Under the (Neighbor)Hood: Understanding Interactions Among Zoning Regulations*

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Abstract

We study how various zoning regulations combine to affect housing supply, prices, and rents of single- and multifamily homes using novel lot-level zoning data from Greater Boston and a cross-sectional boundary discontinuity design at regulation boundaries. Looser density restrictions, alone or with other less restrictive regulations, are most effective in increasing supply and reducing per-housing-unit rents and prices. We theoretically and empirically show that restrictive zoning regulations shift housing stock towards larger units, increasing prices per housing unit. Counterfactuals imply that a recent Massachusetts law increasing building density near transit can reduce long-run rents and prices, particularly in suburbs.

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1. Introduction

Housing prices are rising sharply in many cities worldwide. Vacant lots are scarce in urban areas, implying that any solutions to the rise in prices must include plans to add housing by building more densely in populated areas. However, local zoning regulations often raise barriers to denser construction, making housing more expensive and adversely affecting aggregate output, wealth accumulation by younger households, and geographic mobility (Hsieh and Moretti, 2019; Duranton and Puga, 2023; Parkhomenko, 2023; Dustmann et al., 2022; Ganong and Shoag, 2017).

Over the past century, local governments worldwide have adopted a myriad of zoning regulations that limit new construction. At least 54 municipal, state, and national governments worldwide have recently relaxed one or more zoning regulations in an attempt to reduce housing prices.[1] However, it is unclear how effective these reforms will be; the literature so far has primarily studied specific zoning regulations in isolation (Anagol et al., 2021; Ahlfeldt et al., 2017), leaving under-addressed the question of how zoning regulations affect the housing market cumulatively and in interaction.

Our first contribution is to examine how zoning regulations combine to affect the long-run supply, prices, and rents of single-family and multifamily homes. We focus on the three major types of zoning regulations affecting the residential landscape of most cities worldwide: multifamily zoning restrictions (that is, whether construction of apartments is allowed), maximum height restrictions, and density restrictions (e.g.,

[1] See Appendix Table E.1 for details on upzoning laws and policies across the 54 jurisdictions worldwide.

maximum numbers of units per lot, minimum lot sizes), which determine how many housing units are allowed on an acre of land. We define *relaxing regulations* or *upzoning* as regulations that increase the maximum permitted height for housing, allow more density, or allow multifamily homes when they were previously not allowed.

Our second contribution is to construct a housing market model in which the developer not only determines the residential floorspace, as is standard in the literature, but also decides the number of housing units to build on a land lot given zoning constraints. Incorporating choices on both the intensive (floorspace) and extensive (number of units) margins helps our analysis in two ways. First, one cannot study the effects of two of the three regulations—multifamily and density regulations—without accounting for the developer's (endogenous) choice over the number of housing units. Second, this approach allows us to formalize a key aspect of the housing market: the fact that, as regulations become more restrictive, the size of housing units tends to increase. We refer to this phenomenon as the *composition effect* of zoning regulations, whereby such regulations affect per-housing-unit prices by increasing housing unit size. The model also demonstrates that less restrictive zoning positively impacts land lot prices (option value) and negatively affects housing prices per square foot (supply effect) and that population shocks affect housing prices per square foot (demand effect).

Our third contribution is to develop an empirical framework for economists and policymakers interested in understanding the local effects of upzoning. Using novel lot-level zoning data on 86 municipalities in the Boston metro area, known as Greater Boston, we exploit spatial variation in the three types of zoning regulations using a regression discontinuity (RD) approach. We study the discontinuity in regulations at regulatory boundaries within neighborhoods, instead of the more commonly used municipal boundaries (see Turner et al., 2014; Song, 2025). This approach creates two benefits and a challenge. The first is that by using zoning boundaries to delineate regulatory scenarios where one or more regulations change at the boundary, we can examine how regulations interact and can simulate the policy effects of upzoning. The second benefit is that our results are not confounded by the effects of unobserved differences in municipality characteristics, which also jump at the border between municipalities.

The challenge with our approach arises because the zoning boundaries adopted in the early to mid-20th century were not random. They were drawn to overlap with natural features and municipal and school catchment area boundaries, so neighborhood quality is not continuous across them. To address this, we restrict our analysis to boundaries with no overlap with the aforementioned features. To account for the possibility that the boundaries were carved based on the preexisting built environment, we only study straight-line boundary segments, following Turner et al. (2014). We show no discontinuities in land or neighborhood characteristics across the final boundary sample.

Our first finding is that loose density restrictions along with permitting multifamily housing increase the average number of housing units per lot by 62% across regulatory boundaries. We also find that strict density regulations increase lot size, living area and the number of bedrooms and bathrooms. In addition, we find that monthly multifamily rents per unit are 4.2% and 6.9% ($54 and $101) lower, on average, at boundaries across which density regulations loosen alone or along with height restrictions, respectively. For single-family homes, looser density regulations alone or with regulations permitting multifamily housing lead to an average fall of 4.4% ($28,488) or 2.2% ($13,394) in the per-unit sale price across the boundaries. In contrast, looser height restrictions alone or together with allowance of multifamily housing do not affect housing supply or prices. We conclude that density restrictions are a binding constraint while height regulations are not. Indeed, the former are critical in restricting supply in Greater Boston, but other zoning regulations may act as binding constraints elsewhere. Since we examine the impact of regulations instituted in the early to mid- 20th century on 21st-century outcomes, our results are best interpreted as long-run differences at zoning boundaries.

Second, we find that total per-housing-unit price and rent differences across boundaries are primarily driven by the composition effect: zoning regulations affect per-housing-unit prices by changing housing unit characteristics and increasing the size of the smallest unit in strictly regulated areas. Since—based on calculations from our zoning data—construction is limited to single-family homes on 58% of the land in Greater Boston, building height to not more than 35 feet on 70% of the land, and only one housing unit per acre is permitted on 25% of the land, zoning regulations can increase housing unit size in large portions of the area and drive the prices per housing unit upwards.

Third, we use our causal estimates to simulate the long-run effects of Massachusetts's 2021 Chapter 40A upzoning law, which allows multifamily housing and relaxes density restrictions near public transit stops. Our framework and estimated local average treatment effects are only suited for simulating the long-run effects of local upzoning in a highly developed urban environment such as the areas targeted by the Chapter 40A law. The counterfactual estimates suggest that, under this law, long-run multifamily rents would fall by a median of 4.9%, primarily in suburban municipalities. Median sale prices of single-family housing would fall by 8.5% near transit stations where regulatory stringency is high, as in suburban municipalities, but could increase moderately near transit stations close to Boston because of increased option value.

Related Literature: Past research has studied the effects of land-use regulations in one of two ways. First, many studies analyze the effects of individual zoning regulations (Kulka, 2020; Davidoff et al., 2022), making it difficult to understand how the different regulations interact. Second, studies such as Turner et al. (2014), and Herkenhoff et al. (2018) rely on surveys such as the Wharton index (Gyourko et al., 2021) or misallocation wedges to document the total effects of zoning regulations but do not estimate the price distortions associated with each type of restriction. Our paper expands on this literature by providing a novel method to study how zoning regulations interact and which regulations should be relaxed to measurably affect housing supply and prices.

In contrast to most of the literature, our work studies the effects of zoning on all building types. Glaeser and Ward (2009) and Zabel and Dalton (2011) study only the effects on single-family housing supply and Severen and Plantinga (2018) only the effects on supply of multifamily buildings. This paper adds to the emerging literature on housing supply (Combes et al., 2021) and also relates to the literature studying the long-term consequences of zoning regulations (Shertzer et al., 2016). Last, this paper ties in to the broader literature on the effects of housing unaffordability in neighborhoods with better opportunities (Chyn and Katz, 2021) and of regulations on urban sprawl (Bertaud and Brueckner, 2005; Brueckner and Singh, 2020).

2. Data and Regulatory Framework

The lot-level zoning-regulation data that we use for this research come from the Metropolitan Area Planning Council's (MAPC's) *Zoning Atlas*, covering 101 municipalities in Greater Boston and recording zoning regulations as observed in 2010. While most of the regulations were first enacted in the early to mid-20th century, we believe that the zoning boundaries have stayed relatively constant over time for two reasons.[2] First, a survey of Massachusetts municipalities by Zabel and Dalton (2011) finds only 10 changes to zoning ordinances in the 1980s and 1990s. All of these changes were to the regulation *levels* rather than the *boundaries*. Second, we overlay the 2010 boundaries over the original or first revision zoning maps for a geographically representative 15% of the sample municipalities and find a very high degree of overlap (see Appendix Figure A.2).

We use the Warren Group's property tax assessment data for 2010–18, reflecting the universe of residential and mixed-use buildings in Greater Boston and containing information on the buildings' types (single family or multifamily), year of construction, number of units per lot, housing-unit characteristics (lot size, built area, number bedrooms and bathrooms), and value (land and building assessed value, sale price and year).[3]

[2] Appendix Table E.2 shows the years of first zoning regulation adoption for 42 municipalities in our sample.

[3] Appendix E.4 shows that the housing stock from the Warren data are similar to that reported in the American Community Survey. We exclude condominiums (10% of the residential property records for 2010–18) from all analyses because of inconsistencies in

For single-family homes, we use the most recent sale price if the home was sold between 2010 and 2018. For multifamily buildings, historical housing unit–level rental data are virtually nonexistent, with most studies relying on surveys. For larger apartment buildings, we match the 2010–18 market-rate rent data from CoStar to properties in the Warren Group data. However, the CoStar data cover only buildings with five or more units, so, for housing units without CoStar rent data, we impute rent using the tax-assessed value. Market-rate rent data are used for 18,536 multifamily housing units, with rent imputation required for the remaining 112,992 multifamily units (Appendix A.4 provides details on the imputation). We also collect data on land and neighborhood characteristics, analyzing 86 municipalities in the final sample for which data are available (see Appendix A.5 for details and Appendix E.5 for a map).

2.1 Types of Zoning Regulations and Regulatory Scenarios

We study three types of zoning regulations common in the US that affect residential housing construction.[4] Multifamily zoning regulations limit construction to only single-family (non-apartment) homes. Maximum-height regulations restrict how tall

how they are reported across municipalities that make it difficult to reliably determine their size, sale price, or assessed value.

[4] Different zoning regulations were adopted in the early to mid-20th century as a response to rapid urbanization and growth in housing demand (Dain, 2023). Municipalities likely continue to employ multiple types of regulations because each type serves a specific need and because residents may prefer having multiple regulations to better control the neighborhood's housing stock.

a residential building can be. The third type of regulation are density restrictions—maximums on the percentage of lot coverage, minimum amounts of land per dwelling unit, lot size minimums, maximum numbers of dwelling units, and floor-to-area ratios.[5] However, municipalities rarely regulate density using the same combination of these regulations (see Appendix A.1). To allow cross-municipality comparisons, we consider the dwelling units per acre (DUPAC), which incorporate all density regulations, as a standardized measure of density restrictions.[6]

While the three types of zoning regulations have clear definitions, their interactions can be complex. Different regulations can impose binding constraints on housing supply in different neighborhoods. For example, if a neighborhood permits five units per acre, limits building height to 20 feet, and disallows multifamily housing, then at most five two-story single-family homes can be built. If multifamily housing is later allowed without changing the units per acre and height restrictions, some apartment buildings may be constructed, but there cannot be more than five housing units. Here, DUPAC acts as a binding constraint, and relaxing this regulation will increase housing supply.

