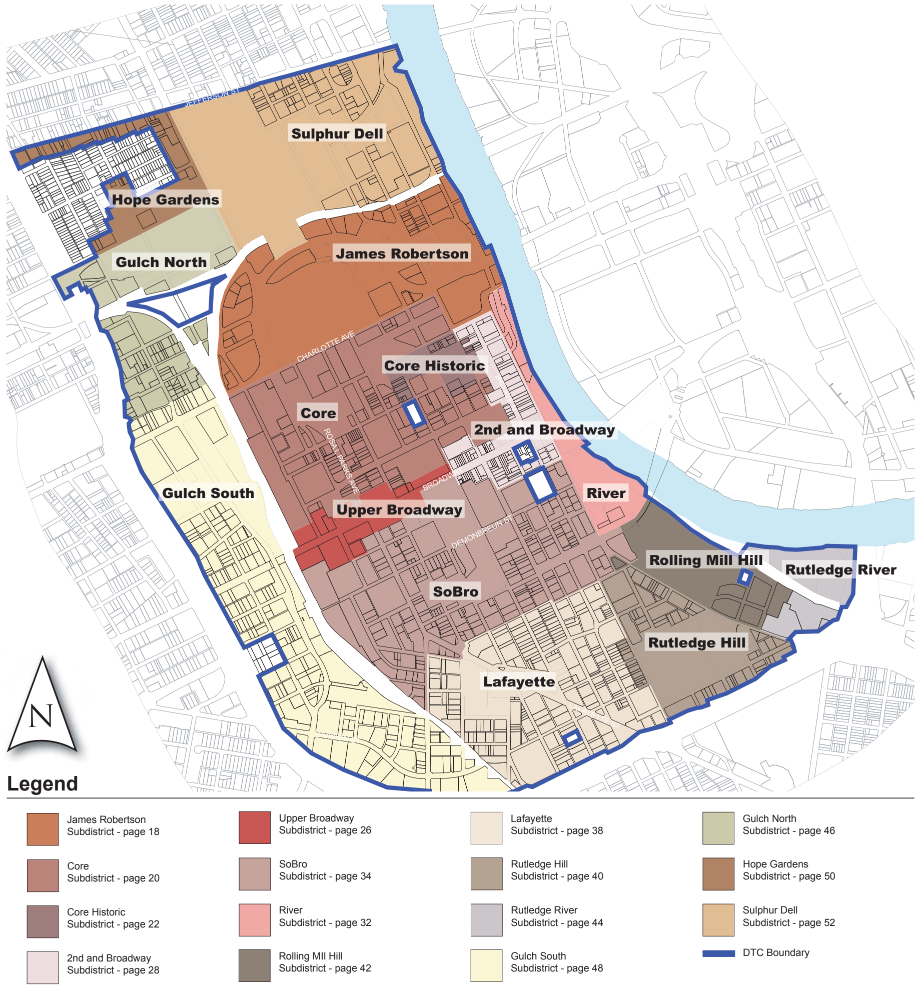
These results have important implications for urban practitioners with relation to land use and housing affordability. We provide evidence for the potential limitations of density upzoning as a tool to increase affordability within upzoned districts. This finding is particularity import in relation to 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 limitations, and removal of minimum parking requirements. Effectively, the policy loosened residential density restrictions to the extent that there has never been an '*spot upzoning*' in the DTC since, allowing for residential densities in excess of 1,000 units per acre.[1] Since February 2010, when BL2009-586 was passed, the

[1]While mixed use zoning and the elimination of parking requirements us 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 predominately consists of limits above 20 stories. For more information, see City of Nashville (2024).

Figure 1: Downtown Code Zoning District and Subdistrict Boundaries



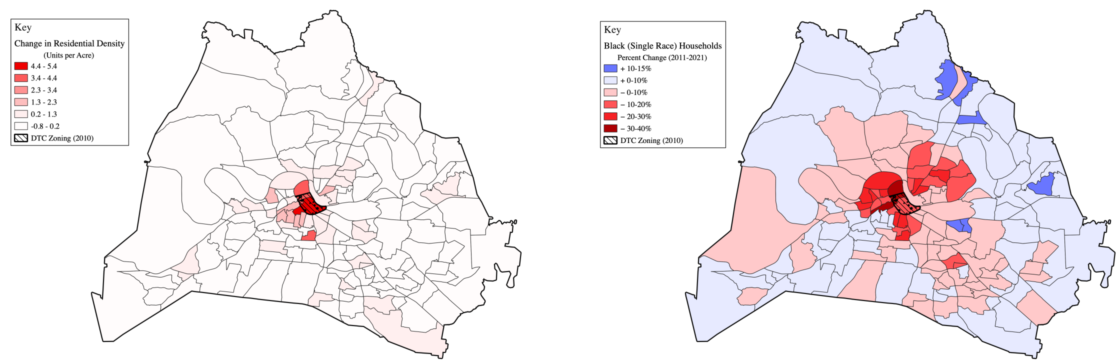
Notes: This map is sourced from City of Nashville (2011), an attachment to Ordinance No. BL2009-586 as adopted on February 02, 2010.

DTC has been amended fifteen times (nearly on an annual basis), ensuring that land use is maximally taken advantage of in the downtown area. 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.

