How to Reduce Housing Costs? Understanding Local Deterrents to Building Multi-Family Housing[*]

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Abstract

This paper studies how local land-use regulations and local community opposition affect the trade-offs to build single-family, multi-family, or affordable housing and affect rent and housing prices differently. Using lot level zoning regulations and a boundary discontinuity design at regulation boundaries in the Greater Boston Area, we obtain causal estimates for the effect of zoning regulations on the supply of different types of housing, single-family house prices, multi-family rents, and households' willingness-to-pay for higher density. We find that relaxing density restrictions (minimum lot size and maximum dwelling units), either alone or combined with relaxing height restrictions or allowing for multi-family housing, are the most fruitful policy reforms to increase supply and reduce multi-family rents and single-family prices. However, enabling multi-family zoning or relaxing height regulations alone has little impact on increasing the number of units built and lowering rents. Moreover, each land-use relaxation scenario where the rental costs fall is accompanied by falling house prices, complicating the political economy of land-use reform. We also find that the mature suburbs closer to the city center with representative town meeting structure of local governance are most restrictive in adding multi-unit housing. Furthermore, inclusionary zoning policies like Chapter 40B rarely substitute for relaxing zoning policies, particularly for building multi-family housing.

Keywords: Multi-family zoning, height restrictions, density, house prices, rents

JEL: R21, R31, R58, H77, H11, K25

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1. Introduction

Housing affordability for poor renters has always been a significant challenge; however, even middle-income families now face more considerable affordability hurdles, particularly in cities with strong labor markets, including in the Greater Boston Area. Only 82 new building permits were issued for every 100 net new households in the Greater Boston Area in the past decade. Where people can afford to live has important implications for health, schooling, and economic mobility. Local barriers like land-use regulation and community opposition play a key role in determining what type of new housing is constructed, if any. This paper studies the impact of the combination of the key land zoning regulations and community opposition, particularly those limiting multi-family housing, on both rents and house prices, and the supply of different types of accommodation, including various types of multi-family housing.

Oregon, California, and Minneapolis have famously allowed for multi-family zoning in most or all of their jurisdictions since 2019.[1] Additionally, the literature has looked at the effect of a single regulation on supply and prices.[2] However, the interaction of zoning regulations is understudied, and it is unclear if allowing for multi-family zoning alone will yield the desired affordability results. It is also unclear which of the zoning regulations is binding in restricting the supply of new units. This paper studies the effects of multi-family zoning, maximum building height restrictions, minimum lot size, and maximum dwelling units per acre density restrictions, both alone and in combination, which negatively affect multi-family housing supply when restricted.

On the one hand, land-use regulation can be considered rent-seeking on behalf of current owners. On the other hand, relaxing regulations can add negative externalities, especially if residents have a negative willingness to pay for higher density. There are often competing interests between current homeowners and new home buyers and renters when promoting housing affordability. We study how the interactions of these regulations affect the trade-offs to building single-family houses, usually owned or multi-

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[1] See Miller (2019), Wamsley (2019), and Economist (2021).

[2] Papers looking into density include Anagol et al. (2021) and Gray and Millsap (2020), building heights include Brueckner and Singh (2020), Brueckner and Sridhar (2012), Ding (2013), and minimum lot size include Kulka (2020), Zabel and Dalton (2011).

family housing (usually rented), affecting rents and housing prices. We break down the effect on housing costs into direct effects that capture how relaxing regulations change the type, size, or the number of units and indirect effects that capture how relaxing regulations change the composition of neighborhood density and neighbors. We estimate the willingness-to-pay for living in high-density areas separately for owners of single-family homes and renters of multi-family units to study the indirect effect.

The political economy of zoning gets more complicated if you take into account that new housing decisions in the U.S. are made at the local town level, and different forms of local governance affect how effective relaxing land-use regulations are. Greater Boston has many advantageous features for studying the role of local zoning laws and local government in housing development as it has over 100 autonomous local communities with their own local governance structures. A key issue in building multi-unit housing is the multiple hurdles, delays, and, most importantly, uncertainty faced by developers to get such projects approved by local town councils (Einstein et al. (2019), Schuetz (2020b)).[3] Given the crucial role local governance plays in deciding whether and what type of housing is constructed, it is important to study the contribution of local governance to rising housing costs.[4]

Inclusionary zoning policies that provide developer incentives to build more affordable housing have gained popularity in many cities like New York and Toronto and can potentially offer a substitute for land-use regulation relaxations, which are often thought to be politically challenging (Glaeser, 2021). We study how the land-use regulations interact with Massachusetts' Chapter 40B Inclusionary zoning policy that is designed so that affordable housing developers could override aspects of municipal zoning bylaws and community opposition to build more affordable units to understand whether the inclusionary zoning policy acts as a substitute for relaxing land regulations to increase housing affordability.

Using a regression discontinuity design framework around land-use regulation bound-

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[3] Based on the 2019 Wharton Land-Use Survey, it takes on average 38 percent longer for multi-family buildings to be approved compared to single-family houses in Greater Boston Area (Gyourko et al. (2021)).

[4] Also see Ahlfeldt and Maennig (2015) and Ahlfeldt et al. (2020) on political economy of what gets built in the neighborhood.

aries, we examine how allowing for multi-family zoning and relaxing height and density restrictions, either alone or in a combination, affect the supply of different types of housing, multi-family rents, and housing prices for single-family homeowners. We also study how these effects vary spatially and by kind of town governance. Finally, given that most spatial regression discontinuity boundaries that examine the impact on prices are due to shifts in demand a la Black (1999), we also provide theoretical underpinnings to use spatial regression discontinuity boundaries to study changes in prices that are due to shifts in supply (stemming from different regulation).

This paper finds that relaxing minimum lot size and maximum dwelling unit restrictions, either alone or combined with relaxing height or allowing for multi-family homes, are the most fruitful policy reforms to increase the supply of multi-family units by between 28-58% and reduce both multi-family rents by 5-6% and single-family prices by 3-7%. However, allowing multi-family zoning alone or relaxing height regulations does not significantly impact increasing the number of units built or rental housing costs. Furthermore, every land-use relaxation scenario where the rental costs fall is accompanied by falling house prices, complicating the political economy of land-use reform. A large part of this is due to high negative willingness to pay for higher density by single-family residents (0.16-0.21% fall in price with 1% increase in density), lending credence to the negative externality school of thought on zoning. For renters, we find no negative willingness to pay for higher density. We see more significant falls in housing costs from land-use reform in and around the central business district, as expected, and in established suburbs farther from the city center compared to mature suburbs that are within 20-40 min commuting distance to Boston downtown. Consistent with findings of Hankinson and Magazinnik (2020), we find that the mayoral and open town meeting local governance system as opposed to representative town meeting structure is most conducive for increasing the supply of multi-family units and consequently reducing rental costs. Finally, we find that inclusionary zoning policies like Chapter 40B rarely substitute for more lax land regulation policies, particularly for providing affordable multi-family units.

This paper ties into many strands of the literature relating to the effect of land-use regulations, inclusionary zoning, and the role of local governments in housing. The effect of land-use regulations and zoning on house prices has been studied for different parts of the country (Glaeser and Gyourko (2002), Glaeser and Gyourko (2018), Gyourko et al. (2021), and Glaeser et al. (2005)) and for the Boston area (Dain (2019), (Glaeser et al., 2006), Chiumenti (2019), Shanks (2021), and Rollins et al. (2006)). However, the existing body of literature almost exclusively focuses on land use regulations in the context of single-family homes, as highlighted by Molloy (2020) in her review of the literature. Notably, research on market-rate multi-family housing is largely absent.[5] We study how land-use regulations affect the supply of multi-family housing and housing costs for single-family owners separately from multi-family rents.