We examine six regulatory scenarios in which one or two of the three major types of

[5] Greater Boston municipalities adopted broad-use zoning for, e.g., residential or commercial use and height restrictions after 1917. After World War II, municipalities found that these regulations "did not sufficiently limit the housing potential of a given lot" and adopted density regulations (MacArthur, 2019).

[6] See Appendix A.1 for discussion of DUPAC and other regulation details, Appendix A.3 on adoption of regulations across municipalities, and Appendix Figures E.1, E.2, and E.3 for maps of the three regulations.

regulations differ across a zoning regulation boundary. The first three columns in Table 1 show scenarios 1–3, in which only one type of regulation differs at the boundary. The next three columns show scenarios 4–6, in which two types of regulations differ at the boundary. Panel A shows the median difference in the differing regulations across each of the regulatory scenarios. Panel B shows the average share of allowable multifamily housing, height, and DUPAC within 0.2 miles of boundaries within each scenario. Appendix Figure A.7 shows the boundaries corresponding to the six scenarios across space.

3. Theoretical Framework

We present a theoretical framework to understand how zoning regulations can affect the number of housing units, floorspace, and housing prices within a city. Suppose there are n neighborhoods in a city, each with exogenous amenities A_n (e.g. green space, school quality).[7] Each neighborhood n has $j \in \{1, 2\}$ areas with different zoning regulations, $\bar{z}_{nj}$. Boundary b_n separates the two nj zoning areas in a neighborhood. Each zoning area nj has a fixed supply of land, $\bar{L}_{nj}$, which is subdivided into L_{nj} lots, each of uniform size ℓ_{nj}. M_{nj} is the (exogenously determined) number of households that live in a zoning area.

Household's Problem: The Cobb–Douglas utility for a household in zoning area nj, that earns income y_{nj}, over nonhousing consumption and residential floorspace (h^D_{nj}), which it rents from a developer at housing rent per square foot p_{nj}, is given by:

[7] While local public goods are not exogenous per se, they are determined at the municipality level rather than the neighborhood level; therefore, they will not vary across zoning areas within a neighborhood n.

$$u_{nj} = (y_{nj} - p_{nj} h_{nj}^{D})^{\alpha} (h_{nj}^{D})^{\beta}; \quad 0 < \alpha, \beta < 1. \tag{1}$$

Developer's Problem: A small-scale developer born into a zoning area nj chooses whether to construct housing. To construct housing, a developer rents a land lot ℓ_{nj} from an absentee landlord at land rent r_{nj} per lot. The developer chooses the number of housing units N_{nj} and the amount of building capital s_{nj} to maximize her profit π_{nj}:

$$\pi_{nj} = p_{nj} N_{nj} h_{nj}^{S}(.) - r_{nj}\ell_{nj} - k s_{nj} - q N_{nj} - \Gamma_{nj}; \quad h_{nj}^{S} = \left(\frac{s_{nj}}{N_{nj}}\right)^{\gamma_1} (\ell_{nj})^{\gamma 2}, \tag{2}$$

where h_{nj}^{S} is the per-housing-unit floorspace production function such that $0 < \gamma_1, \gamma_2 < 1$.[8] The cost of building capital k, e.g., the cost of cement, is taken as given since the city is small relative to the overall capital markets in the country. The cost of constructing each housing unit, q, e.g., the cost of separate entrances, is determined by the construction process, taken as given, and is the same across the city. Γ_{nj} is the fixed cost of development which affects the developer's decision to construct housing or not.

3.1 Regulatory Regimes and Equilibrium

Each zoning area imposes regulations $\bar{z}_{nj}$ on developers. The vector $\bar{z}_{nj} = \begin{pmatrix} \frac{\bar{N}_{nj}}{\ell_{nj}} & \bar{s}_{nj} & \mathbb{1}\{\bar{N} = 1\} \end{pmatrix}$ may include maximum dwelling units per land lot restrictions

[8] The building production function, $N_{nj} \left(\frac{s_{nj}}{N_{nj}}\right)^{\gamma_1} (\ell)_{nj}^{\gamma 2}$, implies that multifamily houses are built vertically and that there is only one housing unit per floor. An alternative building production function, as studied in Tokman (2024), divides the lot by the number of housing units instead of considering units as being added vertically. In Appendix B.2, we show that our baseline model's qualitative results hold for this alternative production function under decreasing returns to scale.

$\frac{\bar{N}_{nj}}{\ell_{nj}}$, maximum size restrictions $\bar{s}_{nj}$ (e.g., building height limits), or bans on multifamily housing $\bar{N}_{nj} = 1$. A larger $\bar{z}_{nj}$ indicates less restrictive regulations. For simplicity, we assume that the land lot size $\ell_{nj} = 1 \ \forall nj$.[9] Thus, the regulation vector becomes $\bar{z}_{nj} = \begin{pmatrix} \bar{N}_{nj} & \bar{s}_{nj} & \mathbb{1}\{\bar{N} = 1\} \end{pmatrix}$. Note that if the land size units are in acres, the first element of the vector directly corresponds to the DUPAC regulation.

In the zoning regulation vector above, one or more regulations may be active in a zoning area. For example, if the regulatory regime specifies a maximum number of units per lot that binds, $\bar{N}_{nj}$, the developer can choose the building size, s_{nj}. If this zoning area also prohibits multifamily housing, i.e., $\bar{N}_{nj} = 1$, the developer can still choose size s_{nj}. Conversely, if the regulatory regime specifies a maximum size that binds, $\bar{s}_{nj}$, the developer can choose the number of units, N_{nj}, unless multifamily housing is prohibited.[10]

Each of the regulatory regimes can result in a different housing market equilibrium. For brevity, we focus on the equilibrium under the regulatory regime where the maximum number of dwelling units allowed per land lot serves as a binding constraint for

[9] This assumption is valid as long as land size units are not small. In Appendix B.5, we consider an alternative regulatory regime with a land lot size $\ell_{nj} \neq 1$. The main equilibrium effects remain unchanged, indicating that our equilibrium effects are not primarily driven by the assumption that $\ell_{nj} = 1$.

[10] If the zoning area sets $\bar{s}_{nj}, \bar{N}_{nj}$ at high levels, the regulations may not bind, allowing the developer to solve an unconstrained profit maximization problem (Appendix B.4). A zoning area that sets both $\bar{s}_{nj}, \bar{N}_{nj}$ at levels that bind implies that developer is not free to choose either the number or the size of the units.

the developer, specifically $\bar{z}_{nj} = N_{nj}$. In Appendices B.3 and B.4, we illustrate how different equilibrium conditions arise under alternative regulatory regimes and compare these conditions with the baseline equilibrium. For the baseline regulatory regime, the profit function in Equation 2 can be rewritten as:

$$\pi_{nj}(p_{nj}, r_{nj}, s_{nj}; \bar{z}_{nj}, \gamma_1) = p_{nj}\bar{z}_{nj}\left(\frac{s_{nj}}{\bar{z}_{nj}}\right)^{\gamma_1} - r_{nj} - ks_{nj} - q\bar{z}_{nj} - \Gamma_{nj}. \tag{3}$$

Given a vector $[k, q, \bar{z}_{nj}, M_{nj}, \alpha, \beta, \gamma_1]$*, the equilibrium is a tuple* $[h^{D*}_{nj}, s^*_{nj}, p^*_{nj}, r^*_{nj}, L^*_{nj}]$ *where the following conditions are satisfied:*

1. Households choose floorspace h^{D*}_{nj} that maximizes their utility in Equation 1.
2. Developers choose s^*_{nj} to maximize their profits in Equation 3. Since identical developers face the same zoning regulations within a zoning area nj, they choose the same s^*_{nj}. Thus, within a neighborhood n, the only variation in the housing stock arises because of zoning regulation differences across zoning areas nj.
3. Zero-profit condition: Since there is free entry by developers born into each zoning area, developers make zero profits per land lot such that $\pi_{nj}(\cdot; \bar{z}_{nj}, \gamma_1) = 0$.
4. Land markets clear: $\bar{L}_{nj} = \ell_{nj}L^*_{nj} = L^*_{nj} \quad \forall nj$.
5. Housing markets clear: $M_{nj}h^{D*}_{nj} = N^*_{nj}L^*_{nj}h^{S*}_{nj} = \bar{z}_{nj}\bar{L}_{nj}h^{S*}_{nj} \quad \forall nj$.[11]

The equilibrium housing rent per square foot, p^*_{nj}, is:

$$p^*_{nj} = \left(\frac{M_{nj}\beta y_{nj}}{\bar{L}_{nj}(\alpha+\beta)}\right)^{1-\gamma_1}\left(\frac{k}{\gamma_1}\right)^{\gamma_1}\bar{z}_{nj}^{\gamma_1-1}. \tag{4}$$

[11] The equilibrium condition implies that positive shocks to population, M_{nj}, lead to lower housing floorspace (h^D_{nj}) demanded by households in nj, e.g., adult children co-residing with their parents.

The equilibrium per-housing-unit floorspace supply, h_{nj}^{S*}, is:

$$h_{nj}^{S*} = \left(\frac{M_{nj}\beta y_{nj}}{\bar{L}_{nj}(\alpha+\beta)}\right)^{\gamma_1} \left(\frac{\gamma_1}{k}\right)^{\gamma_1} \bar{z}_{nj}^{-\gamma_1}. \tag{5}$$

The land rent per lot, r_{nj}, is[12]:

$$r_{nj} = p_{nj}^{*}\bar{z}_{nj}^{1-\gamma_1}\left(\frac{\gamma_1}{k}\right)^{\gamma_1}\left(\frac{M_{nj}\beta y_{nj}}{\bar{L}_{nj}(\alpha+\beta)}\right)^{\gamma_1} - \gamma_1\left(\frac{M_{nj}\beta y_{nj}}{\bar{L}_{nj}(\alpha+\beta)}\right) - q\bar{z}_{nj}. \tag{6}$$

3.1.1 Effects of Zoning Regulations

We show how zoning regulations impact the housing market locally within the neighborhood through four key mechanisms. The first three—–the supply effect, the demand effect, and the option value—are well established in the literature. Our contribution is to formalize the role of the composition effect, whereby strict regulations can increase housing-unit floorspace, increasing the overall price per housing unit.