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 class. Through these changes, the DTC has played a crucial role in guiding Nashville's urban growth towards a densification never before seen in the music city, 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 21st 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. Given that the prior zoning of the DTC was dominated by various forms of lower density multi-family housing, the variation we seek to capture is that of the effect of increased density limits on multi-family housing combined with potential amenity effects associated with the removal of 'by-type' zoning.[4] In addition, our analysis excludes approximately 800 parcels that underwent spot zoning changes during the same period.[5] In an attempt to estimate

[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. These observations are restored for the quantile treatment effect (QTE) estimates

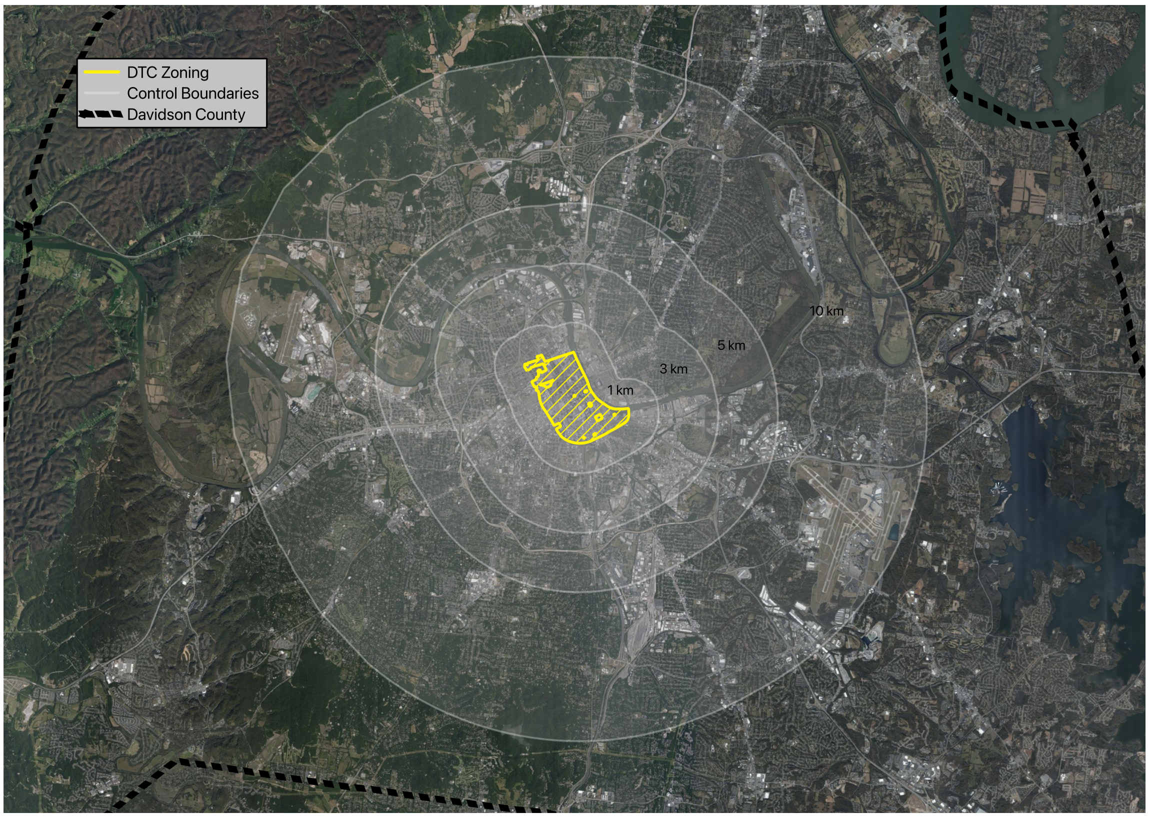
[4]Due to the lack of single-family housing in the core prior to the policy intervention, the common trend assumption does not hold when comparing the core to single-family housing.

[5]There remains large heterogeneity in the type and form of on-spot zoning changes that occured 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 downzings. Furthermore, the

the treatment effect of the policy, our analysis attempts to capture the 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

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



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

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

sequential nature of their implementation leads us to exclude all on-spot zonings from our analysis.

(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 predominately 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 core increases)

An additional limitation of our geographic control boundaries is the potential of capturing spill-over effects from both investments and densification amenities. 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 complimentary 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 a over-estimation of treatment effects.

3.3. Synthetic Control Selection with Matching Methods

To address issues 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 covoraite. 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.

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%
1km Control	202,242	539,621	167%
3km Control	215,191	523,991	143%
5km Control	207,624	512,616	147%
10km 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.