Fisher (2007) studies the application approval rates for MA's inclusionary zoning policy (Chapter 40B), while Soltas (2021) studies New York's inclusionary zoning policy. This paper studies the conditions under which MA's inclusionary zoning policy and developer incentive program can substitute for relaxing land-use regulations.[6] Einstein et al. (2019) study the role of local community opposition in new housing by studying the demographic characteristics of town members who show up for zoning board meetings and Hankinson and Magazinnik (2020) and Mast (2020) study the role of different type of representation governments in the construction of new housing. Following this literature, we study how effective relaxing the zoning regulations, both alone and in combination, are in increasing supply and reducing costs under different town governance representation structures.

Methodologically, this paper is closest to Turner et al. (2014), who use regression discontinuity design at town boundaries and provide analysis both at and away from the border. Like this paper, Anagol et al. (2021) also use regulation boundary design for build-area ratio zoning reform in Sao Paulo. This paper also adds to the literature of

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[5] Mast (2021) and Asquith et al. (2021) study how new market-rate apartment construction affects surrounding areas.Research on housing affordability of multi-family homes is limited to project-based assistance such as LIHTC buildings (Diamond et al. (2019), and Baum-Snow and Marion (2009)) and other programs that are targeted towards very low-income households (Diamond and McQuade (2019)). Also see Ellen (2015) and Schuetz (2020a) on broader discussion on housing affordability.

[6] This paper is also related to the literature in housing supply and developer decisions (Murphy (2018), Saiz (2010), Baum-Snow and Han (2019)), although we only focus on supply and developer incentives through the lens of their interactions with local land-use.

neighborhood and house choice (Bayer et al., 2007, 2016; Albouy, 2016) by estimating owners' and renters' willingness to pay for density in their neighborhoods. Lastly, our local policy estimates are based on the mythology laid out by (Bajari and Benkard, 2005) and implemented by (Diamond and McQuade, 2019).

Local land-use and governance policies preventing new home construction not only affect the housing supply and prices but can also have negative spillover effects on geographic mobility, local labor markets, and growth (Ganong and Shoag (2017)). Restrictive land-use regulations have been shown to slow economic growth by distorting the flow of workers to productive cities (Hsieh and Moretti, 2019). If households cannot afford to live near productive places of work, they may potentially be re-locating to less productive regions with worse inter-generational mobility and health and educational outcomes for both children and adults (Chetty and Hendren (2018), Chyn and Katz (2021), and Deryugina and Molitor (2021)). Lastly, the racial segregation consequences of land-use zoning have been documented in many settings (Resseger (2013), Shertzer et al. (2016), Trounstine (2018), and Rothstein (2017)).

2. Regulatory Framework for Multi-Family Housing

This section introduces the different components of the regulatory environment for building multi-and single-family homes in the Greater Boston Area that we consider in this paper.

2.1 Zoning Regulations

We focus on three land-use zoning regulations that affect the building of multi-family units and single-family units though potentially in different ways. These are whether or not multi-family housing is allowed, maximum height restrictions, and maximum dwelling units per acre (DUPAC) restrictions. Figure 1 shows how the three regulations vary across the municipalities in our sample in the Greater Boston Area. While all three land-use regulations have relatively straightforward definitions, these regulations' actual implementation and interaction can be complex. Below we provide details.

Multi-Family Zoning: This zoning regulates whether multi-family housing is a permitted use "by-right", by special permit, or not allowed (single-family zoning only) on a particular lot.[7] This regulation is the primary way to limit multi-family housing and affordable housing, which mostly tends to be multi-family buildings. In particular, multi-family zoning regulates the *type* of housing. As can be seen from Figure B.2, there is considerable with-in and across-town variation in the zoning of this policy.

Building Heights Restrictions: Building heights restrictions indicate the maximum allowable building height in feet of the built structure. Even if multi-family zoning is allowed, municipalities often limit the *size or shape* of buildings by using building heights restrictions. Bertaud and Brueckner (2005) and Brueckner and Singh (2020) show that building height restrictions cause urban sprawl and limit housing near the economic centers. Figure B.3 shows how the building heights restrictions vary across the Greater Boston Area.

Dwelling Units per Acre: Dwelling units per acre (DUPAC) limit *density and the total number of units* built in a region. DUPAC is calculated by counting the number of lots that can be constructed on an acre after taking into account *minimum lot size requirements* and multiplying this number by the maximum allowable dwelling units for each of those lots. Thus, this measure not only captures the land-use restrictions from *minimum lot size* requirements but also *maximum dwelling units* allowing a standardized comparison of density across single-family (DUPAC =1) and multi-family homes. Figure B.4 shows how the DUPAC restrictions vary across the Greater Boston Area.

Interaction of Zoning Laws: While the individual effects of some of these regulations on single-family supply and prices have been documented, it is not well understood how these zoning laws interact and differently affect the supply for single and multi-family housing and prices for renters and owners.[8] For instance, given multi-family zoning, how do maximum building heights restrictions interact with density restrictions to affect whether multi-family housing is below or above nine units. Thus, we have three types of interaction scenarios: First, only one of the three zoning laws changes at the

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[7] It is expressly defined in the local zoning code if regulation is by-right. If a regulation is by special permit, then a developer must request special approval from a local zoning board (MAPC (2020)). We combine multi-family allowed by-right with a special permit and compare the effect of this policy against the policy where multi-family is now allowed.

[8] In the data, we observe single and multi-family housing units but not the share of renters in each of these categories. We categorize results by single-family "owners" and multi-family "renters" for simplicity, given that most single-family residents are owners and most multi-family residents are renters.

boundary segment. Second, two zoning laws change, but the other remains the same. Third, all three regulations change. Table 1 shows all seven possible regulation zoning scenarios we study. Most of the analysis focuses on scenarios 3, 5, and 6 since these are the most common regulation combinations in the Greater Boston Area.[9] Note that, as can be seen from Figure 1, regulation scenarios 6 and 7 (DUPAC and height changing and all three regulations changing) are more prevalent near downtown, while regulation scenarios 3 and 5 (only DUPAC and DUPAC and multi-family zoning changing) are prevalent in both downtown and suburbs.

Comparison with the Wharton Residential Land Use Regulatory Index: Twenty-six of the towns in our sample are also part of the Wharton Land Use Survey (WRLURI) (Gyourko et al., 2019). To give a sense of comparability, we correlate regulations in these 26 towns with WRLURI. A one dwelling unit per acre increase in average town-level density in our sample corresponds to a fall by 0.001 standard deviations in WRLURI. A one floor (10 feet) increase in average town-level height corresponds to a decrease by 0.05 in WRLURI. Finally, we find that allowing multi-family zoning either by-right or by special permit in our sample positively correlates with 0.146 standard deviations of WRLURI. Correlating with multi-family by-right only gives the more intuitive negative correlation of 0.351 with the Wharton index, suggesting that special permitting is otherwise correlated with strict zoning.

2.2 Inclusionary Zoning and Chapter 40B

Many states and cities in the U.S. have inclusionary zoning policies that provide incentives to developers to build affordable housing units (e.g., New York City's 421-a property tax exemption (Soltas, 2021)). In Massachusetts, Chapter 40B is a state statute, which enables local Zoning Boards of Appeals to approve affordable housing developments under relaxed zoning laws if at least 20-25% of the units have long-term affordability restrictions. Chapter 40B is used chiefly as a zoning tool to build single-family (20.8% of

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[9] In this paper, we focus mostly on density regulations since they affect the supply of housing of all types and are strongly binding on average. In general, it is interesting to consider under which conditions different regulations may bind. For example, we expect height restrictions to bind if households prefer space, while density restrictions might be lax. On the other hand, if households have strong preferences for neighborhood amenities such as good public schools and are willing to trade off larger, cheaper homes for smaller homes in high-amenity areas, we may expect density regulations to bind first.

the sample) or multi-family units with more lax zoning, such as taller building heights or more units per acre. Chapter 40B is not a fool-proof program as these projects face massive community opposition, and many approvals are repealed in courts with lengthy litigation processes that reduce incentives for developers to use this program (Greenberg, 2021). This paper studies how the Chapter 40B program interacts with the three key zoning regulations, mainly if Chapter 40B is a compliment or a substitute for relaxed zoning.