Supply Effect: From Equation 4, we can see that:

$$\frac{\partial p_{nj}^{*}}{\partial \overline{N}_{nj}} = \frac{\partial p_{nj}^{*}}{\partial \bar{z}_{nj}} = (\gamma_1 - 1)\cdot\left(\frac{M_{nj}\beta y_{nj}}{\bar{L}_{nj}(\alpha+\beta)}\right)^{1-\gamma_1}\left(\frac{k}{\gamma_1}\right)^{\gamma_1}\cdot\bar{z}_{nj}^{\gamma_1-2} < 0. \tag{7}$$

The equilibrium housing rent per square foot of floorspace falls as $\bar{z}_{nj}$ increases because less restrictive zoning regulations increase the supply of housing units.[13]

Demand Effect: From Equation 4, note that $\frac{\partial p_{nj}^{*}}{\partial M_{nj}} > 0$. Exogenous demand shocks to a zoning area result in higher housing rent per square foot. A positive demand effect can arise either because of city- or neighborhood-wide demand shocks, yielding similar

[12] See Appendix B.1 for model details.

[13] Note that Equation 4 decreases with the fixed supply of land $\bar{L}_{nj}$. Thus, if regulation changes, such as reduced greenbelts, increase developable land, housing rent per square foot will decline.

effects in both zoning areas within a neighborhood n, or because of differential demand shocks in zoning areas $n1$ and $n2$ within the same neighborhood n.

Option Value: From Equation 6, we can see that $\frac{\partial r_{nj}}{\partial \bar{z}_{nj}} > 0$. Thus, the land rent per lot increases as $\bar{z}_{nj}$ increases because less restrictive zoning regulations increase the option value of land, which can now be used for denser housing (e.g., buildings on smaller lots) or for single-family or multifamily housing.

Composition Effect: From Equation 5, we can see that:

$$\frac{\partial h_{nj}^{S*}}{\partial \bar{z}_{nj}} = -\gamma_1 \cdot \left(\frac{M_{nj} \beta y_{nj}}{\overline{L}_{nj}(\alpha + \beta)} \right)^{\gamma_1} \left(\frac{\gamma_1}{k} \right)^{\gamma_1} \bar{z}_{nj}^{-\gamma_1 - 1} < 0. \tag{8}$$

The equilibrium housing-unit floorspace increases as zoning regulations become stricter. This increase may involve a greater number of bedrooms, bathrooms, etc. Since both housing rent per square foot (Equation 7) and housing-unit floorspace (Equation 8) increase as regulations become more restrictive, the price per housing unit, $P_{nj}(p_{nj}^*, h_{nj}^{S*}) \equiv p_{nj}^* h_{nj}^{S*}$, also increases with more restrictive zoning. Thus, by altering the size of housing units, stricter zoning regulations increase the price per housing unit P_{nj}. The mechanism of the composition effect driving housing size differences across zoning areas is novel in the literature on how zoning regulations affect housing markets.

3.1.2 Model Limitations and Extensions

Note that this framework excludes household decisions regarding zoning area choice since the primary aim is to illustrate how regulations can impact the housing market across boundaries within small neighborhoods, which we can effectively do by taking the location choice as given. In addition, since our empirical setting is at a narrow bandwidth around zoning boundaries, where we show continuity in neighborhood characteristics, we do not incorporate heterogeneity across households in the baseline model. However, we show that both p^*_{nj} and h^{S*}_{nj} increase as incomes y_{nj} rise (see Appendix B.6). This indicates that if the income of households increases (decreases) in a zoning area, the equilibrium price per square foot and the size of housing units would also increase (decrease). Lastly, the theoretical framework is static, even though the durability of housing introduces a dynamic element to the housing market. We focus on a static model primarily due to the lack of data spanning decades to analyze the dynamics associated with durability. However, the vector $\bar{z}_{nj}$ can be interpreted as a reduced form vector that also encapsulates durability dynamics—housing durability implies that past regulation levels serve as a binding constraint in the present-day equilibrium.

4. Empirical Strategy

To study the effects of zoning regulations on the housing market, we implement an RD design leveraging the boundary b_n separating the two zoning areas nj within a neighborhood n, which we define in Section 4.4, inside a municipality. In our baseline estimation, we study the effects of six zoning regulatory scenarios close to a regulatory boundary (within 0.2 miles on either side) for two reasons. First, we can show continuity in neighborhood amenities A_n close to the boundary across the two zoning areas. Second, households close to the boundary in zoning areas $n1$ and $n2$ are exposed to the same immediate neighbors and neighborhood density levels, which further ensures continuity across the boundaries. As we examine the impact of zoning regulations instituted in the early to mid-20th century on housing supply, type, characteristics, land values, and prices and rents per housing unit (P_{nj}) in the 21st century, the results are best interpreted as long-run differences across zoning regulation boundaries.

4.1 Nonparametric Model

We estimate nonparametric differences in housing supply, characteristics, prices, rents, and land values across regulatory boundaries following Bayer et al. (2007). We estimate the following model:

$$Y_{it} = \eta_0 + \sum_{\substack{x(i)=\underline{x} \\ x(i)\neq 0 \text{ to } 0.02}}^{\overline{x}} \eta_x \delta_{x(i)} + \lambda_{b_n(i)} + \phi_t + \epsilon_{it} \tag{9}$$

The dependent variables Y_{it} for a housing unit i in year t located in bin x of distance d to the boundary $b_n(i)$, where $b_n(i)$ is at distance $d = 0$ include the number of housing units, lot size in acres, built area in square feet, number of bedrooms and bathrooms, log sale price for single-family homes, log monthly rent for multifamily buildings, or log of assessed land value. η_x quantifies the total treatment effect of a regulatory scenario at distance bin x, where $-0.2 = \underline{x} \leq x \leq \overline{x} = 0.2$ miles and $\delta_{x(i)}$ is an indicator variable for housing unit i located in bin x. The width of each distance bin x is 0.02 miles, which corresponds to the average optimal bandwidth calculated according to Calonico et al. (2020) across the six scenarios (see Appendix C.1 for details on the optimal bandwidth calculation). Negative distances indicate the more strictly regulated side. We normalize the coefficient on bin x on the less regulated side (0 to 0.02 miles) to zero. $\lambda_{b_n(i)}$ is the boundary fixed effect, which captures unobserved differences at the boundary.

For the effects of the six regulatory scenarios on the number of housing units per lot and unit characteristics, we report estimates for a snapshot at $t = 2018$ and restrict the sample to units built after the adoption of the first zoning restrictions in 1918 so that our estimates on housing supply and characteristics are not confounded by pre-adoption grandfathered-in residential structures. When we study the effects of the regulatory scenarios on single-family sale prices, monthly multifamily rents and land assessed values, $t = $ 2010–18 for all housing units in our sample, no matter the build year. ϕ_t is the sale year fixed effect, applicable when the outcome variable is sale price, or year fixed effect, applicable when rent or land assessed value is the outcome.

4.2 Semiparametric Model

We also consider a semiparametric RD model that provides estimates of the marginal impact of a one-unit change in regulation and the interaction effects between two regulations. In Section 6, we apply this model to evaluate Massachusetts's Chapter 40A upzoning policy. Additionally, we use it to study the regulation effects on the type of building. The semiparametric regression model is given by:

$$Y_{it} = \rho_0 + \rho_1 \text{reg}^1_{nj(i)} + \rho_2 \text{reg}^2_{nj(i)} + \rho_3 \text{reg}^1_{nj(i)} \text{reg}^2_{nj(i)} + f^{n1}_{-d(i)} + f^{n2}_{d(i)} + \lambda_{b_n(i)} + \phi_t + \epsilon_{it}. \quad (10)$$

The dependent variables Y_{it} are the same as those for the nonparametric model but also include an indicator for the building type—either two- or three-unit buildings or four- or more-unit buildings relative to single-family homes. $\text{reg}^m_{nj(i)}$ for $m \in 1, 2$ is a continuous measure of the DUPAC or height (in 10-foot units) or an indicator for whether multifamily houses are allowed in housing unit i's zoning area. ρ_1 and ρ_2 are estimates of the marginal effects of each regulation individually, while ρ_3 shows the interaction effect between two types of regulations. For scenarios 1, 2, and 3, where only one regulation differs at the boundary, $\rho_2, \rho_3 = 0$. $f^{n1}_{-d(i)}$ and $f^{n2}_{d(i)}$ are nth-degree polynomials in the distance $-0.2 \leq d \leq 0.2$ of housing unit i to the boundary $b_n(i)$, varying from a linear to a third-degree polynomial, specified separately on both sides of the boundary.

4.3 Exploring Mechanisms Behind Price Differences

The baseline nonparametric and semiparametric models estimate the per-housing-unit price and rent ($P_{nj} \equiv h^*_{nj}p^*_{nj}$) differences across boundaries. Additional specifications help us understand the role of the four mechanisms—the composition effect, option value, supply effect, and demand effect—in creating these price differences.[14]

Composition Effect: Since the differences in house characteristics across boundaries operate through differences in zoning regulations across zoning areas nj (Equation 8), controlling for housing-unit characteristics in our empirical models isolates the role of the composition effect in driving the housing-unit price and rent differences across regulation boundaries. In principal, if we could observe all the housing unit characteristics, the residual per-housing-unit sale-price differences for single-family houses would arise from the option value effect or supply and demand effects, and the residual per-housing-unit monthly rent differences for multifamily houses would arise only from the supply and demand effects, as there is no option value effect in rental prices. In practice, we can control only for observable housing unit characteristics. Thus, the remaining price effects, after we control for housing unit characteristics, could also arise from housing-unit characteristics that are unobserved to the econometrician.

Option Value: Ideally, one would use the sale price for vacant lots to study the option value mechanism. However, in Greater Boston, vacant lots constitute only 0.04% of land

[14] The baseline effects close to the boundary exclude the externality effects of zoning regulations, which reflect the value of one's neighbors' zoning. See Section 5.6 for a discussion of these effects.

lots and are geographically dispersed, with only 158 lots within 0.2 miles of the boundaries (see Appendix E.7). Instead, we use the log of assessed land values per square foot as an outcome variable in the empirical models to study the role of option value.[15]

Disentangling Supply and Demand Effects: Since we are estimating the long-run differences across boundaries in the 21st century, a supply effect on prices could arise if the number of housing units was below the levels permissible under zoning regulations in 2010, and a demand effect on prices could arise if there were zoning area–wide, neighborhood-wide, or city-wide demand shocks between 2010 and 2018. In general, we cannot disentangle demand and supply effects on prices without a shifter that affects supply but not demand or vice versa. However, we can isolate the demand effect from the supply effect by focusing on boundaries where the number of housing units was already at the regulation level on both sides of the boundary such that there would not be a supply effect observed between 2010 and 2018. To estimate the role of the demand effect at these boundaries, we estimate the models with controls for the housing unit characteristics (the composition effect). The remaining price difference at these boundaries then arises only from the demand effects for multifamily housing rental units and from either the option value effect or the demand effect for single-family housing units.

4.4 RD Boundary Selection

Zoning boundaries are not randomly drawn across space. In many cases, they overlap with municipal and school boundaries and natural features such that neighborhood

[15] We discuss caveats of biased assessed values (Avenancio-León and Howard, 2022) in Section 5.5.

amenities A_n are not continuous across zoning area boundaries b_n. Such discontinuities in amenities violate the assumption that relevant covariates other than the regulation treatment and outcome variables vary smoothly at regulatory boundaries.