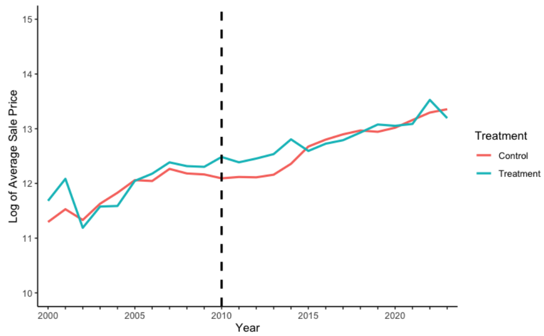
3.4. Pre-Treatment Trends

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

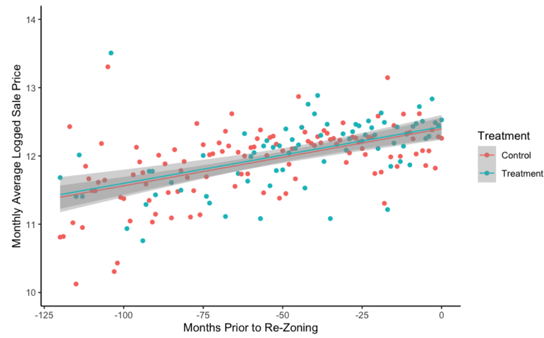
Figure 4a provides a basic visual comparison of the trend changes in the annual

Figure 4: Average Sale Price Trends Sale Price By Treatment (3km Control)

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



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



average prices of the control and treatment parcels. For the 3 km diameter control, the trends are broadly similar with a deviation in direction in only one of the 10 pre-treatment years.[6] Our visual inspection of average annual price trends is further supported at the monthly level, as shown in Figure 4b. 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 plotted standard error of our trend lines (shaded in the grey area) further demonstrates the similarity of trends between upzoned and control parcels in the pre-treatment period. Finally, 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. The results are shown in Figure 5. Using 95% and 99% confidence intervals, we find no statistical significance in any of our pre-treatment placebo DiD indicators regardless of date. These results combined with Figure 4a support the common trend assumption.

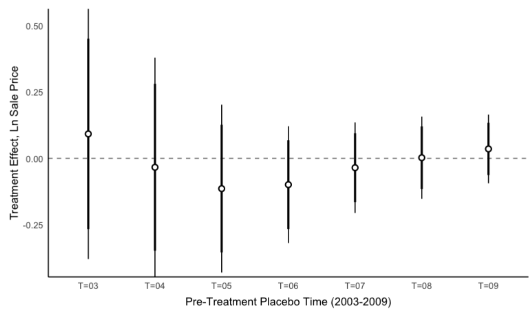
4. Empirical Strategy

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

[6]While Figure 4a isolates the 3 km control group, all other control group trends can be found in the appendix.

Figure 5: Pre-Treatment Placebo, 3 km Control



Note: Plain lines represent 99% confidence interval, and Bold lines signify 95% confidence intervals.

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.[7] 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 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).[8] 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.

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

[7] 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.

[8] 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.

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). 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 limited sample sizes. QDiD was used to estimate treatment effects at the first, second and third quartiles representing low, medium and high market value transactions.

5. Findings

5.1. Average Treatment Effects

Tables A.20a and A.20b 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 compared to the larger control group. These results are furthered by our 3km TWFE event study presented in Figure A.20 which demonstrates an upward trend in housing prices in the five years after policy implementation, with waning increases as the years after implementation increases.[9]

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 **??**). We observe that when the 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 hous-

[9]Complete event study figures for all control groups can be found in the appendix.

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 on housing price. Each column represents a different geographic control area (as depicted in Figure 3). The variable of key variable representing the effect of the policy is DTC*Time Period.* *p<0.1; **p<0.05; ***p<0.01.

ing, 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. These results are robust to changes in sample size for all three matching methods. This provides 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. Our estimates are robust to changes in sample selection size.

5.2. Quantile Treatment Effects

The results shown in Tables 6a and 6b provide strong evidence of a heterogeneous treatment effect across quartiles. We observe that the treatment effect among transactions in the first quartile is consistently positive and significant across geographic controls. 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, partly over shorter time periods.

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

a Sale Price

	Dependent variable: log(Sale Price)		
Matching Method:	(Propensity Score)	(Generalized Boosted)	(Random Forrest)
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 Per Sqr. ft)		
Matching Method:	(Propensity Score)	(Generalized Boosted)	(Random Forrest)
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 on housing price. Each column represents a matching methodology to produce synthetic control groups. The variable of key variable representing the effect of the policy is DTC*Time Period. *p<0.1; **p<0.05; ***p<0.01.*

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)
q=0.25	9.056***	0.896	0.535**	0.655***
	(1.521)	(1.095)	(0.252)	(0.092)
q=0.50	−0.180**	−0.083	-0.040	-0.092**
	(0.080)	(0.058)	(0.036)	(0.038)
q=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 Per Sqr. Foot)			
tau	(1 km)	(3 km)	(5 km)	(10 km)
q=0.25	2.334***	0.634***	0.127	1.22***
	(0.506)	(0.218)	(0.276)	(0.222)
q=0.50	0.068	0.051	0.032	-0.061
	(0.096)	(0.055)	(0.030)	(0.054)
q=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, estimates are unable to be made with the addition of neighborhood fixed effects, as in the ATE DiD. *p<0.1; **p<0.05; ***p<0.01*

Importantly, our results show that over longer periods, investment effects, combined with potential amenity effects associated with increased density, can reduce affordability, particularly at the lower end of the market. Second, we observe that third quartile transaction prices are significantly lower in the treated groups than in the untreated groups. This finding is consistent with Anagol et al. (2021), who find potential price reductions as a result of supply induction through upzoning.