3. Data

3.1 Land-Use Data

The data on parcel-level land-use zoning regulations comes from the maps compiled by the Metropolitan Area Planning Council (MAPC) for their Zoning Atlas project of the Greater Boston area. The 101 cities and towns included in the Zoning Atlas dictate our sample of municipalities in the Greater Boston Area. The Zoning Atlas was constructed between 2010-2020 and provides a snapshot of zoning regulations. However, most zoning regulations were set during the early to mid-20th century (the first height regulations were put in place in the Boston area in 1918) with few zoning changes afterward and almost always in the direction of more restrictive zoning.[10] As previously described, we focus on whether multi-family homes are allowed, maximum height, and maximum dwelling units per acre. These are also the most widely implemented regulations across Massachusetts, and elsewhere in the U.S.[11]

3.2 Housing Market and Price Data

Housing Characteristics: The data on housing units and characteristics [2010-2018] come from the Warren Group that collects tax assessment records across towns. The Warren Group provides the universe of all residential and mixed-use buildings in the

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[10] Zabel and Dalton (2011) find that there are 27 changes to minimum lot size regulations in the Greater Boston area between 1988-1997. The towns that adopted these zoning changes had higher house prices and larger lot sizes. Kulka (2020) finds that in Wake County, rezoning requests concern minimal amounts of land. Annually, there are around five rezonings that take place. For additional details, see section 4.4.2.

[11] The Zoning Atlas includes some further information on bylaws and ordinances that may influence the approval of multi-family projects. This information is less extensive than the information we use, and we do not include it in our analysis to reduce complexity.

Greater Boston area. Figure A.2 plots the total single-family and multi-family units from Warren group data against the units from American Community Survey (ACS). The dataset contains information on the type of building (single-family, two-three units, four-eight unit, nine-plus units, or mixed-use), lot and building area, year built, 2010-2018 tax assessed value, sale value and date, building characteristics like number of rooms, bathrooms, etc.[12]

Prices for Single-Family Houses: We use tax assessor data for pricing information for single-family houses. We do this for two reasons. First, given that we look within 0.5 miles of our regulations boundaries which are, on average, 0.1 miles long, we do not have enough sales data for 2010-2018 for our analysis. Second, in our sample, the assessed value to sales price ratio is similar on both sides of the boundary. Figure A.3 in the appendix plots the assessed-sales ratio for the single-family houses sold (2010-2018) against the sales value. Following the literature (Berry (2021)), we drop the top and bottom 2% of the sample. The pattern observed in the figure with the higher assessed-sales ratio for lower sale price homes compared with higher sales prices is a nationwide phenomenon documented in Berry (2021). However, since this pattern is the same on both sides of the boundary, we do not think that using assessed values instead of sale values changes the qualitative nature of the results. To compare house prices to rents, we follow the procedure laid out by the Bureau of Economic Analysis (BEA) (Katz et al., 2017) and use 6.29% of house assessed value to get the annual owner cost of housing.

Multi-Family Rents: For multi-family units, unit or building level rental data are challenging to find, especially historical rental data. McMillen and Singh (2020), for instance, use survey data on rent. CoStar provides the historical rental information for many buildings with five or more units as well as detailed information on multi-family building characteristics such as the number of units, floors, year built, lot size, etc.[13] For the buildings that have CoStar market rent available [18,536 buildings from 2010-2018], we use it directly. For the remaining 112,992 buildings, we impute rent using CoStar characteristics, Warren Group data, and ACS block group characteristics. Appendix A

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[12] Condominiums are excluded from this analysis because they can have one or more units, and it is not easy to classify them into either single-family or multi-family categories.

[13] CoStar uses websites like Apartment.com and field visits and surveys to get market rental data.

describes the procedure in detail.

3.3 Other Data

School Attendance Boundaries: School attendance area boundaries are another component needed for our analysis. Quality of school is known to be an essential factor for household location (Black, 1999). We are therefore careful to rule out that this channel drives our estimates. We use the 2016 elementary school attendance area boundaries from the National Center for Education Statistics (NCES) School Attendance Boundary Survey (SABS). Unfortunately, we cannot find school attendance boundary information for 15 of the 101 municipalities in our zoning data in SABS, even though they use attendance areas to dictate school enrollment. In the final sample, we exclude 15 towns. Figure B.1 displays the final sample of 86 towns.

Inclusionary Zoning (Chapter 40B) and Town Governance: We get data on Massachusetts' Inclusionary Zoning law Chapter 40B from the Massachusetts Department of Housing and Community Development. Of the 522 comprehensive permits Chapter 40B buildings in the 86 towns, we can geocode 85.8% buildings. We do a better job geocoding the multi-family 40B buildings (89.9%) than single-family 40B buildings (75.7%), for which house numbers are missing to preserve anonymity. 79.2% percent of Chapter 40B buildings are rented multi-family buildings. The data on different local town governance forms comes from Massachusetts's Municipal forms of Governance.

4. Model and Empirical Framework

To study how land-use regulations affect different types of housing, the number of units, multi-family rents, and single-family house prices, we outline a theoretical framework in Section 4.1, discuss channels of the regulatory effects in Section 4.2, outline the empirical specification in Section 4.3, and discuss the empirical strategy in Section 4.4.

4.1 Theoretical Framework

To understand how various land-use regulations interact and affect the type of housing, supply, and housing costs and rents, we adapt the framework in Turner et al. (2014) to our setting to incorporate both single-family and multi-family housing. In a monocentric model of a city, consider two neighborhoods L and R on either side of a regulation boundary at location $x = 0$.[14] At each location within $-\bar{x}$ and $\bar{x}$, land can be developed for single-family or multi-family use. The two neighborhoods L and R share a border at 0. $p(x, z)$ is the price for a housing unit at location x. The price is also a function of zoning regulation vector $z \in \{z^L, z^R\}$. Vector z denotes whether multi-family zoning is allowed, the maximum building height, and the maximum dwelling units per acre in neighborhoods L and R. A higher z indicates lower zoning regulations. Without loss of generality, assume that the left neighborhood is always more regulated than the right such that $z^L \leq z^R$. Assume that zoning regulations are binding.

Consumers earn wage w, pay $p(x, z)$ for their chosen location, choose location x and derive utility $V(x)$ from their location. The utility of a resident is $U(x) = u(w - p(x, z))V(x)$, where $V(x)$ is the utility derived from location x. For ease of discussion, we assume $u(x) = \exp^{w-p(x,z)}$. Consumers choose to live between the two neighborhoods (L, R) and an outside option location with reservation utility ν. We assume that there are no moving costs across locations. In equilibrium, residents are indifferent between all locations within the city.