To account for this non-randomness, we take several steps to arrive at a set of plausibly exogenous regulatory boundaries. There are 26,078 zoning boundaries along which at least one type of zoning regulation differs in the *Zoning Atlas* data. We remove 4,027 zoning boundaries that overlap with municipal borders, geographic features (lakes and waterways), and infrastructure (interstates and major roadways). Properties on either side of boundaries that overlap with these features cannot be considered similar because local public goods differ or because the boundaries represent physical barriers (for example, highways and rivers). Next, we remove zoning boundaries that overlap with elementary school catchment area boundaries (Kulka, 2020). We also remove zoning boundaries across which the zone-use type—residential or mixed use—differs since the amenities associated with different zone-use-type areas likely vary discretely at the boundary. After these boundaries are eliminated, 43% of the original boundaries remain (see Appendix A.6 for maps of step-by-step boundary selection). Finally, buildings are assigned to their closest zoning boundary within the same municipality, elementary school catchment area, and zone-use type, which forms a neighborhood n.

From Dain (2023) and Gallagher et al. (2024), we know that the zoning boundaries adopted initially in the early to mid-20th century often followed existing built structures and developers' decisions of that time. These boundaries curved around natural geographies and the pre-existing built environment, much of which we already removed. However, if curves not eliminated in previous steps correlate with unobserved differences in neighborhood quality today (Sood and Ehrman-Solberg, 2026), it would violate the RD continuity assumption. To address this, we restrict our sample to properties assigned along straight-line boundary segments, following Turner et al. (2014).[16]

This results in a final sample of plausibly exogenous boundaries, whose orientation, length, and location may have been historically relevant to city planners and developers but arguably are no longer significant decades later. The final sample includes 2,835 zoning boundaries, which constitute 10.9% of the original sample (Appendix A.6). The average boundary length for the final sample is 0.35 miles, longer than the original average boundary length of 0.2 miles. Our boundary selection strategy leads us to remove shorter boundary segments, which are likelier to be endogenously determined.

4.5 Testing Spatial RD Assumptions

To test if relevant covariates are continuous across boundaries, we estimate Equation 9 using measures of land quality and neighborhood amenities as dependent variables. Table 2 shows the parameter estimate η_x for the distance bin x on the more regulated side (–0.02 to 0 miles). Standard errors are clustered at the boundary level to account for spatial correlation.

There are, for the most part, no statistical differences in the land quality measures that can affect construction costs—slope over 15°, average lot slope, depth to bedrock,

[16] We draw a straight line between a building and its boundary. We draw a second line of 100 meters with a midpoint where the straight line meets the boundary, with 50-meter segments on each side. If both endpoints are within 15 meters of the boundary, the building lies on a straight segment of the boundary.

and percent of sand and clay in soil—for lots on either side of the boundaries (Table 2, Panel A). In Panel B, for almost all the scenarios, the differences in commuting distance to central Boston and Euclidean distance to the assigned elementary school, municipality center, nearest major body of water, green space, and highways for all housing units on either side of the boundaries are not statistically distinguishable from zero.[17] In addition, for almost all the scenarios, the differences in walkability index value and mix of establishment types (such as retail, office, or industrial) for all housing on either side of the boundary are not statistically distinguishable from zero. However, for a few land quality and neighborhood amenity measures, we do observe a statistically significant jump at either one or two of the six types of regulatory boundaries. In Section 5.6, we show that none of the key results are driven by any of these covariate differences.

When we investigate the continuity of land and neighborhood amenities by regressing the log single-family home sale prices and monthly multifamily rents on the measures in Panel A and B and test for discontinuities in predicted prices or rents, we find no statistically significant jumps for any scenarios (Panel C). While Table 2 displays the covariate continuity for the -0.02- to 0-mile distance bin, we find no differences for bins farther from the boundaries (between -0.2 to 0.2 miles; see Appendix Figures C.1 and C.2). Since we find continuity across zoning boundaries on a wide range of covariates, we are confident that the final sample of straight-line boundaries is plausibly exoge-

[17] We use the Euclidean distance since, in our sample, the Euclidean and walking distance between a building and its nearest neighbor across the boundary are highly correlated (Appendix E.6).

nous.[18]

Incidentally, when we test for continuity of land quality and neighborhood amenities across the regulation boundaries that overlap with municipal boundaries, as is standard in the literature (Turner et al., 2014; Song, 2025), we find discrete jumps on many of the land quality and amenity measures across boundaries, especially where multifamily zoning changes at the boundary (see Appendix Table C.2). These findings further support our decision to use straight-line boundaries within neighborhoods of a municipality.

4.6 Comparison across regulatory scenarios

If the six regulatory scenarios are not randomly assigned to boundaries across space, comparing results across scenarios may be problematic due to unobserved factors influencing both local average treatment effects and assignment of scenarios to boundaries. We use a t-test to evaluate differences in neighborhood characteristics within both sides of the boundaries across scenarios (Table 1, Panel C). For the first five scenarios, differences in age, race, travel distance to central Boston, transport mode, or education level are minimal. However, for scenario 6, significant differences arise due to its boundaries being mainly near central Boston, unlike the spatially dispersed boundaries of the other scenarios. Thus, we can compare our estimates across the first five scenarios, but

[18] We also test for discontinuity in the residuals from a regression of log single-family home sale prices and monthly multifamily rents on land and neighborhood amenities, regulation levels, and housing-unit characteristics, finding no significant jumps across most boundaries (Appendix Table C.3).

for scenario 6 we specify potential caveats when discussing results in Section 5.

5. Results

5.1 Effects on the Number of Units per Lot

Our first finding is that the largest effects on housing supply occur at boundaries across which the restrictiveness of DUPAC regulations declines with allowing for multifamily housing. Figure 1 displays the nonparametric differences in the number of housing units per lot across zoning boundaries as estimated from Equation 9. The parameter estimate (η_x), 95% standard errors clustered at the boundary level (in parentheses), and robust standard errors (in brackets) are reported for the –0.02- to 0-mile distance bin x.

For boundaries across which only DUPAC regulations change, there is an average jump of 0.1 housing units per lot, reflecting a 7% increase over the average of 1.6 units per lot on the strict side of the boundary. At boundaries across which both DUPAC and multifamily housing regulations are less restrictive, the average number of units jumps by 62%. Looser DUPAC and height regulations together result in an 85% jump. Looser multifamily housing regulations alone lead to a 50% increase at the boundary. In scenarios where height regulations change either alone or along with regulations on multifamily housing, we find no long-run differences in the number of housing units across boundaries. These null effects suggest that height regulations are not a binding constraint for developers at the regulations' current levels. Instead, housing supply is likely limited by area-wide density restrictions and the difficulty of constructing multifamily housing. While height restrictions do not limit supply in Greater Boston, they can act as a binding constraint in other US cities, such as New York (Brueckner and Singh, 2020).

5.2 Effects by Type of Housing

Our second key finding is that while looser DUPAC restrictions, alone or with other less restrictive regulations, increase the number of housing units, allowing multifamily zoning changes the types of buildings. Table 3 shows the coefficients ρ_1, ρ_2, and ρ_3 from Equation 10, which analyzes the effects on housing supply of two types of multifamily buildings—–those with two or three units and those with four or more units—–compared to single-family housing. Allowance of multifamily housing, either alone or alongside looser DUPAC regulations, increases the number of 2- or 3-unit buildings in a neighborhood relative to the number of single-family homes. When multifamily housing is allowed alone (column 1), the frequency of 2- or 3-unit buildings relative to that of single-family homes rises from an average of 0.08 on the stricter side of the boundary to 0.48. At boundaries across which multifamily housing and DUPAC regulations are looser, the frequency of 2- or 3-unit buildings is 107% higher where multifamily regulation is allowed and 1.2% higher for each additional unit allowed by a loosening of DUPAC (column 2).[19] The effects on buildings with four or more units are less precisely estimated because of smaller sample size or other confounding barriers like higher costs and greater community opposition. We continue to find null effects of looser height regulations alone or with allowance of multifamily housing (Appendix Table C.4).

[19] Note that $(0.005+0.016*11.17)/0.171=1.07$ and $0.016-0.004 = 0.012$. The joint effect F-statistics are 19.03 for DUPAC and 30.43 for allowing multifamily homes.

5.3 Effects on Housing Characteristics

Our third key finding is that restrictive zoning regulations increase housing unit size, consistent with our theoretical result (Equation 8). For boundaries at which only DUPAC regulations change, there is a notable jump in lot size, housing unit living area, and number of bedrooms and bathrooms (Figure 2). For boundaries at which both DUPAC and multifamily-housing regulations differ, we also observe a jump in living area and number of bedrooms and bathrooms. Across boundaries at which both DUPAC and height regulations are looser, we find no differences in housing characteristics. As highlighted in Section 4.6, regulatory scenario 6 boundaries are mainly located closer to central Boston, and while there are differences in the number of housing units across these boundaries, the characteristics of the units on both sides are statistically similar.[20]

5.4 Baseline Total Price Effects

Our fourth key finding is that looser DUPAC regulations either alone or with other regulations reduce housing prices. When only DUPAC regulations are looser across the boundary, per-housing-unit sale prices for single-family homes on the more relaxed side are 4.4%, or $27,449, lower than the mean single-family sale price on the stricter side of the boundary (Figure 3). At boundaries across which DUPAC and multifamily-housing regulations are looser, sale prices are 2.2%, or $13,517, lower than the mean single-family price on the stricter side. We find no statistical differences in sale price at

[20] Similar to our finding of null effects on housing unit numbers and types, we find no significant differences in housing characteristics at boundaries across which height regulations change (Appendix Table C.8).

boundaries across which DUPAC and height regulations differ or only multifamily regulation differs, even though we find supply effects at these boundaries.[21] At boundaries across which only DUPAC regulations are looser, per-housing-unit monthly multifamily rents are 7%, or \$104, lower than the mean rent on the strict side.[22] Across boundaries where DUPAC and height regulations are looser, multifamily rents are an average of 4%, or \$56, lower than the mean rent on the restrictive side (see Appendix C.4 for details).

5.5 Mechanisms Behind Price Effects

Composition Effect: Our fifth key finding is that the composition effect is the primary driver of the baseline price differences across regulation boundaries in Figure 3. After controlling for house characteristics in Equation 9, we find no statistically significant differences in prices or rents for boundaries across which DUPAC changes alone or in combination with multifamily regulation (Figures 4a–4c). However, the composition effect does not drive the rent differences at boundaries across which DUPAC and height regulations differ (Figure 4d). This is expected as housing characteristics do not change across these boundaries, indicating that rent differences across boundaries corresponding to scenario 6 may stem from unobserved characteristics or other mechanisms.

[21] Looser height regulations or multifamily zoning have no supply impact, so price differences here may arise from option value or demand effects, though we find no evidence for this (see Appendix Figure C.6).

[22] We cannot study rent differences where multifamily-housing regulation differs across the boundary, as no multifamily rents are observed on the strictly regulated side of the boundary.

Option Value: We find a strong option value effect under looser DUPAC regulations alone or in combination with one of the other two types of regulations (Figures 4e–4f). We find little evidence of a systematic option value effect where multifamily and height regulations change alone or together (see Appendix Figure C.7). These results further bolster our first findings that not all regulations are equally effective and that density regulations are a primary binding constraint on new development in Greater Boston.