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

a Treatment Effect, Sale Price

	Dependent variable: log(Sale Price)		
Matching Method:	(Propensity Score)	(Generalized Boosted)	(Random Forrest)
q=0.25	0.079***	0.245***	0.134***
	(0.024)	(0.027)	(0.023)
q=0.50	−0.015	0.009	-0.090***
	(0.028)	(0.036)	(0.034)
q=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 Per Sqr. Foot)		
Matching Method:	(Propensity Score)	(Generalized Boosted)	(Random Forrest)
q=0.25	−0.058	0.209***	0.103**
	(0.048)	(0.039)	(0.032)
q=0.50	−0.229***	0.005	−0.097***
	(0.021)	(0.017)	(0.018)
q=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, estimates are unable to be made with the addition of neighborhood fixed effects, as in the ATE DiD. **p<0.1;* ***p<0.05;* ****p<0.01*

A 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 investment could potentially induce an upward pressure on low-value transactions through spillover amenity effects. Overall, these results are consistent with previous postulations regarding the differential distribution of market segmentation leading to differences in ATE estimates across 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.

6. Discussion and Conclusions

While researchers have largely concluded that in high-demand markets, such as Nashville, land use deregulation typically leads to higher property values in the short run, little research has examined the effects of upzoning over longer time horizons. To our knowledge this study utilizes the longest time period of any upzoning analysis in the American context, examining 13 years after the DTC upzoning. We present two important findings with implications for the relationship between upzoning and housing affordability. Estimating both 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. Second, estimating quantile treatment effect, we document evidence of heterogeneous treatment effects across housing market segments. Our QDiD estimates suggest that upzoning led to approximately 2%-28% higher prices for low-end (first quartile) treated parcels. Simultaneously high-end (third quartile) treated parcels observed 4%-25% price decreases, consistent with Anagol et al. (2021)'s supply induction finding. Combined with our finding of 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.

It is worth noting that our analysis does not compare single-family to multifamily as in Kuhlmann (2021), but rather focuses on the increase in density limits, in combination with the effects of eliminating 'by-type' zoning. Furthermore, when conducting research on housing prices, we must remain aware that there is a constellation of factors, including zoning regimes, migration patterns, financial incentive, and amenities structures which contribute to the production of sense of place which may be desirable to specific forms of housing production and consumption in a given place at a given time (and thus determine price). Such discrepancies are important to take into account, as the plurality of policy results are necessarily a consequence of the diversity of applications, histories and cultures in which policy regimes are enacted. Our finding that the price effects of DTC are not uniform across different segments of the housing market and can be moderated by amenity quality is of particular interest for future research. Further empirical research is needed on the link between public urban infrastructure and upzoning policies and their impact on housing affordability.

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.

References

Santosh Anagol, Fernando Vendramel Ferreira, and Jonah M Rexer. Estimating the economic value of zoning reform. Technical report, National Bureau of Economic Research, 2021.

Tom Angotti and Sylvia Morse. *Zoned out!: race, displacement, and city planning in New York City*. Terreform, 2016.

Susan Athey and Guido W Imbens. Identification and inference in nonlinear difference-in-differences models. *Econometrica*, 74(2):431–497, 2006.

Carol Atkinson-Palombo. Comparing the capitalisation benefits of light-rail transit and overlay zoning for single-family houses and condos by neighbourhood type in metropolitan phoenix, arizona. *Urban studies*, 47(11):2409–2426, 2010.

Simon Büchler and Elena Catharina Lutz. The local effects of relaxing land use regulation on housing supply and rents. *MIT Center for Real Estate Research Paper*, (21/18), 2021.

Benjamin J Carrier. Contextualizing nashville's response to its affordable housing crisis. Master's thesis, University of Minnesota, 2021.

City of Nashville. Downtown code amended by ordinance no. bl2011-896. Available online at the City of Nashville Planning Department's website, May 2011. URL https://bpb-us-w2.wpmucdn.com/sites.wustl.edu/dist/a/3075/files/2022/01/A-Nashville-DowntownCode.pdf. Amended by Ordinance No. BL2011-896 as adopted on May 26, 2011, and Attachment to Ordinance No. BL2009-586 as adopted on February 02, 2010.

City of Nashville. Nashville downtown code, August 2024. URL https://www.nashville.gov/sites/default/files/2025-01/Downtown-Code-with-East-Bank-Expansion.pdf?ct=1737749434. Chapter 17.37 of the Metropolitan Nashville and Davidson County Zoning Code, originally adopted on February 02, 2010, with multiple amendments through August 20, 2024.

Terry Nichols Clark, Richard Lloyd, Kenneth K Wong, and Pushpam Jain. Amenities drive urban growth. *Journal of urban affairs*, 24(5):493–515, 2002.

Metro Human Relations Commission. Understanding nashville's housing crisis part 1: Affordable for who? Technical report, Metropolitan Government of Nashville and Davidson County, 2018a.

Metro Human Relations Commission. Understanding nashville's housing crisis part 2: Residential segregation: How do people lose their homes? Technical report, Metropolitan Government of Nashville and Davidson County, 2018b.

Metro Human Relations Commission. Understanding nashville's housing crisis part 3: Residential segregation: How did it happen and why does it persist? Technical report, Metropolitan Government of Nashville and Davidson County, 2019.