4.2 Mechanisms behind Supply and Price Effects

Four fundamental mechanisms would result in land value and price changes across regulation boundaries when the type of land-use regulation changes. Consider the *direct effects* of land-use regulations on land value ($V^{direct}(x)$). First, there is the supply effect where an increase in supply from relaxed land-use regulation would lower prices (movement along the demand curve) on the relaxed (R) side of the boundary, assuming no shifts in demand. The direct effect operates by allowing smaller housing units in areas with relaxed regulation. Second, there is the demand effect where an increase in supply (of smaller units) from relaxed land-use regulation would increase prices if the shift in demand outweighs the increase in supply from the relaxed regulation. This is likely in locations near downtown where land-use regulations are already more flexible,

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[14] We focus on the monocentric model of the city because we are characterizing spatial equilibrium within a metro area, and the model allows for changes in equilibrium prices when supply changes due to changes in land-use regulation. This is in contrast to the open-city Rosen-Roback model, where changes in supply result in cross migration across cities, and both prices and amenities can adjust to the inflow of new residents.

on average, and high demand is not met with sufficient supply.[15] Third, building owners receive a direct effect from relaxed land-use regulations in the form of an increased *option value* because the land they own can now be used for both single-family and multi-family use (or different heights, different lot sizes etc), which increases the future sale value of the land. The direct effect creates a discontinuity at the regulation border $x = 0$, creating a step function if $z^L \neq z^R$.

$$V^{direct}(x, z^L, z^R) = \begin{cases} V^{direct}(z^L) & \text{if } x \leq 0 \\ V^{direct}(z^R) & \text{if } x > 0 \end{cases}$$

In addition, there is the *indirect effect* on land value ($V^{indirect}(x)$) from relaxing regulation if, for instance, households dislike higher density and relaxing the regulation increases the supply of housing (Strange, 1992; Turner et al., 2014). In this case, the indirect effect of relaxing land-use regulation on land values and house prices is negative, i.e., higher density would reduce prices. The indirect effect ($V^{indirect}$(x))is continuous at the border $x = 0$ as lots close to the border on either side are equally exposed to the regulation of the other side. The effect of regulation spillovers of the neighboring side decays fast as one moves away from the boundary (Irwin and Bockstael, 2002; McConnell and Walls, 2005; Pennington, 2021).

With a general formulation of the utility over income after housing expenditure (U), we define the utility of living in location x, $u(x)$ as a function of both direct and indirect effects of regulation as follows:

$$u(x) = U(w - p(x, z))V^{direct}(x, z)V^{indirect}(x, z) \tag{1}$$

Under the functional form of $U(x) = \exp^{(w-p(x))}$, the land rent gradient is then given by:

$$p(x, z) = w - \nu + \ln(V^{direct}(x, z)) + \ln(V^{indirect}(x, z)) \tag{2}$$

In the existing literature, boundary discontinuities are commonly used to elicit the willingness to pay for characteristics that change discontinuously at boundaries, such

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[15] It could occur as a consequence of shifts in demand *within* the area as well as demand from *new residents* now moving into the area as supply expands (Ahlfeldt and Barr, 2021). In our framework, we restrict attention to the first case.

as education (e.g., Black (1999)). Suppose housing supply (type and number of units) are the same across the boundary and households have homogeneous preferences and outside options. In that case, neighborhood demand for land is perfectly elastic. If observed and unobserved neighborhood amenities are continuous at the border, but for one amenity, like education, one can estimate the willingness to pay for that amenity. In such scenarios (Black, 1999; Glaeser et al., 2005), housing supply shifts from regulation would not affect prices across boundaries.

If households are heterogeneous in their outside options, this generates a downward sloping demand curve near any boundary (Turner et al., 2014), meaning that shifts in supply can affect prices. Outside options can be heterogeneous due to differences in income and affordability of neighborhoods and land use regulations themselves. For example, land use regulations change what can be built where, so a household looking for an apartment building does not have the same set of outside options as a household searching for a single-family home. Building on this assumption, we now highlight how we study the effects of regulations on prices when supply and type of buildings change across the border.[16]

As highlighted above, land use regulations affect land values through the direct supply and option value mechanism (V^{direct}) and through the indirect neighborhood composition and density change mechanism ($V^{indirect}$). Figure 3 illustrates various scenarios to highlight which mechanisms our framework can identify. Figure 3a demonstrates that the neighborhood density amenity ($V^{indirect}$) is continuous at the boundary but changes away from it. In places with relaxed land use regulation, a higher number of smaller and cheaper units are available than in areas with strict regulation, but these differences are only perceivable away from the boundary. Figure 3b highlights that the type of housing, in particular, the smallest unit available, drops at the border on the relaxed side of the boundary. The highlighted change in the figure comes from changes in density regulations like DUPAC, which imply a smaller minimum size for the R neighborhood.[17] Therefore, price per unit shifts at the boundary because regulations change

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[16] Turner et al. (2014) and Anagol et al. (2021) also use regulation boundary RD analysis.

[17] In the case that maximum height changes across the border, the shift would be in the number of floors.

the type and size of housing, even though density and other amenities at the border remain the same.

Close to the boundary, where there is a density spillover from the more relaxed side to the more restricted side, the direct effect on price per unit can be estimated, holding fixed the indirect spillover effect.[18] $x = -C, C$ represent the cutoff distances between the direct effect estimates (V^{direct}) and the indirect spillover effects ($V^{indirect}$). For $-C \leq x \leq C$, we can estimate the direct effect of regulation while amenities remain constant. As one moves away from the boundary, the regulation effect on land valuation cannot be easily disentangled between the direct and indirect effects. Figures 3c to 3f highlight under what conditions we can make statements about the direct and indirect effects.

Figures 3c and 3d show conditions under which households dislike neighborhood density, so price per unit fall as density increases. Figures 3e and 3f present the case where there is a positive taste for neighborhood density. Suppose the supply effect dominates the demand effect and lowers the price per unit at the boundary, and the indirect effect is negative (Figure 3c). In that case, the framework cannot easily distinguish whether the indirect effect captures a willingness to pay for density or if it is the supply effect for $x > |c|$. The same is true in the scenario represented in Figure 3f. If the indirect and direct effects have opposite signs, i.e., Figures 3d and 3e, the framework can make a statement about preference for density compared to the direct effect of regulation for $x > |c|$. If there is no preference for density, the only effect of the regulation is the direct effect. Finally, if there is no detectable direct effect near the boundary, the indirect effects are informative about preferences for density away from the border. We further discuss these cases when discussing our results. Next, we turn to our empirical specification.

4.3 Empirical Specification

If one is not interested in disentangling the direct and indirect effects of regulations, Equation 2 can be estimated around the borders as is standard in the literature. However, direct effects of regulations on land valuation can be different from indirect effects

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[18] Turner et al. (2014) study the different effects close to and away from the border on the same side of the boundary.

in sign, magnitude, and policy response. We use a spatial regression discontinuity design and the theoretical framework highlighted above to estimate causal (a) direct effects of regulation on prices and supply and (b) indirect effects on prices (residents' valuations of surrounding residential density). We show our main estimates for a range of bandwidths ($x = -\bar{x}, \bar{x}, -C, C$) and discuss sensitivity with respect to the chosen bandwidth. To estimate the direct effect of the regulation, note that from Equation 2:

$$p(x, z^L) - p(x, z^R) = \ln(V^{direct}(x, z^L)) - \ln(V^{direct}(x, z^R)) \tag{3}$$

if ($-C \leq x \leq C$) and $\ln(V^{indirect}(x, z^L)) = \ln(V^{indirect}(x, z^R))$. When we take Equation 3 to the data, we estimate the direct effects of regulations in levels rather than differences as follows. The parsimonious regression specification is given by Equation 4

$$Y_{xt} = \rho_0 + \rho_1 1\{\text{Regulation}_x\} + f_x(\text{dist}) + \lambda_x^{seg} + \tau_t + \epsilon_{xt} \quad \text{if} - C \leq x \leq C \tag{4}$$

where Y_x is log owner cost of housing for single-family homes and rent for multi-family houses at location x for year t. Regulation$_x$ is either DUPAC, maximum height, multi-family allowed (0/1 dummy), or a combination of these three regulations at location x. ρ_1 captures the effect of the regulations. $f_x(\text{dist})$ is a linear function in distance away from boundary estimated separately on either side of the boundary. λ_x^{seg} is the boundary fixed effect for boundary segment seg which captures differences in unobserved amenities at the boundary level, and τ_t is a set of year fixed effects.

The direct effect includes all aspects of regulation that affect prices, including the option value of the relaxed regulation and the fact that relaxed regulation changes the type of housing built. Since house characteristics are endogenous to the regulation, we do not control for them in this regression.[19] While land-use regulations also change neighborhoods through sorting of households, right at the boundary, units on either side are subject to the same neighborhood quality.