Disentangling Supply and Demand Effects: For boundaries at which the surrounding housing units already matched zoning regulations in 2010, we should observe no supply effect between 2010 and 2018.[23] After controlling for housing unit characteristics (the composition effect), we find no statistical differences in housing prices or rents across the subsample of boundaries for which units were already at regulation levels (see Table C.11). Regarding multifamily rents, for which there is no effect of zoning on option value, we can conclusively say that there is no difference in the demand effect across boundaries between 2010 and 2018 for the subset of boundaries for which zoning binds supply. For single-family sale prices, across this subset of boundaries, it is the case either that differences in the demand effect across the boundaries are not a major driver of the price effects or that price effects from the demand effect are equal to and opposite the option value effect—we cannot disentangle these two mechanisms with our methods.

Taking Stock: We note that our estimates are local average treatment effects based on

[23] These boundaries are defined as where $\geq$ 15% of the units on both sides—approximately half or slightly less of the baseline sample observations—already matched regulatory specifications.

housing units within 0.2 miles of a regulation boundary. Like all RD designs, these results may not generalize beyond this sample. However, they reveal two key findings. First, not all regulations are the same, and only a relaxation of those regulations that bind supply and characteristics (which may vary from city to city) will affect housing supply and prices. Second, the role of the composition effect of zoning can be crucial. Local differences in per-unit housing prices and rents can be driven by the effect of regulations on housing characteristics, with quality-adjusted prices showing little change across boundaries. Instead, looser density regulations allow smaller housing units to be built, which can cause prices and rents to fall. Thus, zoning regulations raise the entry cost in highly regulated areas, even within neighborhoods in a municipality.

5.6 Robustness and Additional Results

Alternative Analysis Samples: The impact of regulations on housing supply, type, and characteristics is consistent, regardless of the build year cutoff used, whether it's 1918 (baseline), 1956 (the year before density regulations were adopted), or no year restriction (see Appendix Figures C.3, C.4, C.5 ,and Tables C.6 and C.7). Another concern is that rent results may be affected by how we impute rents for certain multifamily units. While CoStar and imputed rents align with American Community Survey data, we overestimate units with rents between $500 and $1,400 (Appendix A.4), which could introduce upward bias in estimates if low rents are imputed on the less restrictive side of the boundary. Excluding these units shows rent differences are similar across boundaries where only DUPAC differs, but boundaries where both DUPAC and height regulation differ yield less precise estimates due to fewer observations (Figures C.12a–C.12b).[24] In addition, while the literature mainly examines minimum lot size (MLS) within broader density regulations, comparing MLS with DUPAC is insightful. We find that MLS impacts prices and rents similarly to DUPAC regulations (see Appendix C.7).

Controlling for Neighborhood Quality Differences: Most covariates in Table 2 show no discontinuities at boundaries, though a few amenities vary across one or two scenarios. Controlling for relevant amenities across the different scenarios does not change the baseline results (Appendix Figures C.12c–C.12f), and our findings remain robust after controlling for block-level neighbor demographics (Appendix Figure C.9).

Removing Streets: If neighbors do not interact with each other across boundaries overlapping small residential streets, this would challenge the continuous amenities assumption. We exclude boundaries overlapping with any street, removing about half of the baseline boundaries. The results in Appendix Figures C.12g–C.12f remain similar to the baseline, albeit with slightly larger standard errors (see Appendix C.5.1 for details).

Alternative Definitions of Less Restrictive Boundary Side: When two types of regulations differ across a boundary, 68–89% of the associated observations correspond to boundaries where both regulations are stricter on one side than the other. In the remaining cases, our baseline estimation defines the strictly regulated side as the one where multifamily housing is not allowed (scenarios 4 and 5) or the height or DUPAC is lower (scenario 6). In Appendix C.5.2, we examine alternative ways of defining the less

[24] Including an indicator for imputed rents produces estimates similar to the baseline (Appendix Figure C.8).

restrictive side when regulations differ in opposite directions; we find that our baseline results either are robust to the alternative definition or offer a conservative estimate.

Externality Effects of Regulations: The baseline estimates for the distance bins near the boundary do not measure the externality effects of regulations, as neighborhood amenities remain continuous there. Further away, externality effects may still matter (Turner et al., 2014). In Appendix C.6, we show that externality effects beyond 0.15 miles are small and negative for sale prices at boundaries where density restrictions change and for rents where height regulations change with density, suggesting a negative willingness to pay for higher neighborhood density and height. Thus, our nonparametric estimates at the boundary likely underestimate the total impact of zoning regulations on prices and rents further away for scenarios involving density and height restrictions.

6. Policy Effects of Relaxing Regulations

We use our causal estimates to simulate the long-run effects of Massachusetts's 2021 Chapter 40A reforms, which mandated that municipalities permit multifamily housing and density of 15 units per acre within a 0.5-mile radius of train stations. Such small-scale upzoning reforms, particularly for areas near transit stations and commercial districts, are becoming a popular policy response (see Appendix E.1). Although it is too early to assess the actual effects of the 2021 reforms, we can simulate their long-run impacts. Given that our estimates from Section 5 reflect long-run effects over 60 years (during which Greater Boston's population rose by 59%), our counterfactual estimates represent long-run (~ 60 years) effects of the reforms, assuming a similar growth rate.[25]

To examine the effects of Chapter 40A, we increase the DUPAC to the maximum allowable 15 units and allow multifamily housing around existing regulatory boundaries within 0.2 miles of a train station. The new vector of regulations is denoted as $\bar{z}_{nj}^{40A}(d)$, while the pre-2021 vector is given by $\bar{z}_{nj}^{0}(d)$. The average change in sale prices, rents, and the number of housing units $(p_{nj}(d))$ at distance $\underline{d} = 0.2 \geq d \geq 0.2 = \bar{d}$ is given by Δp_{nj}.

$$\Delta p_{nj} = \frac{1}{\bar{d} - \underline{d}} \int_{\underline{d}}^{\bar{d}} \big(\max\{0, (\bar{z}_{nj}^{40A}(d) - \bar{z}_{nj}^{0}(d))\} \times \theta^c \times p_{nj}(d) \big) \mathrm{d}d \quad \forall nj; \tag{11}$$

$$\theta^c = \begin{cases} \hat{\rho}_1 & c = \text{regulatory scenarios 1, 2, 3} \\ \\ \hat{\rho}_1 + \hat{\rho}_3 \text{reg}_{nj}^1 + \hat{\rho}_2 + \hat{\rho}_3 \text{reg}_{nj}^2 & c = \text{regulatory scenarios 4, 5, 6,} \end{cases}$$

where θ^c is the average joint treatment effect of a marginal one-unit change in regulations from Equation 10 and $\text{reg}_{nj}^1 = 15$, $\text{reg}_{nj}^2 = 1 \; \forall nj$.[26]

We find that areas near 34% of the train stations already allow multifamily housing and have DUPAC $\geq$ 15 and should remain unaffected by the Chapter 40A reforms (gray triangles in Figure 5). First, the median long-run increase in housing supply is approximately 0.18 units per lot, a 23% increase, particularly notable in suburban areas closer to Boston (Figure 5a). Second, long-run multifamily-housing rents decrease by a median

[25] Our RD design is best suited for analyzing small-scale upzoning in developed urban environments, but not for assessing general equilibrium effects of zoning reforms in larger metros or mostly vacant areas.

[26] See Chiumenti and Sood (2022) and Appendix D for details. Chapter 40A's impact may be mitigated if housing durability limits new construction differently under Chapter 40A than captured by our estimates.

of \$88 per month, or 4.9%, mainly in municipalities further from Boston (Figure 5b).

Third, the effects of Chapter 40A on sale prices for single-family homes are spatially heterogeneous, with long-run prices increasing in some areas and decreasing in others (Figure 5c). This heterogeneity is driven by the positive interaction term ($\hat{\rho}_3$) for boundaries where DUPAC and multifamily regulations change together (Appendix D.1). In suburban municipalities with strict pre-2021 density regulations, the Chapter 40A upzoning will significantly lower the median sale prices for single-family homes by \$131,617 (8.5%). Conversely, in areas closer to central Boston, where housing density regulations are already looser, the marginal price effect of allowing multifamily housing is positive, indicating strong option value or demand effects, resulting in a moderate increase in the median sale price for single-family housing of \$5,735, or a mere 1.2%.[27]

7. Conclusion

This paper examines which zoning reforms are most effective in increasing housing supply and lowering prices. Using an RD design, we find that looser density regulations along with allowing multifamily homes increase housing unit supply per lot while looser density regulations—on their own or with less restrictive height and multifamily-housing regulations—reduce single-family-home sale prices and multifamily-housing rents in Greater Boston, where density restrictions are the binding constraint on new development. Thus, recent policy efforts allowing multifamily housing in Minneapo-

[27] The counterfactual estimates confirm theoretical results (Molloy et al., 2022), showing that upzoning effects are more substantial for prices than for rents in both magnitude and scope.

lis, California, and Oregon are likely to affect supply and prices only if this regulation is the binding constraint in these regions. We also theoretically and empirically show that more restrictive zoning regulations can affect housing-unit size and effectively increase per-unit prices by shifting the composition of the housing stock toward larger housing units. Last, our counterfactual results suggest that small-scale upzoning policies, such as Massachusetts's Chapter 40A law, could reduce rents and sale prices, particularly in suburban towns with strict zoning regulations.