Thomas Davidoff, Andrey Pavlov, and Tsur Somerville. Not in my neighbour's back yard? laneway homes and neighbours' property values. *Journal of Urban Economics*, 128:103405, 2022.

DCMO. Affordable housing task force report 2021. Technical report, Davidson County Mayor's Office, Metropolitan Government of Nashville and Davidson County, 2021.

Walter D'Lima, Timothy Komarek, and Luis A Lopez. Risk perception in housing markets: Evidence from a fighter jet crash. *Real Estate Economics*, 51(4):819–854, 2023.

Hongwei Dong. Exploring the impacts of zoning and upzoning on housing development: A quasi-experimental analysis at the parcel level. *Journal of Planning Education and Research*, 44(1): 403–415, 2024.

Mario A Fernandez, Gonzalo E Sánchez, and Santiago Bucaram. Price effects of the special housing areas in auckland. *New Zealand Economic Papers*, 55(1):141–154, 2021.

Richard Florida. *The new urban crisis: How our cities are increasing inequality, deepening segregation, and failing the middle class-and what we can do about it.* Hachette UK, 2017.

Yonah Freemark. Upzoning chicago: Impacts of a zoning reform on property values and housing construction. *Urban Affairs Review*, 56(3):758–789, 2020.

Yonah Freemark. Zoning change: Upzonings, downzonings, and their impacts on residential construction, housing costs, and neighborhood demographics. *Journal of Planning Literature*, page 08854122231166961, 2023.

CJ Gabbe, Michael Kevane, and William A Sundstrom. The effects of an "urban village" planning and zoning strategy in san jose, california. *Regional Science and Urban Economics*, 88:103648, 2021.

Edward L Glaeser, Joseph Gyourko, and Raven E Saks. Why have housing prices gone up? *American Economic Review*, 95(2):329–333, 2005.

Jenny Gnagey, Matt Gnagey, and Christopher Yencha. The impact of legalizing accessory dwelling unit rentals on property values: Evidence from ogden, utah. *Journal of Housing Research*, 32 (2):103–122, 2023.

Ryan Greenaway-McGrevy, Gail Pacheco, and Kade Sorensen. The effect of upzoning on house prices and redevelopment premiums in auckland, new zealand. *Urban studies*, 58(5):959–976, 2021.

Joseph Gyourko and Raven Molloy. Regulation and housing supply. In *Handbook of regional and urban economics*, volume 5, pages 1289–1337. Elsevier, 2015.

Katherine H Hatfield. *How the Music City Is Losing Its Soul: Gentrification in Nashville and How Historic Preservation Could Hinder the Process.* PhD thesis, Middle Tennessee State University, 2018.

Cameron Hightower and James C Fraser. The raced–space of gentrification: "reverse blockbusting," home selling, and neighborhood remake in north nashville. *City & Community*, 19(1):223–244, 2020.

Keith R Ihlanfeldt. The effect of land use regulation on housing and land prices. *Journal of urban economics*, 61(3):420–435, 2007.

Stephanie Johnson. *An Uphill Battle: Nashville's Fight for Affordable Housing*. PhD thesis, Tufts University, 2018.

Daniel Kuhlmann. Upzoning and single-family housing prices: A (very) early analysis of the minneapolis 2040 plan. *Journal of the American planning association*, 87(3):383–395, 2021.

Richard Lawson. This southeast city named best real estate prospect for third year by the urban land institute, Nov 2023. URL https://www.forbes.com/sites/richardlawson/2023/10/31/this-southeast-city-named-best-real-estate-prospect-for-third-year/.

Xiangxin Liu, Jeffrey Cohen, Chinmoy Ghosh, and Ran Lu-Andrews. Accessory dwelling units' contagion effects: New spatial evidence from los angeles. *Available at SSRN 4948180*, 2024.

Richard Lloyd. East nashville skyline. *Ethnography*, 12(1):114–145, 2011.

Richard Lloyd and Brian D Christens. Reaching for dubai: Nashville dreams of a twenty-first century skyline. *Global downtowns*, pages 113–135, 2012.

E Janney Lockman. Old money, new nashville: A tale of changing wealth in music city. *Agora Journal of Urban Planning and Design*, pages 62–67, 2019.

Jeffrey S Lowe and Assata Richards. Pro-growth ethos mediated by race: No yimby, no zoning and the housing crisis in houston. *International Journal of Urban and Regional Research*, 46(2): 301–306, 2022.

Mac McComas Luis Quintero. Finding the next nashville. Technical report, Johns Hopkins University, 21st Century Cities Initiative, 2021.

Juliana Maantay. Industrial zoning changes in new york city: A case study of "expulsive" zoning. *Projections 3: The MIT Journal of Planning: Planning for Environmental Justice*, 3:68–108, 2002.

William Jordan Miller. A model for identifying gentrification in east nashville, tennessee. Master's thesis, University of Kentucky, 2015.

Cameron Murray and Mark Limb. We zoned for density and got higher house prices: Supply and price effects of upzoning over 20 years. *Urban Policy and Research*, 41(2):129–147, 2023.

Antonio Olmos and Priyalatha Govindasamy. A practical guide for using propensity score weighting in r. *Practical assessment, research, and evaluation*, 20(1):13, 2019.