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[19] The appendix also shows results for a version in which we control for the year a given building was built. We recognize that structures built at different times can vary in quality and style, entirely unrelated to the zoning regulation.

We use a linear probability version of Equation 4 to study the effects of land use regulation on housing supply where Y_x is an indicator for either two-three unit buildings relative to single-family homes or four or more unit buildings relative to single-family homes. For our linear probability model specification, we focus on buildings built after 1918 or 1956 (in appendix), which are two critical dates in the history of land use regulation in Greater Boston (see Section 4.4.2). Buildings built before these years were not subject to the regulation and could therefore look quite different and bias our supply results. Therefore, we also use these years to analyze the endogeneity of the regulations in section 4.4.2.

To estimate the indirect effects of land use regulations on house prices and rents, we focus on areas away from the border ($x > |C|$). From Equation 2 it follows:

$$\begin{aligned} p(x, z^L) - p(x, z^R) = \ln(V^{direct}(x, z^L)) - \ln(V^{direct}(x, z^R)) + \\ \ln(V^{indirect}(x, z^L)) - \ln(V^{indirect}(x, z^R)) \end{aligned} \tag{5}$$

i.e. away from the border, prices are a function of both direct and indirect effects. To disentangle the two effects, we estimate the following *hedonic* regression:

$$Y_{xt} = \rho_0 + \rho_1 1\{\text{Regulation}_x\} + \rho_2 \theta_x^{HD} + \rho_3 \theta_x^{GD} + \rho_4 H_x + f_x(\text{dist}) + \lambda_x^{seg} + \tau_t + \epsilon_{xt} \tag{6}$$

Like Equation 3, ρ_1 estimates the direct effect of the regulation changes. To study the effects of regulation changes on neighborhood density, for which households have different valuations, we will consider two measures that we call gentle density and high density.[20] Gentle density, θ_{GD}, is given by the fraction of 2-3 unit buildings in a 0.1-mile radius of a given property x. High density, θ_{HD}, is given by the fraction of 4+ unit buildings in a 0.1 miles radius of property x. ρ_2 and ρ_3 are the coefficients of interest for estimating indirect effects. In contrast to our broad stance taken on the direct effect of the land use regulation in Equation 3, estimating the indirect effect requires controlling for a rich set of unit level attributes that affect prices following traditional hedonic price

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[20] We follow Baca et al. (2019) in their concept and definition of gentle density.

models. H_x is a vector of unit-level characteristics, such as year built, lot size, building area, number of bedrooms, etc. Since neighborhood quality spills over right at the border and there is no change in density, we estimate this specification as a "donut RD" starting at $x = 0.1$ miles from the boundary on both sides. Again, we show robustness with respect to bandwidth choice.

We mention two caveats at this point. First, at present, we do not distinguish between the effect of higher density itself from changes in neighbor characteristics and neighborhood quality that follow from changes in residential density. Second, in general, we cannot distinguish between a distaste for density and the supply effect of relaxed regulation, both leading to negative signs on ρ_2 and ρ_3 in a hedonic model. However, as discussed in section 4.2, interpreting the indirect effects in conjuncture with the direct effects allows us to qualify the spillover effects in some cases. In addition, plotting direct effects over space, i.e., for various bandwidths, allows us to assess the importance of preferences for density since we expect direct effects of regulations to not change with distance on the same side of the boundary. However, indirect effects should change as density continues to change away from the border. Therefore, before turning to results, we discuss how different types of regulations and their combinations would affect housing supply and prices based on their effects on density.

Differential Effects of Regulations on Supply and Prices

All regulations do not affect the supply of housing and, therefore, prices in the same manner. Here, we briefly discuss how we expect different (combinations of) regulations to affect density. Table 3 guides our analysis. The first row indicates how we expect different regulations to impact the number of units. As discussed in section 2.1, the only individual regulation directly targeting density is dwelling units per acre. Allowing multi-family housing and maximum height regulations affect the size and type of housing, conditional on density. Consequently, we expect density and its interactions with other regulations to be the only regulations that increase units directly.

The predictions we make for price changes follow the predictions on supply. Regulations that do not impact supply (in terms of units) are not expected to lower prices through the supply effect.[21] For single-family homes, relaxing any regulation increases the option value. Finally, the impact of residential spillovers is specific to the definition of spillovers used in this paper, i.e., the share of 2-3 or 4+ unit homes within a 0.1 miles radius of a building. Therefore, regulations that affect the *type* of housing or the number of units should affect this share. The only regulation that affects neither the type of housing nor density is the maximum height (alone). Therefore, we expect no spillover effects at boundaries where only height regulation changes.

4.4 Empirical Strategy and Identification

To study the causal effects of land-use regulations on the prices ($p(x, z)$) and the supply of all housing types, we need to address endogeneity concerns. The price of housing and rent is correlated with the underlying quality of that location, including the unobserved or latent location quality. Thus, we need a source of variation that is orthogonal to the unobserved location amenities for causal price effects. Boundary discontinuity design around the land-use zoning regulation boundaries, under certain conditions, serves this criterion. The identifying assumptions for this empirical strategy are:

1. On both sides of the regulation boundary, type of housing and density change.
2. Close to boundary, unobserved quality of location does not change, and public amenities and municipal services are continuous along the boundaries.
3. The shape and location of the zoning boundaries in not endogenous to location.

To see that the regulation boundaries affect both the number of units built and the type of buildings built (single-family, two-three unit buildings, or larger apartment complexes with four units or more) across the regulation boundaries see Section 5.1, Figure 4 and Table 4. Below, we discuss assumptions (2) and (3).

4.4.1 Amenities along Zoning Boundaries

To ensure that across the regulation boundaries, major amenities associated with municipalities like taxes, government spending, and town-specific zoning laws on wetlands do not change across the borders, we restrict our across regulation boundary comparisons to within each town individually. In addition, school quality is a primary location

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[21] In terms of demand effect, an increase in height can increase demand.

amenity for many households that enters their utility. To control for school quality variation, we compare houses and buildings within the primary school attendance area for those buildings. Additionally, many regulation boundaries may coincide with significant roads or geographic features. To account for this and keep the latent quality of the location continuous at the boundary, we remove all regulation boundaries that intersect with highways, major roads, and geographic features like rivers, streams, and lakes. Figure 1 plots all the admissible boundaries where either multi-family regulation, maximum height restrictions, or density units per acre (DUPAC) changes either by themselves or in a combination. Lastly, we compare buildings within the same broader land-use type–residential and mixed-use.

We ensure continuity of location amenities across boundaries, other than the change in the regulation itself, by comparing buildings within 0.5 miles (or smaller) on either side of the permissible boundaries within towns and school attendance zones. The maximum bandwidth of 0.5 miles is chosen because beyond this, distance to neighborhood amenities changes across the border (Cattaneo et al. (2019)).[22] Figures 2 and B.6 plots the coefficients on the distance bins from regressing building distance to various amenities on boundary fixed effects and bins of distance to the boundary (bins of 0.02 miles) where negative distances indicate the more regulated side of a boundary. As can be seen from the figures, distance to rivers or lakes, town center, major roads, assigned primary school, and open space is continuous at the regulation boundaries for the three most common regulation scenarios in the Greater Boston Area.