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Table 1: Zoning-regulation scenarios

	(1)	(2)	(3)	(4)	(5)	(6)
Regulatory Scenarios (Sc.)	Sc. 1	Sc. 2	Sc. 3	Sc. 4	Sc. 5	Sc. 6
Panel A: Median regulation differences (Δ) across boundary						
Δ Multifamily	1	0	0	1	1	0
Δ Height (10 feet)	0	1.0	0	0.5	0	1.5
Δ DUPAC	0	0	3	0	4	22
Panel B: Mean regulation levels within 0.2 miles of boundary on either side						
Multifamily	0.5	0.5	0.6	0.5	0.5	0.8
Height (10 feet)	3.5	4.3	3.4	3.6	3.4	4.2
DUPAC	9.4	7.5	14.9	10.6	11.4	33.3
No. of Boundaries	90	77	900	37	441	275
Panel C: t-test of mean differences across regulatory scenarios						
Mean Share ≤ 18	0.210	0.207	0.220	0.231	0.223	0.185
(Difference)	(-0.010)	(-0.013)	-	(0.011)	(0.003)	(-0.035)***
Mean Share ≥ 65	0.139	0.133	0.139	0.145	0.143	0.114
(Difference)	(-0.000)	(-0.006)	-	(0.006)	(0.005)	(-0.024)***
Mean Share Black	0.060	0.064	0.049	0.087	0.125	0.089
(Difference)	(0.011)	(0.015)	-	(0.038)	(0.076)***	(0.040)***
Mean Share Asian	0.042	0.056	0.055	0.077	0.054	0.076
(Difference)	(-0.013)	(0.001)	-	(0.022)*	(-0.001)	(0.021)***
Transit Dist. to Central Boston	14.43	18.83	16.49	16.38	14.35	10.65
(Difference)	(-2.061)	(2.337)	-	(-0.112)	(-2.138)***	(-5.841)***
Mean Share Car or Bike	0.718	0.731	0.707	0.729	0.722	0.589
(Difference)	(0.011)	(0.023)	-	(0.022)	(0.014)	(-0.119)***
Mean Share with Bachelor's	0.200	0.188	0.203	0.185	0.177	0.170
(Difference)	(-0.003)	(-0.015)*	-	(-0.018)	(-0.026)***	(-0.033)***
No. of Boundaries	90	77	900	37	441	275

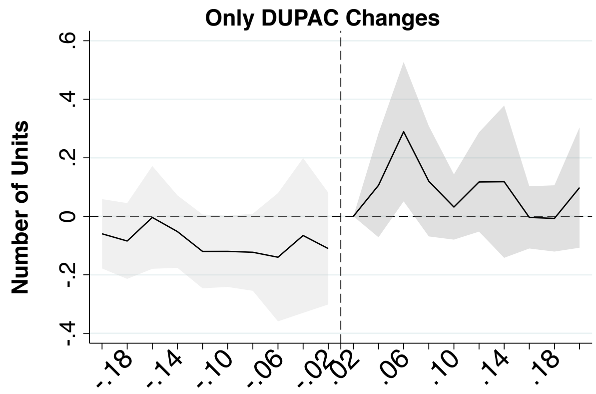
Note: Scenarios (Sc.) where multifamily (MF) housing (0 if not allowed, 1 if allowed), height, or DUPAC (dwelling units per acre) regulations differ at boundaries. Sc. 1 involves differing MF regulations, Sc. 2 differs in height, Sc. 3 differs in DUPAC, Sc. 4 differs in MF & height, Sc. 5 in MF & DUPAC, and Sc. 6 in DUPAC & height. Panel A displays median regulation Δ, Panel B shows mean regulations within 0.2 miles of the boundary. Panel C reports mean neighborhood characteristics on both sides of the boundaries across regulatory scenarios. Differences in means relative to Sc. 3 are in parentheses; t-test results for statistical difference: * p< 0.05, ** p< 0.01, *** p< 0.001.

Table 2: Balance tests for location quality

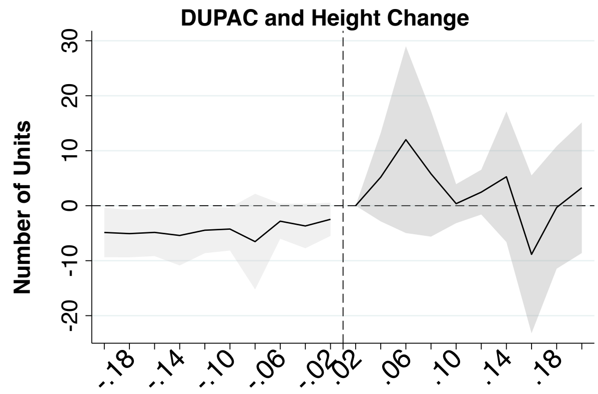
	Only MF		Only Height		Only DU		MF & Height		MF & DU		DU & Height	
	η_x	s.e.	η_x	s.e.	η_x	s.e.	η_x	s.e.	η_x	s.e.	η_x	s.e.
Panel A Dependent Variables: Land Quality												
Slope >15°	-0.013	(0.014)	-0.039*	(0.016)	-0.002	(0.010)	0.036	(0.029)	0.025	(0.014)	-0.003	(0.007)
Average Slope (°)	-0.182	(0.238)	-1.275	(0.658)	0.117	(0.207)	1.272*	(0.580)	0.226	(0.251)	0.144	(0.280)
Bedrock Depth (centimeters)	1.475	(2.601)	8.232	(8.814)	-3.441	(2.018)	-7.130	(7.814)	-1.493	(3.001)	-6.192	(4.084)
Percent Clay	0.057	(0.180)	-0.513	(0.365)	0.100	(0.074)	0.232	(0.249)	-0.084	(0.118)	0.266	(0.219)
Percent Sand	0.569	(1.174)	-4.089	(3.974)	-0.313	(0.586)	0.774	(1.107)	1.152	(1.046)	1.499	(2.250)
Observations	1,941		1,961		34,172		635		14,484		3,941	
Panel B Dependent Variables: Neighborhood Amenities												
Travel Dist. to Boston (miles)	-0.015	(0.022)	0.033	(0.032)	0.042	(0.039)	-0.036	(0.032)	-0.031*	(0.015)	0.004	(0.024)
Dist. to School (miles)	-0.000	(0.004)	0.015	(0.017)	0.004	(0.006)	-0.006	(0.011)	0.005	(0.005)	-0.005	(0.006)
Dist. to Muni. Center (miles)	0.010*	(0.005)	0.026	(0.019)	0.016*	(0.007)	-0.000	(0.013)	-0.003	(0.008)	-0.004	(0.005)
Distance to Water Body (miles)	0.002	(0.005)	0.044	(0.022)	-0.001	(0.003)	0.006	(0.005)	0.005	(0.003)	0.002	(0.006)
Distance to Green Space (miles)	0.003	(0.005)	0.053*	(0.026)	-0.004	(0.008)	-0.022	(0.011)	0.006	(0.007)	-0.007	(0.005)
Distance to Highways (miles)	0.004	(0.004)	0.029	(0.018)	0.011*	(0.005)	-0.006	(0.009)	0.005	(0.003)	0.008	(0.004)
Walkability Index	-0.925*	(0.400)	-0.313	(0.172)	-0.125	(0.096)	0.511	(0.382)	-0.176*	(0.081)	-0.197	(0.123)
Establishment Mix Index	-0.017	(0.034)	-0.014	(0.013)	-0.010	(0.009)	-0.011	(0.037)	0.004	(0.008)	0.002	(0.010)
Observations	2,298		2,593		42,702		753		17,184		4,570	
Panel C Dependent Variables: Predicted Sales Prices and Rents												
Predicted Log Sales Prices	-0.006	(0.009)	0.011	(0.008)	0.004	(0.004)	-0.002	(0.011)	0.006	(0.004)	0.014	(0.008)
Observations	1,824		2,391		44,053		837		15,031		2,669	
Predicted Log Monthly Rents	–	–	-0.026	(0.015)	0.001	(0.005)	–	–	–	–	-0.006	(0.005)
Observations			390		6,045						3,101	

Note: η_x from Equation 9 is for the –0.02- to 0-mile x bin. Predicted prices and rents (Panel C) come from regressing these prices on boundary fixed effects and Panels A and B variables. Standard errors (s.e.) are clustered at the boundary-segment level. * p<0.05, ** p<0.01, *** p<0.001. Observations cover all x bins from -0.2 to 0.2 miles. Labels "Only MF," "Only Height," & "Only DU" denote boundaries with differing regulations, while combinations like "MF & Height" indicate where two regulations differ. See Appendix Table C.1 for means for each dependent variable.

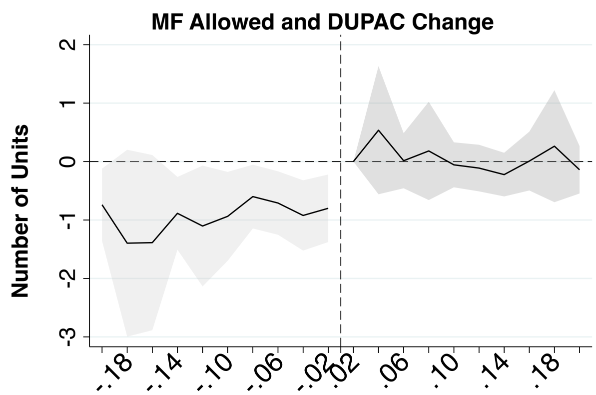
Figure 1: Effect of regulations on number of units per lot



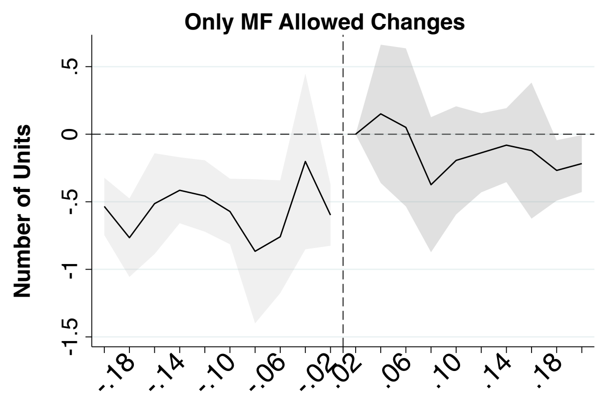
(a) η_x = -0.110 (0.097) [0.075], $\mathbb{E}(y)$ = 1.6, n (all x bins) = 33,940



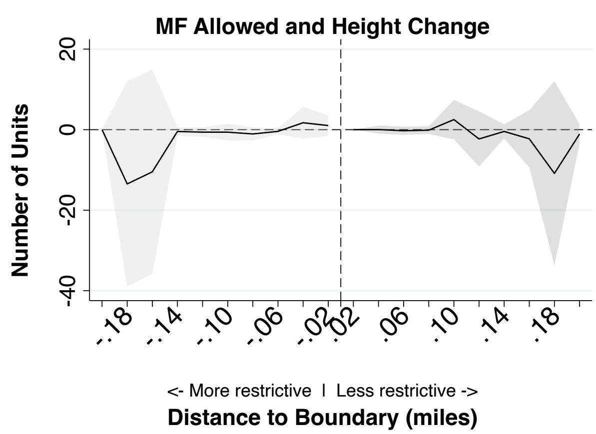
(b) η_x = -2.474 (1.532) [1.075]*, $\mathbb{E}(y)$ = 2.9, n (all x bins) = 1,806



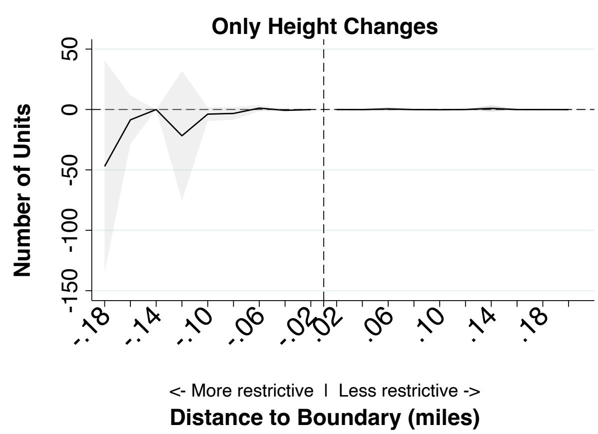
(c) η_x = -0.799 (0.294)** [0.253]**, $\mathbb{E}(y)$ = 1.3, n (all x bins) = 11,541



(d) η_x = -0.598 (0.114)*** [0.075]***, $\mathbb{E}(y)$ = 1.2, n (all x bins) = 1,535