Nashville Open Table. Statistics on homelessness, 2017.

Myron W Orfield. American neighborhood change in the 21st century. Technical report, The Institute on Metropolitan Opportunity, University of Minnesota, 2019.

Marcelo Ortiz-Villavicencio, Gonzalo E Sánchez, and Mario A Fernández. Heterogenous treatment effects of a voluntary inclusionary zoning program on housing prices. *Housing Studies*, pages 1–23, 2024.

Darrah Peklak. The quantile treatment of the treated after hurricane ike: An analysis of the houston, tx housing market. 2020.

John M Quigley and Steven Raphael. Regulation and the high cost of housing in california. *American Economic Review*, 95(2):323–328, 2005.

Andrés Rodríguez-Pose and Michael Storper. Housing, urban growth and inequalities: The limits to deregulation and upzoning in reducing economic and spatial inequality. *Urban Studies*, 57(2): 223–248, 2020.

Jonathan Rothwell and Douglas S Massey. The effect of density zoning on racial segregation in us urban areas. *Urban Affairs Review*, 44(6):779–806, 2009.

Allison Shertzer, Tate Twinam, and Randall P Walsh. Race, ethnicity, and discriminatory zoning. *American Economic Journal: Applied Economics*, 8(3):217–246, 2016.

Christina Stacy, Chris Davis, Yonah Slifkin Freemark, Lydia Lo, Graham MacDonald, Vivian Zheng, and Rolf Pendall. Land-use reforms and housing costs: Does allowing for increased density lead to greater affordability? *Urban Studies*, 60(14):2919–2940, 2023.

Elizabeth A Stuart, Gary King, Kosuke Imai, and Daniel Ho. Matchit: nonparametric preprocessing for parametric causal inference. *Journal of statistical software*, 2011.

Peter A Tatian, Karolina Ramos, and Gabe Samuels. Promoting affordable housing partnerships in nashville. Technical report, Urban Institute, 2023.

Lorenz Thomschke. Distributional price effects of rent controls in berlin: When expectation meets reality. Technical report, CAWM discussion paper, 2016.

A Thurber, J Gupta, J Fraser, and D Perkins. Equitable development: Promising practices to maximize affordability and minimize displacement in nashville's urban core, 2014.

Amie Thurber, Amy Krings, Linda S Martinez, and Mary Ohmer. Resisting gentrification: The theoretical and practice contributions of social work. *Journal of Social Work*, 21(1):26–45, 2021.

U.S. Census Bureau. 2010 decennial census, table p3: Race, 2010a. URL https://www.census.gov.

U.S. Census Bureau. 2010 Decennial Census, Table H1: Housing Unit Data, 2010b. URL https://www.census.gov.

U.S. Census Bureau. 2020 Decennial Census, Table H1: Housing Unit Data, 2021a. URL https://www.census.gov.

U.S. Census Bureau. 2020 decennial census, table p3, 2021b. URL https://www.census.gov.

Andrew H Whittemore. Racial and class bias in zoning: Rezonings involving heavy commercial and industrial land use in durham (nc), 1945–2014. *Journal of the American Planning Association*, 83(3):235–248, 2017.

Andrew H Whittemore. Exclusionary zoning: Origins, open suburbs, and contemporary debates. *Journal of the American Planning Association*, 87(2):167–180, 2021.

Jeffrey Zabel and Maurice Dalton. The impact of minimum lot size regulations on house prices in eastern massachusetts. *Regional Science and Urban Economics*, 41(6):571–583, 2011.

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 (Propesnsity 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)

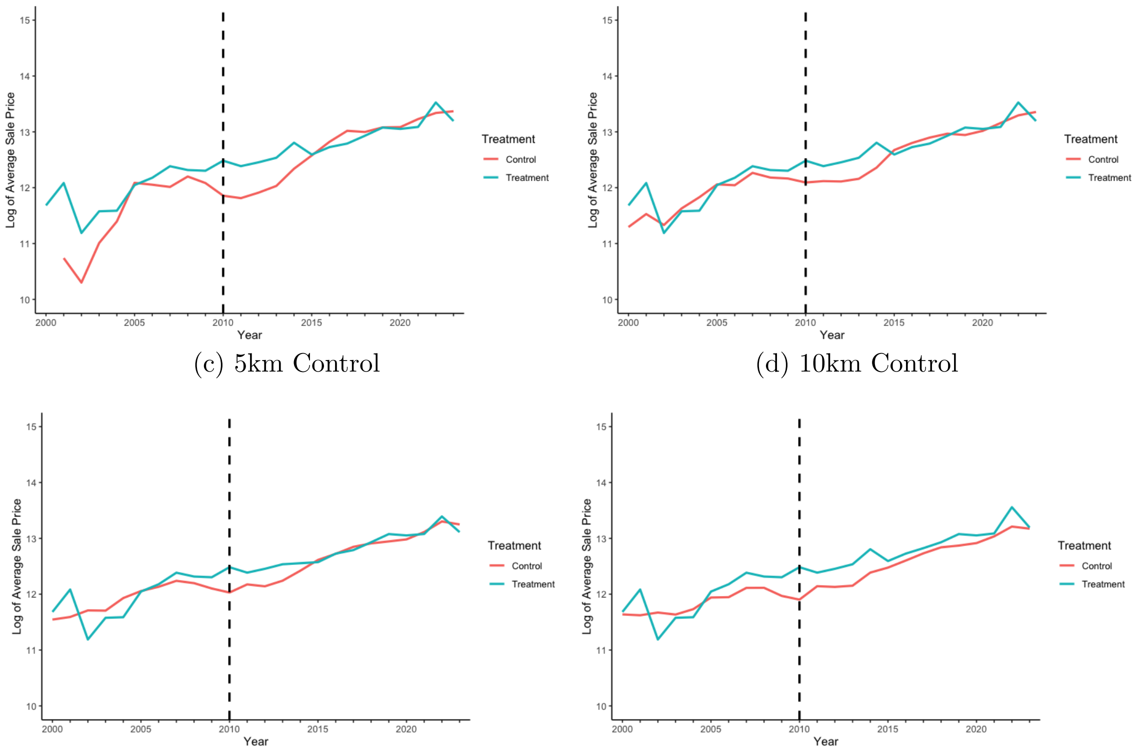
Variable	Treated Mean	Control Mean	Std. Mean Diff.
OLS Distance	0.4885	0.1079	1.7667
Age	9.3239	28.5317	-2.3559
Finished Area	1090.40	1889.97	-0.5702
% White	61.08	69.14	-0.8537
% Bachelors Degree	0.4334	0.4243	0.2311
Building Permits	45.51	40.52	0.2212