4.4.2 Historical Perspective on Zoning Boundaries

There is a concern that regulation zoning boundaries themselves are endogenous to location or neighborhood quality. For example, Shertzer et al. (2016) find evidence in Chicago that industrial use zoning was disproportionately allocated to neighborhoods with ethnic and racial minorities. Our analysis compares buildings within towns, school attendance zones, and land-use type (residential or mixed-use) controls for such factors. While we control for observed and unobserved amenities of a location such that

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[22] 0.5 miles is the maximum bandwidth. In most of the analysis, smaller bandwidth is used. See Section 5.3 for optimal bandwidth selection.

they do not vary across the land-use regulation boundaries, another potential concern is that these boundaries would have been shaped around the historic building structures of the Greater Boston Area. To address this concern, we study whether the type of buildings built (either two-three unit apartments or four or more unit apartments versus single-family buildings) before 1918 or 1956 (years of critical zoning adoption) do not differ across the present-day regulation boundaries.

The city of Boston and Cambridge first adopted maximum height restrictions in 1918 (Bobrowski (2002) and MacArthur (2019)) following New York's 1916 zoning regulation.[23] Neighboring suburban towns of Brockton, Brookline, and Newton soon followed and adopted maximum height restrictions in the early 1920s (see Hillard (2020), Neilson (1934), and Knauss (1933)). Table A5 illustrates the year and type of first zoning adoption (mostly maximum height restrictions) across 42 towns in our sample. Other than 1918, 1956 also became a critical year when Boston and Cambridge passed the Enabling Act and adopted the first comprehensive zoning code in the area. While the pre-1950s zoning used building height limits, the Planning Board of Boston and Cambridge in the early 1950s found that these did not "sufficiently limit the housing potential of a given lot, and recommended changing to the zoning to cap the total amount of density (floor-area ratio) of the building" (MacArthur (2019)).

The linear probability model (LPM) laid out in Section 4.3 (equation 4) tests whether the type of buildings built (either two-three unit apartments or four or more unit apartments versus single-family buildings) before 1918 or 1956 differ across the present-day regulation boundaries. Table 2 shows the results from the LPM for buildings built before 1918 (see Table A1 in Appendix for buildings built before 1956). As can be seen from Table 2, the type of building built (single-family versus multi-family) do not vary in any statistically significant ways across density (DUPAC) and multi-family boundaries. For density (DUPAC) and multi-family boundaries, it appears that DUPAC and multi-family regulation was designed around both historic gentle-density (two-three unit apartments) and high-density (four or more unit apartments) buildings. This is also true, to some extent, for density (DUPAC) and height boundary designs regard-

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[23] Boston had adopted residential land-use regulation for some areas in 1904 (Knauss (1933)).

ing historic high-density buildings only. Therefore, based on these results, we are more confident in the exogeneity of only multi-family, only density (DUPAC), and density and height regulation boundaries than the boundaries where multi-family and DUPAC restrictions change.

5. Results

5.1 Supply

As highlighted in the previous section, different land-use regulations differ in their effect on the supply of housing (Table 3). In particular, multi-family zoning or relaxing height restrictions do not necessarily result in more units built unless these regulations are accompanied by relaxing density or dwelling units per acre. Allowing multi-family zoning change the *type* of housing, and relaxing height restrictions change the *size* of the unit. However, unless the number of allowable units built per acre (DUPAC) changes, relaxing multi-family zoning or height restrictions do not increase housing units.

Figure 4 displays the change in the number of units supplied on the more restrictive side of a regulation boundary relative to the less restrictive side of the boundary (normalized to 0.0 - 0.02 miles distance bin from the border).[24] As can be seen from subfigures (a), (b), and (c) of Figure 4, relaxing density (DUPAC) restriction alone or in combination with allowing multi-family or relaxing height restriction has the largest and most significant effect on increasing supply, as measured by the number of units built. Relaxing density restrictions alone result in an average 0.43 unit increase 0.02 miles from the regulation boundary. Relaxing both density and allowing for multi-family housing results in an average 0.45 unit increase, and relaxing both density and height restrictions results in an average 2.4 unit increase at 0.02 miles from the border. For these three regulation scenarios, the effect is persistent away from the boundary and precisely estimated up to 0.2 miles from the border. While these effect sizes may seem small, note that the average units are 1.6 at boundaries where only density regulations change, and

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[24] While we discuss robustness for bandwidth choice in Section 5.3.1, it is worth noting that the optimal bandwidth calculated using Calonico et al. (2020) lies between 0.01-0.03 miles for all types of boundaries and dependent variables. The closest distance bins to the boundary that we show in the following figures correspond well to the optimal bandwidth calculated in this way.

both density and multi-family regulations change. In addition, there are, on average, 2.6 units at boundaries where both density and height change, implying that the changes in these three regulation scenarios increase the supply of units between 27-92%.

As expected, we see no effects at boundaries where either height regulation alone changes or it changes along with allowing for multi-family homes. Neither of these regulations is targeted at increasing residential density. The number of units increases by 0.63 units right at the boundary on the less restrictive boundary when only multi-family regulation changes. However, examining confidence intervals, it is not clear that this effect is persistent away from the border. This result is consistent with recent examples of regulatory zoning reforms enacted in the U.S. city of Minneapolis, which became the first city in the U.S. to allow building 2-3-unit houses on land previously zoned for single-family use. Recent reporting has found that "only 23 building permits have been issued for new duplexes and triplexes in places they would not have previously allowed" (Webster and Corey (2021)).

To study housing supply changes, it is also important to look at the type of housing because the avenue of land-use regulation reform might be more effective in increasing the supply of certain multi-family housing types than others. To investigate this question, we run a linear probability model (equation 4) where the outcome is the type of housing: gentle-density (2-3 unit) or high density (4+ unit).[25] We focus on buildings built after the adoption of the first height restrictions in 1918 (i.e., buildings that were not grandfathered in). We interpret the effects of a given regulation as increasing the probability of a certain multi-family house type *compared to* single-family housing. Table 4 shows the results (see Table A2 restricted to buildings built after 1956.)

We find that allowing for multi-family homes and more density (DUPAC) increases the probability of a given property being a gentle-density unit property compared to a single-family home. In particular, column 1 shows that the probability of gentle-density buildings more than doubles relative to the baseline when multi-family homes are allowed. However, we find no statistically significant effect of multi-family zoning on the likelihood of high-density buildings (column 5). This could be both because allowing

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[25] We also use same definition to study density externalities.

multi-family homes on its own does not increase density but could also point to the fact that facilitating the supply of higher density buildings is more complicated as other factors likely inhibit the construction of larger apartment buildings, such as higher construction costs and community opposition.

Increasing density (DUPAC) by 4.4 units, the average change across such boundaries, increases the likelihood of gentle-density building by 14.4% (column 2). Similarly, increasing density by 6.3 units, the average change across borders where both density and multi-family zoning changes, increase the likelihood of gentle-density building by 15.8% (column 3). For boundaries where density and multi-family zoning change, allowing multi-family regulation increases the probability by 75.2% (column 3). For the supply of high-density buildings, we continue to find a substantial effect of allowing more dwelling units per acre, either alone or by allowing multi-family housing. Increasing density (DUPAC) by 4.1 units, the average change across such boundaries, increases the likelihood of gentle-density building by 34.1% (column 6). Similarly, increasing density by 5.9 units, the average change across borders where both density and multi-family zoning changes, increase the likelihood of gentle-density building by 78.7% (column 7). We find strong effects for boundaries where density and height change only for high-density buildings but not gentle-density ones. This is not surprising as such boundaries are more likely in areas with more high-density buildings (see Figures 1 and B.5).

In summary, we find that relaxing density alone and in combination with other regulations reliably increases the supply of units. In contrast, height regulations and height regulations with multi-family zoning have no such effect. We also find that allowing more dwelling units per acre alone or in combination with enabling multi-family housing is most effective at increasing the supply of both gentle and high-density homes.