(e) η_x = 1.022 (1.268) [1.109], $\mathbb{E}(y)$ = 2.3, n (all x bins) = 504



(f) η_x = -0.063 (0.293) [0.208], $\mathbb{E}(y)$ = 1.4, n (all x bins) = 1,854

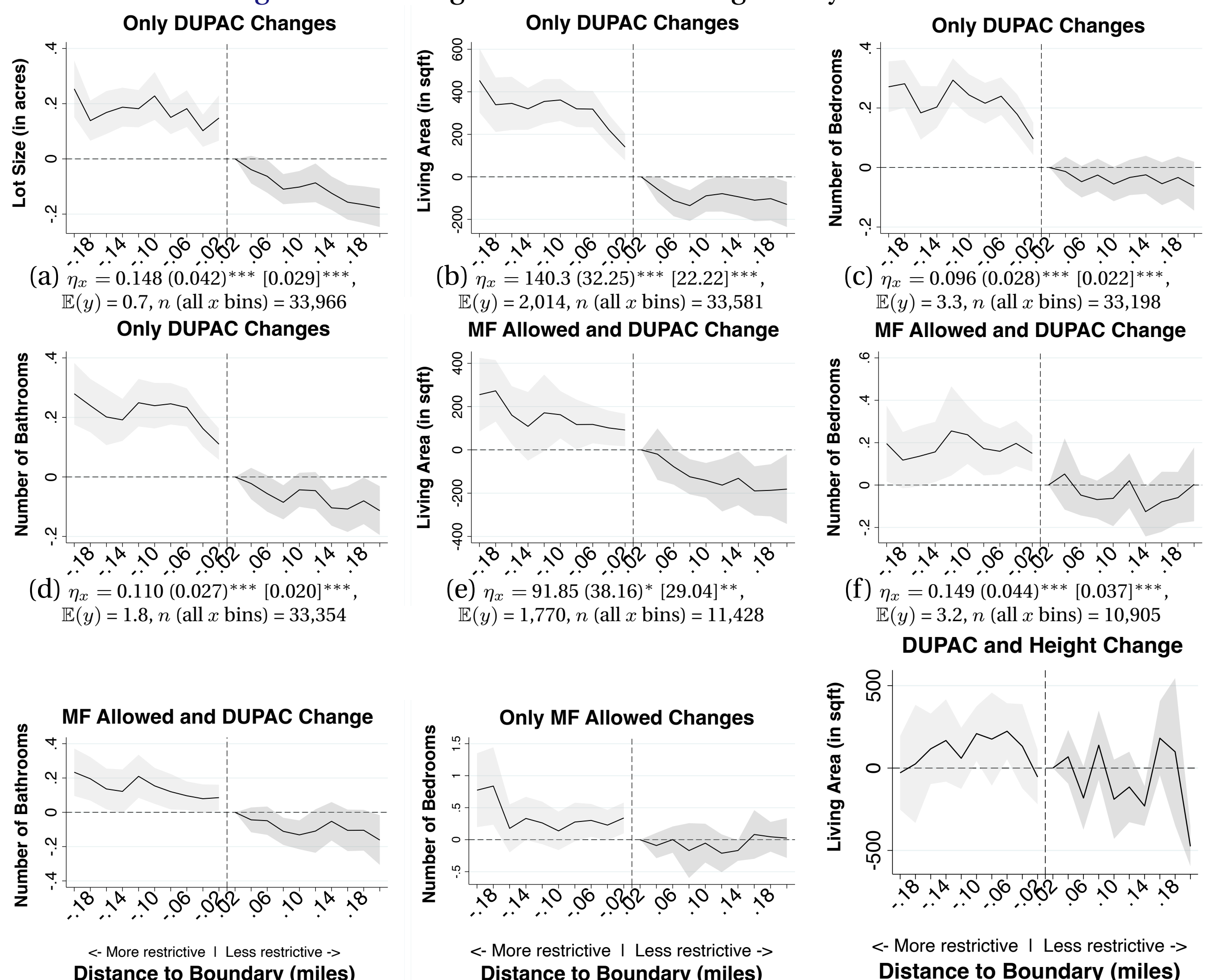
Note: η_x from Equation 9 is plotted for number of housing units built after 1918. DUPAC is dwelling units per acre. MF is multifamily. η_x, clustered boundary (parentheses) & robust standard errors (square brackets), & mean $\mathbb{E}(y)$ are reported for -0.02- to 0-mile x bin. * p< 0.05, ** p< 0.01, *** p< 0.001.

Table 3: Supply: Types of buildings across regulatory boundaries (built after 1918)

Dep. Var.:	$\mathbb{1}$[Building type = 2–3 units]		$\mathbb{1}$[Building type = 4+ units]	
Reg. Scenario:	Only MF	MF & DU	Only MF	MF & DU
	(1)	(2)	(3)	(4)
MF allowed	0.478***	0.005	0.016	0.006
	(0.098)	(0.025)	(0.012)	(0.015)
DUPAC (DU)		-0.004		0.001
		(0.004)		(0.001)
MFXDU		0.016***		0.002
		(0.003)		(0.002)
N	1,495	11,264	1,165	9,477
R^2	0.539	0.389	0.598	0.309
$\mathbb{E}(y)$	0.081	0.121	0.014	0.015
$\mathbb{E}$(DU)	8.90	11.17	8.90	11.17

Note: This table presents parameter estimates ρ_1, ρ_2, ρ_3 from Equation 10, where the dependent variable takes 0 if the building is a single-family home and 1 if the building is either a 2- to 3-unit building or 4- or more unit building within -0.2 to 0.2 miles around the boundary. All buildings were built after 1918. "Only MF" are boundaries where only multifamily-housing (MF) regulation differ. "MF & DU" are boundaries where MF and DU (DUPAC—dwelling units per acre) regulation differ. The unit on height is in 10 feet. This estimation uses a linear polynomial in distance to the boundary (f), though we obtain similar results with a cubic polynomial (Appendix Table C.5). Standard errors are clustered at the boundary level (in parentheses). $\mathbb{E}(y)$ and $\mathbb{E}$(DU) are the mean on the more restrictive side. * p< 0.05, ** p< 0.01, *** p< 0.001.

Figure 2: Housing characteristics at regulatory boundaries



(a) $\eta_x = 0.148$ (0.042)*** [0.029]***, $\mathbb{E}(y)$ = 0.7, n (all x bins) = 33,966

(b) $\eta_x = 140.3$ (32.25)*** [22.22]***, $\mathbb{E}(y)$ = 2,014, n (all x bins) = 33,581

(c) $\eta_x = 0.096$ (0.028)*** [0.022]***, $\mathbb{E}(y)$ = 3.3, n (all x bins) = 33,198

(d) $\eta_x = 0.110$ (0.027)*** [0.020]***, $\mathbb{E}(y)$ = 1.8, n (all x bins) = 33,354

(e) $\eta_x = 91.85$ (38.16)* [29.04]**, $\mathbb{E}(y)$ = 1,770, n (all x bins) = 11,428

(f) $\eta_x = 0.149$ (0.044)*** [0.037]***, $\mathbb{E}(y)$ = 3.2, n (all x bins) = 10,905

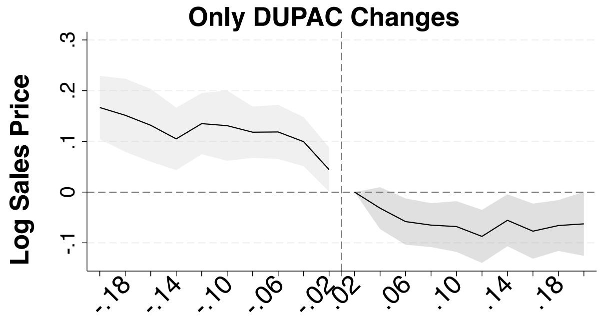
(g) $\eta_x = 0.086$ (0.038)* [0.029]**, $\mathbb{E}(y)$ = 1.6, n (all x bins) = 11,316

(h) $\eta_x = 0.340$ (0.121)*** [0.080]***, $\mathbb{E}(y)$ = 3.0, n (all x bins) = 1,501

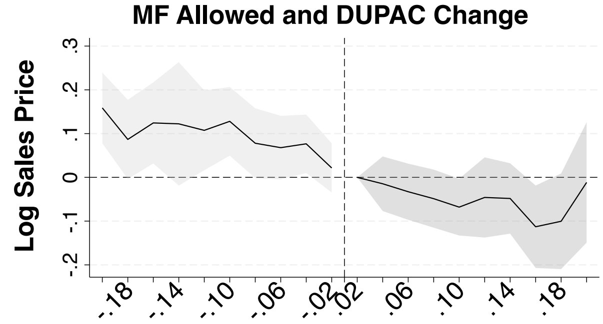
(i) η_x = -54.12 (84.10) [64.43], $\mathbb{E}(y)$ = 1,365, n (all x bins) = 1,734

Note: η_x from Equation 9 plotted for characteristics for housing built after 1918. DUPAC is dwelling units per acre. MF is multifamily. sqft is square feet. η_x, clustered boundary (parentheses) & robust standard errors (square brackets), & mean $\mathbb{E}(y)$ are reported for -0.02- to 0-mile x bin. * p< 0.05, ** p< 0.01, *** p< 0.001.

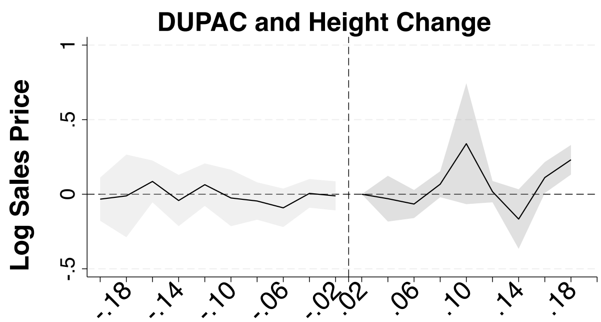
Figure 3: Effects of regulations on rents and sale prices



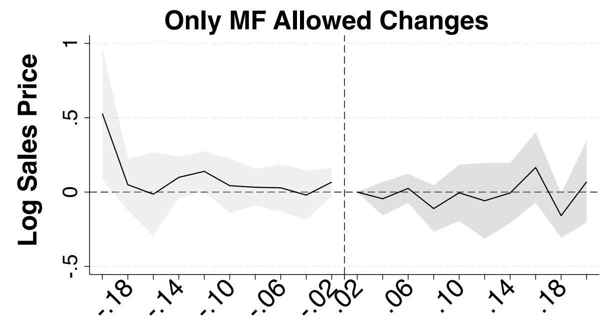
(a) $\eta_x = 0.044\ (0.022)^{*}\ [0.007]^{***}$,
$\mathbb{E}(y)$ = \$623,843, n (all x bins) = 56,561