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

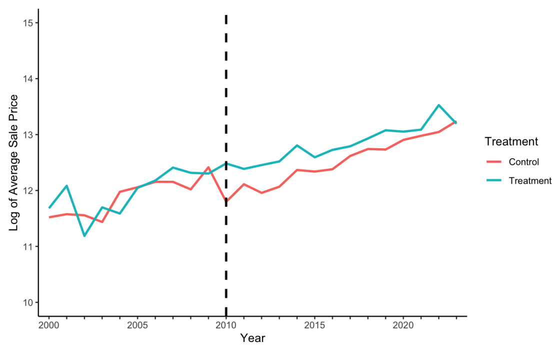
(a) 1km Control (b) 3km Control (c) 5km Control (d) 10km Control



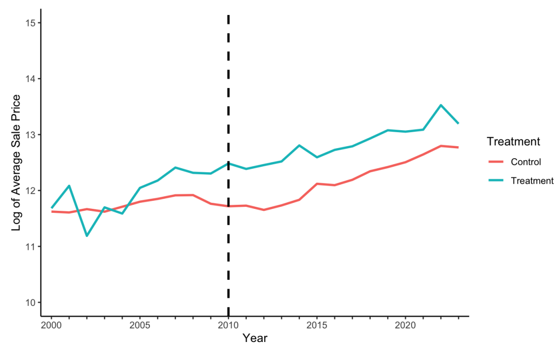
Note: Average sale price by year. Geographic control bands (1km, 3km, and 10k) are compared to the DTC.