5.2 Direct Effects: Housing Prices and Rents

5.2.1 Direct Price Effects of Regulations

We now discuss how land-use regulations affect the prices of single-family homes and rents for multi-family apartments. We will focus on regulations that interact with density (DUPAC) regulations from this point in the paper. As seen in the previous section, other regulations have little bite in adding housing. Concretely, we focus on density and combinations of density with maximum height and multi-family regulation. In Table 1 these are Scenarios 3, 5, and 6, which amount to 77% of our multi-family and 84% of our single-family housing sample. Figure 1 shows that the remaining scenarios tend to be locally concentrated, and their external validity is less convincing. While we find moderate effects of allowing multi-family housing on supply, this regulation primarily affects single-family home prices. There is no sensible effect of allowing multi-family homes on rents since one side of the boundary does not allow rental units. See Figure B.7 in the appendix for the impact of non-density regulations on rents and housing prices. Finally, we turn our attention to boundaries where all regulations change when we talk about Chapter 40B in Section 7.2.

Figures 5 and 6 plot the effects of regulations on house prices (monthly owner cost of housing) for single-family (SF) homeowners and monthly rents for multi-family (MF) renters. Following Bayer et al. (2007), we run regressions of log prices on boundary fixed effects and 0.02-mile bins of distance to the boundary. Positive distances indicate the more relaxed side of a boundary, negative distances the stricter side. We plot the distance coefficients and normalize the first bin on the relaxed side to 0. When only density (DUPAC) regulations are relaxed, rents in multi-family properties 0.02 miles away from the boundary are 5.4% lower on the less restrictive side than those on the more stringent side. This decrease in rents is 12.6% or \$144 per unit, relative to the increase in the number of units in Figure 4. Meanwhile, the monthly housing costs for single-family property owners fall by an average of 7.2% (or 16.7% $\approx$ \$425 per unit). These effects are for the average change of 15.5 units for multi-family apartments and 5.1 units for single-family houses across boundaries where only dwelling units per acre change.[26] Given that there is also an option value for single-family homes, which increases the price when regulation is relaxed, we can conclude that density regulation's supply and indirect effects are stronger for single-family homes than for rental units.

When DUPAC is relaxed and multi-family is allowed, there is little rent change across

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[26] Table A3 displays the per unit changes in prices–0.1 percentage point decrease in rents and 0.2 percentage point decrease in the price of single-family homes.

the boundary, except right at the border. While we see a positive effect of 3.9% or 8.7% per unit (≈$89) at 0.02 miles, this effect disappears further away from the border. Table A3 suggests that there are negative supply effects of both allowing multi-family and dwelling units per acre individually, but the interaction effect between the two is positive. In particular, in areas that allow multi-family housing for high-density levels, the overall impact (which is visible in the graph) could turn positive or close to zero. House prices fall by 4.1% right at the boundary on the more relaxed side, with an increasing gap as we move further away. These are substantial effects amounting to a 9.17% drop in monthly owner cost for each unit added which is equivalent to a decrease in $204, again suggesting that negative externalities of density kick in away from the border. Finally, the affordability impact of allowing multi-family housing and relaxing density is more significant for house prices than multi-family rents, making it more difficult to achieve politically.

When density (DUPAC) and height regulations change together, rents fall by an average of 6.2% at the border while there is no detectable effect on the prices of single-family homes. As the number of units added on the relaxed side of this boundary type was over 2, the per-unit fall in rents is smaller here but not negligible, namely 2.6% or $27. Monthly owner costs drop by 0.7% or $16, though this effect is not statistically significant even near the boundary. These findings are further borne out in Table A3 where we find negative effects on rents driven by the supply effects of dwelling units per acre (as before, we do not expect height alone to have a negative effect on prices). Still, we do not find precisely measured effects for single-family home prices. Returning to Figure 1 and B.5, we can see that boundaries where density and height regulations change together tend to be concentrated near downtown. These areas are typically denser urban cores with fewer single-family homes. Therefore, it is not surprising that we find a more substantial impact of this regulation type on rents than home prices.

In Section 4.4, we showed evidence of the exogeneity of zoning regulations, in particular of the continuous height and density regulations. Nevertheless, we realize that supply could vary substantially from year to year, particularly in terms of its quality and type, i.e., more recently built multi-family properties might be more likely to be luxury apartment buildings. This type of variation may not be related to regulations and may bias the direct effects upwards or downwards. Table A4 shows results of equation 4 where we additionally control for year built. Compared to results from Table A3, we find that when we control for the year built, there are no quantitative differences in the effects on rents. For single-family home values, we find that effect sizes are similar except for the effect of allowing multi-family homes, which shrinks considerably, suggesting that the characteristics of properties change systematically over time.

5.2.2 Regulations and Building Charecterisitcs

In all the regulation change scenarios discussed above, the direct effect of relaxing zoning operates through the supply of smaller, more affordable units. Since there is no change in amenities at the boundary, these characteristics should be driving a large part of the price differences. Figures 7 - B.8 corroborate this mechanism of price effect. Boundaries where only density(DUPAC) changes with allowing multi-family show precisely estimated drops in the number of bathrooms, bedrooms, and the unit-level living area in square feet. Relative to the mean at boundaries where only DUPAC changes, we find a 3.9% decrease in the number of bedrooms, a 9.5% decrease in the number of bathrooms, a fall in the living area by 10.4% and a decrease in lot size by 25.9%. The corresponding numbers at boundaries where both multi-family and density change are a fall of 5.2% in the number of bedrooms, 5.7% fall in the number of bathrooms, a 6.5% fall in the living area, and a 9.1% fall in lot size. The lot size is defined at the building level for both apartments and single-family houses, which explains why there is no effect in Figure 8d.

Interestingly, we find almost no differences in house characteristics at boundaries where height and density regulations change. As mentioned before, these boundaries tend to lie in already quite dense areas. The only characteristic that we see somewhat of an effect in is lot size. The more relaxed side of these boundaries may offer larger apartment blocks that have more units in them, though the number of units themselves does not vary much at these boundaries. Consequently, these boundaries seem to represent the cleanest shift in just the supply of homogeneous units.

5.2.3 Taking Stock

Summing up, we find that the supply effects dominate the demand effects (and the option value) for density regulation for both rents and home prices. We find that relaxing density with allowing multi-family strongly impacts house prices but not rents. In this case, there may be increased demand for apartments in locations with this type of regulation scenario (evidenced by a positive interaction term for DUPAC and multi-family), which mitigates the supply effects. When both density and height regulations change, we find strong supply effects on rents and none on the prices of single-family homes.

Comparing Figures 5b and B.7b for single-family homes with rents (Figures 5a and B.7b), we see a steeper price gradient for single-family home prices away from the boundary than we do for rents. This leads us to the indirect effects of land use regulations, namely the spillovers that different housing types have on surrounding properties. Graphically, it appears that the spillovers of density are larger and negative for single-family home prices than they are for rents. In the next section, we disentangle the indirect effects.

5.3 Indirect Effects: Housing Prices and Rents

In this section, we study the indirect effects of the regulations, recognizing that these zoning regulations can change the neighborhood's perceived quality by changing neighborhood density. For example, increasing the housing supply through DUPAC, by definition, increases density, indirectly lowering housing costs if people prefer to live in less dense areas. This change in housing costs can be considered a willingness to pay for density.

As highlighted in Section 4.2, if the supply effect dominates (Figure 3c) and lowers the prices, and the indirect effect is also negative, the model cannot distinguish between the willingness to pay for density and the overall supply effect. These two effects cannot be disentangled without a shifter that affects willingness to pay but not the neighborhood supply or density (or vice-versa). In addition, there is sorting of different types of households to each side of the boundary, with potentially different willingness to pay for the same neighborhood. This section offers two methodologies to study which of the two effects–supply and willingness to pay–dominate away from the boundary. However, the analysis can not distinguish between the effects of density per se, i.e., the impact of open space and the effects of higher residential density leading to different neighbor demographics.