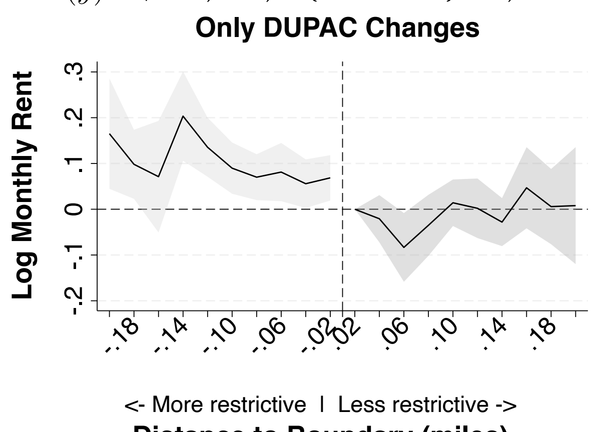
(b) $\eta_x = 0.022\ (0.029)\ [0.010]^{*}$,
$\mathbb{E}(y)$ = \$614,430, n (all x bins) = 18,815



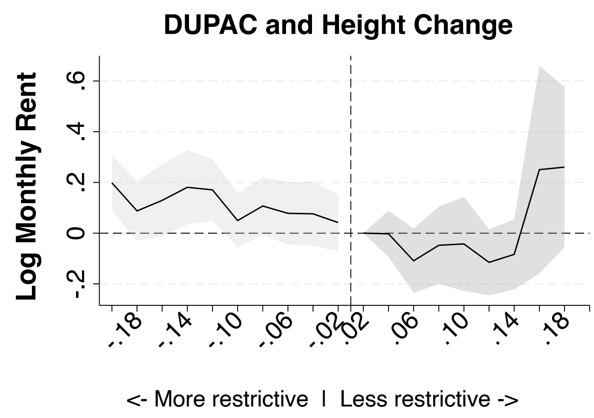
(c) $\eta_x =$ -0.011 (0.049) [0.019],
$\mathbb{E}(y)$ = \$526,963, n (all x bins) = 3,117



(d) $\eta_x = 0.067\ (0.047)\ [0.026]^{*}$,
$\mathbb{E}(y)$ = \$646,886, n (all x bins) = 2,178



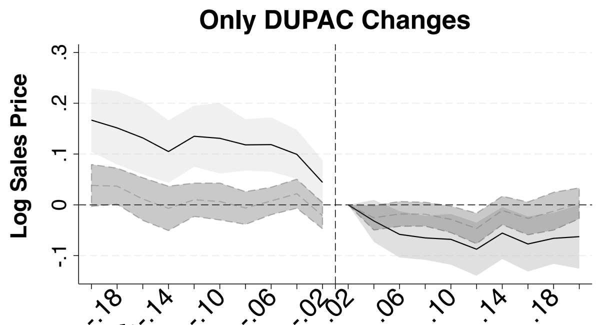
(e) $\eta_x = 0.069\ (0.025)^{**}\ [0.006]^{***}$,
$\mathbb{E}(y)$ = \$1,510, n (all x bins) = 50,374



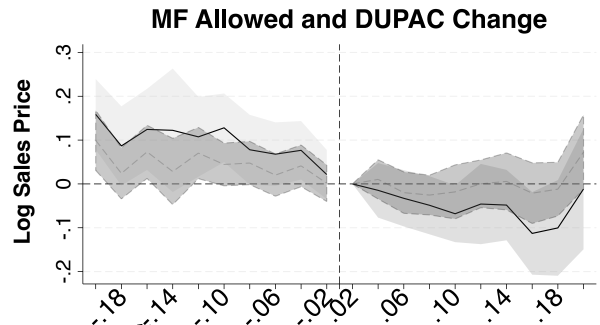
(f) $\eta_x = 0.042\ (0.057)\ [0.010]^{***}$,
$\mathbb{E}(y)$ = \$1,338, n (all x bins) = 21,925

Note: η_x from Equation 9 is ploatted for prices for single-family homes or rents for multi-family housing. DUPAC is dwelling units per acre. MF is multifamily. η_x, clustered boundary (parentheses) & robust standard errors (square brackets), & mean $\mathbb{E}(y)$ are reported for -0.02- to 0-mile x bin. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

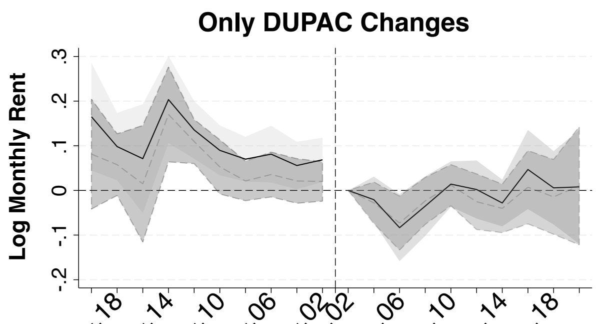
Figure 4: Mechanisms behind equilibrium price effects



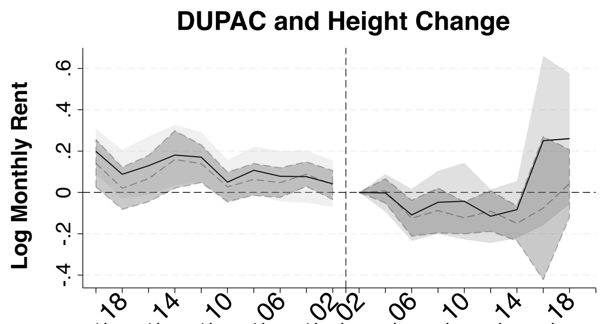
(a) Baseline $\eta_x = 0.044\ (0.022)^{*}\ [0.007]^{***}$, Comp. $\eta_x = \text{-}0.021 (0.013)\ [0.005]^{***}$



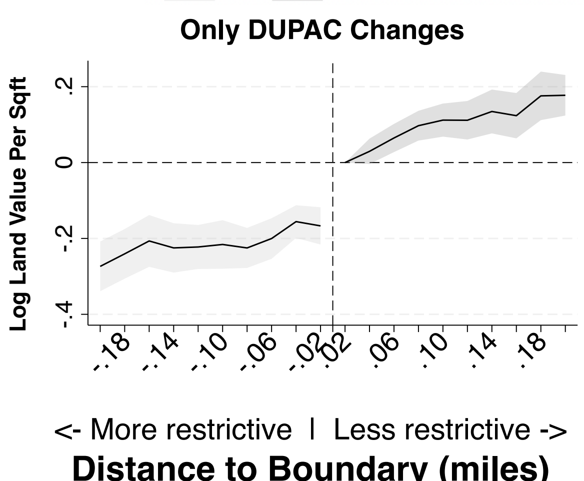
(b) Baseline $\eta_x = 0.022\ (0.029)\ [0.010]^{*}$, Comp. $\eta_x = 0.002\ (0.021)\ [0.009]$



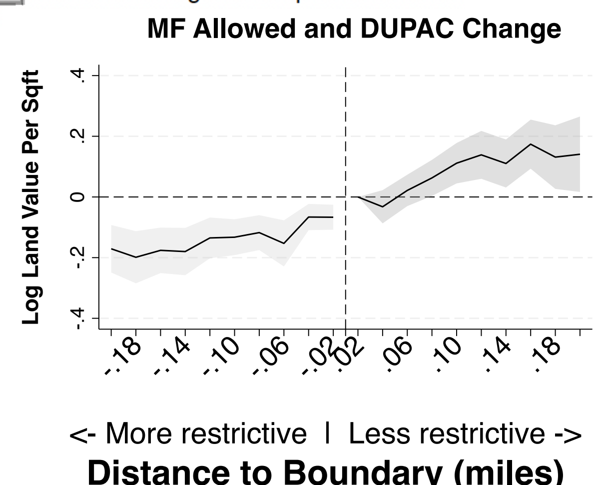
(c) Baseline $\eta_x = 0.069\ (0.025)^{**}\ [0.006]^{***}$, Comp. $\eta_x = 0.020\ (0.023)\ [0.006]^{***}$



(d) Baseline $\eta_x = 0.042\ (0.057)\ [0.010]^{***}$, Comp. $\eta_x = 0.036\ (0.036)\ [0.008]^{***}$



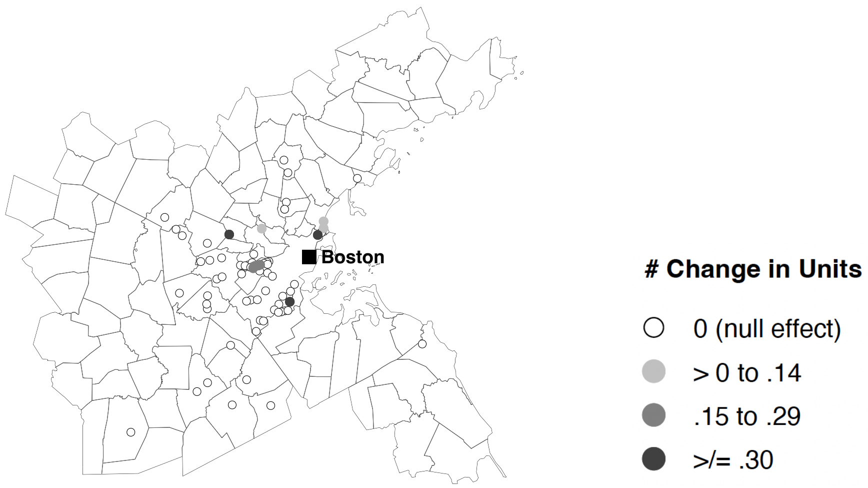
(e) $\eta_x = \text{-}0.167\ (0.025)^{***}\ [0.004]^{***}$, $\mathbb{E}(y)$ = \$36.81, n (all x bins) = 381,941



(f) $\eta_x = \text{-}0.067\ (0.021)^{**}\ [0.004]^{***}$, $\mathbb{E}(y)$ = \$26.00, n (all x bins) = 154,433

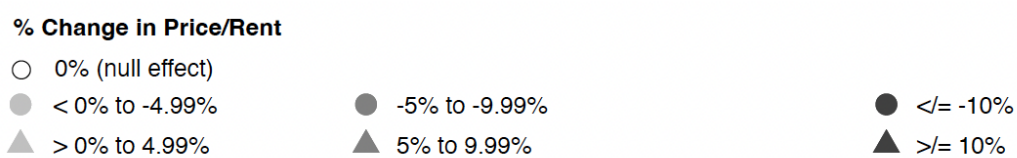
Note: η_x from Equation 9 is plotted for prices for single-family & rents for multifamily housing, or land value per square foot (sqft). DUPAC is dwelling units per acre. MF is multifamily. Composition-effect (Comp.) controls for house characteristics. η_x, clustered boundary (parentheses) & robust standard errors (square brackets), & mean $\mathbb{E}(y)$ are reported for -0.02- to 0-mile x bin.

Figure 5: Policy effects of Chapter 40A: Relaxing regulations near transit stations



(a) Δ in number of units

(b) Δ in monthly rents (c) Δ in single-family sale prices



Note: Average change (Δ) in housing units and % Δ in rents for multifamily and sale prices for single-family homes from relaxing regulations under Chapter 40A. Stations without zoning boundaries within 0.5-mile radius are omitted. Refer to Appendix Figure D.1 for a colored version of this figure.