Figure A.7: Average Sale Price By Year and Treatment

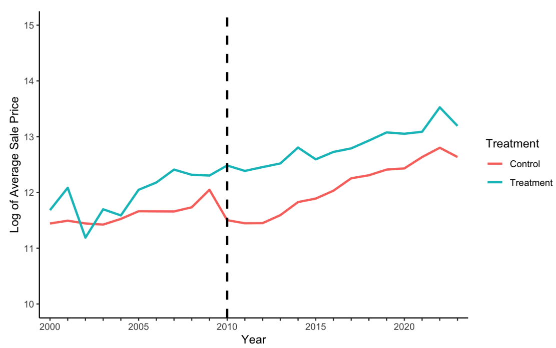
(a) Propensity Score Matching



(b) Generalized Boosted Matching

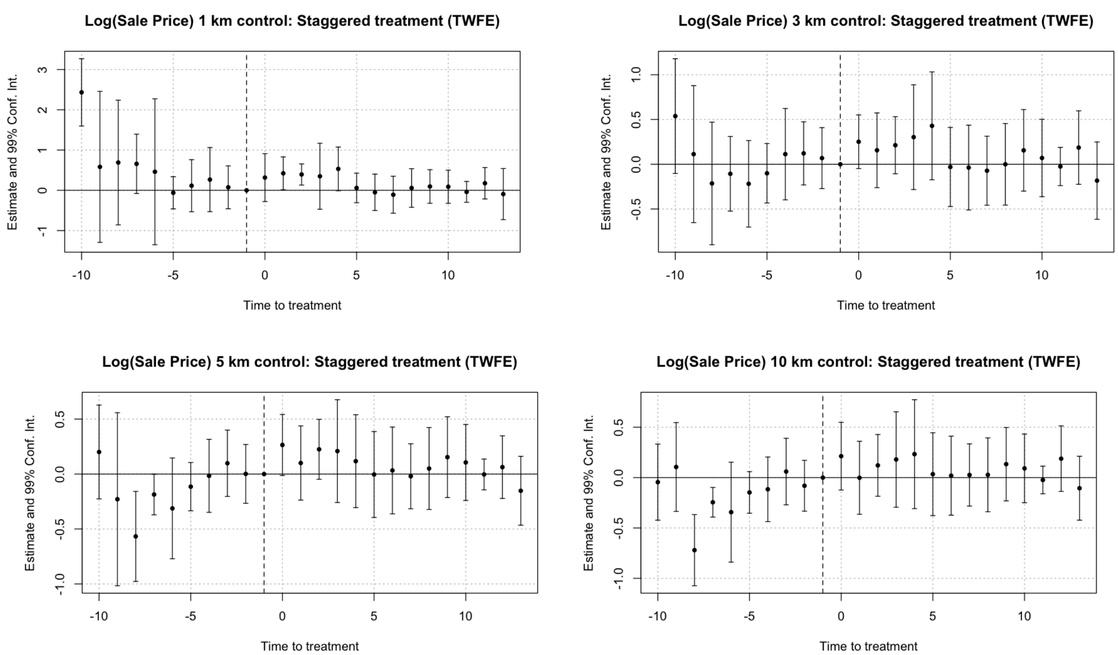


(c) 5km Control



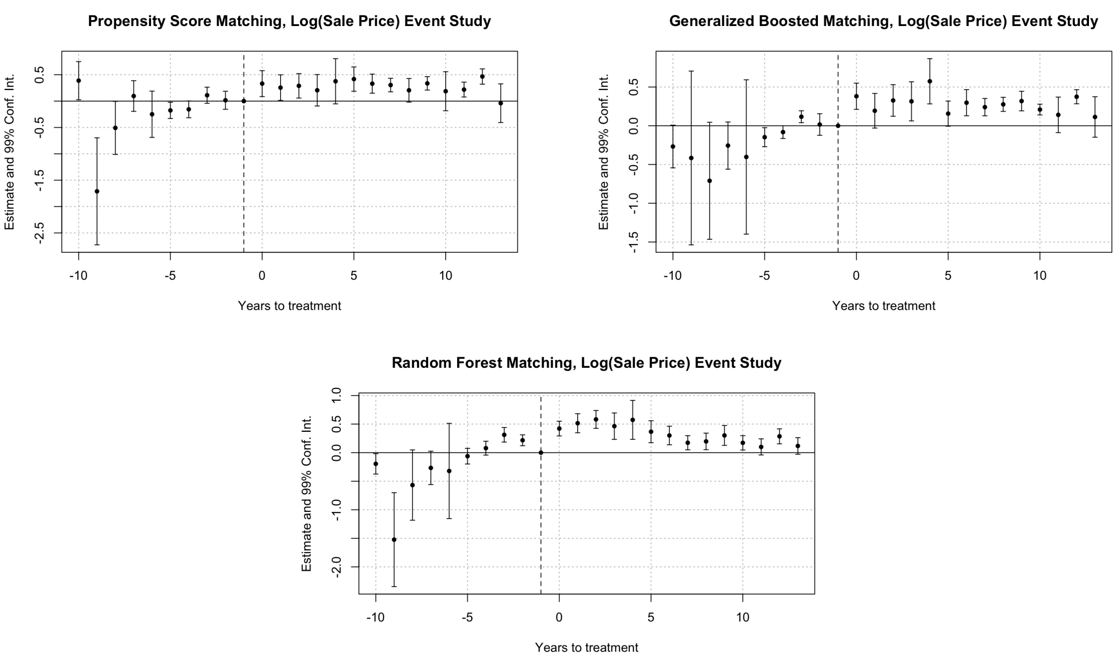
Note: Average sale price by year. Geographic control bands (1km, 3km, and 10k) are compared to the DTC.

Figure A.8: Event Studies with Geographic Controls:



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

Figure A.9: Event Studies with Matched Controls:



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

Table A.17: log(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 on housing price. Each column represents a different geographic control area (as depicted in Figure 3). The variable of key variable representing the effect of the policy is DTC*Time Period.* $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

Table A.18: log(Sale Price Per Sqr. ft) 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 on housing price. Each column represents a different geographic control area (as depicted in Figure 3). The variable of key variable representing the effect of the policy is DTC*Time Period.* $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

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

a (2010-2015)

	Dependent variable: log(Sale Price)		
Matching Method:	(Propensity Score)	(Generalized Boosted)	(Random Forrest)
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:	(Propensity Score)	(Generalized Boosted)	(Random Forrest)
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 on housing price. Each column represents a matching methodology to produce synthetic control groups. The variable of key variable representing the effect of the policy is DTC*Time Period.* $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

Table A.20: log(Sale Price Per Sqr. ft) Fixed Effects Difference-in-Differences with Matched Control Groups

a (2010-2015)

	Dependent variable: log(Sale Price Per Sqr. ft)		
Matching Method:	(Propensity Score)	(Generalized Boosted)	(Random Forrest)
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:	(Propensity Score)	(Generalized Boosted)	(Random Forrest)
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 on housing price. Each column represents a matching methodology to produce synthetic control groups. The variable of key variable 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)
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)

(Continued on next page)

(Continued)

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%.	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)
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)

(Continued on next page)

(Continued)

Years examined	Scale/Intensity	Effects	Study
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)
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)

(Continued on next page)

(Continued)

Years examined	**Scale/Intensity**	**Effects**	**Study**
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.