5.3.1 Bandwidth Analysis

We begin by showing how the direct effects vary with the bandwidth choice. This analysis is more than a check of robustness concerning bandwidth selection since the distance to the boundary meaningfully alters the economic interpretation of the treatment effect of the regulation as it incorporates spillover effects. Figure 9 plots the direct effect for the three main regulation scenarios for bandwidths ranging from 0.05 miles to 0.35 miles to the boundary in increments of 0.05 following the recent literature (Shanks, 2021; Severen and Plantinga, 2018).

For renters (left panels of Figure 9), we find that the direct effect is not sensitive to the choice of bandwidth across all regulations. The only coefficient that seems to diverge slightly is the coefficient at 0.05 miles to the boundary. Note that this is a minimal bandwidth with few properties and many partially excluded. Nevertheless, this coefficient is not statistically different from the others. The stability of these coefficients across different bandwidths implies that there is unlikely to be a significant taste or distaste for density among renters. Otherwise, as the residential density changes away from the boundary, we would have seen different direct effect coefficients for renters. Compared with the discussion on mechanisms (Section 4.2), these plots look similar to Figure 3e–the case where there is little to no preference for residential density. Concluding from these figures, we conjecture that we will not see strong effects on rents when we estimate equation 6 (discussed below).

Results for owners are on the right side panels of Figure 9.[27] Here, except for boundaries where both height and density regulations change together[28], the choice of bandwidth *matters* for the size of the direct regulation effect. The larger the bandwidth, i.e.,

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[27] The boundaries for multi-family and single-family homes are directly comparable. Less than 1% of properties in the sample lie at boundaries where there are no multi-family homes. Less than 2% of properties lie at boundaries with no single-family homes on either side.

[28] We previously showed that these boundaries have no impact on house prices.

the more distance away from the boundary, there is a larger and more negative effect of density regulation (Figure 9b). In addition, the larger the bandwidth, the more negative is the effect on single-family house prices of allowing multi-family homes (Figure 9d). This suggests that in addition to a supply effect, single-family households also have a *distaste* for density which manifests itself at an increased distance to the boundary as density changes systematically with regulation.[29] This case corresponds to Figure 3c. In the previous section, we had highlighted the significant negative direct effects of DUPAC, either alone or with multi-family zoning. Based on these figures, we also expect to find a negative coefficient of residential density on single-family home prices.

5.3.2 Estimating Effects Away from Boundary

The findings from bandwidth selection are supported by Table 5 which reports the results from estimating equation 6. Here buildings are considered within 0.1-0.3 miles around the border. Table 5 highlights the effects for multi-family rents in the top panel and owner cost of housing of single-family houses in the bottom panel for different neighborhood density–the share of high-density (4 or more unit buildings, θ_{HD}) and gentle-density (2-3 unit buildings, θ_{GD}) within a 0.1-mile radius of a property. We find a wide range of coefficient sizes for multi-family renters–almost all not precisely estimated. This corroborates our findings from the bandwidth analysis that there is no significant preference for residential density for multi-family renters. Therefore, the only effect of regulation on rental prices is through the direct effect of increased supply. The only precisely estimated indirect effect is a 0.1 percentage points decrease in rents for a one percentage point increase in the gentle-density share within a 0.1-mile radius of the building around boundaries where density (DUPAC) changes. Note that the average DUPAC at such boundaries is much lower at 12.1 units than the average DUPAC at boundaries where multi-family and density change (17.3 units) and height and density change (27.8 units). If heterogeneous households sort around different kinds of boundaries, then renters in lower-density areas may have a more negative willingness to pay than renters in high-density areas.

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[29] Dislike for density is not a given. Anagol et al. (2021) find a positive willingness to pay for density in Sao Paulo.

The bottom panel of Table 5 highlights the extent to which single-family homeowners might dislike living near higher-density buildings. These coefficients are all negative with one exception and precisely estimated. As the bandwidth analysis suggested, we find sizable negative effects of higher neighborhood gentle density on owner costs of housing at boundaries where density regulations change, either alone, with multi-family zoning, or with both multi-family zoning and height changes. An increase in the share of the gentle-density of 1 percentage points results in 0.17 percentage points falls in home prices at boundaries where density regulation changes, and 0.21 percentage points fall at boundaries where dwelling units change together with allowing multi-family homes and boundaries where all three regulations change at the same time. We find no effects at boundaries where density and height restrictions vary together. This is not surprising given spatial sorting across boundaries as such boundaries have, on average, higher density (10.3 units) than other boundaries (5.2 units when only density regulation varies and 6.7 units when density and multi-family regulation varies).

Somewhat counter-intuitively, the negative effect sizes are larger for neighborhood gentle density than for high density, implying that homeowners dislike 2-3 unit buildings in their immediate vicinity more than four or more unit homes. However, by comparing the sample averages for different types of density, we can see that this is misleading. The fraction of high-density buildings is meager, between 0.1-2.3%, whereas the fraction of gentle-density buildings is 5.3-19.2%. Therefore, we attribute the larger and more precise effects for gentle density to the fact that single-family homes rarely lie directly next to high-density properties. If they do, there are also 2-3 unit buildings nearby. This can also be seen in Figure B.5. We show robustness to bandwidth choice in Table A6. The effects of gentle density are precisely estimated and do not change much, particularly when increasing the bandwidth.

When considering various avenues for zoning reforms that increase supply and lower prices, it is crucial to consider the direct (supply) and indirect (supply and willingness-to-pay for density) effects to avoid the pitfalls that new construction can generate from neighborhood opposition. For example, relaxing DUPAC restrictions alone or with multi-family zoning increases supply and decreases rents, and reduces single-family house prices. In contrast, relaxing DUPAC and height restrictions in higher density areas reduce rents but not single-family house prices through direct or indirect channels. Given the bandwidth analysis and indirect effects analysis, one can reasonably conclude that single-family residents do not like living near higher densities. In contrast, multi-family residents generally do not have a strong taste or distaste for density. It is also helpful here to return to Figure 1. DUPAC boundaries tend to be more suburban, and boundaries at which DUPAC and height regulations change are notably closer to the city center. The estimates we find here align with sorting households that dislike density into suburban areas and households with less distaste into urban centers. In the next section, we further investigate the importance of spatial heterogeneity on the varied effects of regulation changes.

6. Spatial Heterogeneity

So far, we have concentrated on the average treatment effects of the regulation, but these can be heterogeneous across space, and prices may vary differently depending on the distance to the central business district (CBD). For example, prices may be more likely not to change much or increase in the CBD due to high demand and new households moving into the area, as predicted in a standard Rosen-Roback framework. Additionally, indirect effects of regulations are likely higher in areas that exhibit more considerable resistance to multi-family homes. For spatial heterogeneity analysis, we follow the MAPC (see Figure B.12) in their classification of towns into one of four categories: inner core, regional urban centers, mature suburbs, and developing suburbs. The CBD represents the inner core, suburbs closer to the CBD are mature suburbs, and suburbs further from the CBD are developing suburbs. Regional centers sustain their local economy and form somewhat self-contained labor markets. We estimate supply effects and direct and indirect price effects separately for these four types of towns. We plot statistically significant coefficients at the 5% level (imprecisely estimated results are grey).

Figure 10 shows supply and direct price effects for boundaries at which only density (DUPAC) changes. We find increases in the supply of 2-3 family homes in the mature suburbs and substantial increases in the supply of 4+ family homes in the inner core and regional centers (top panel). We also find significant but imprecisely estimated increases in the supply of 2-3 family homes in the developing suburbs. The inner core and regional centers are more densely populated urban areas, so these results are reasonable. The bottom panel shows the direct price effects. We find supply effects dominate in the inner core resulting in falling rents. Given the effects on housing supply, we can infer that rents fall due to the construction of more high-density housing. Owner costs of single-family homes also fall in the inner core and the developing suburbs.

Figure B.10 highlights how the supply of gentle and high density buildings increases in the mature suburbs and the inner core along boundaries where multi-family is allowed and density is relaxed. We find no precisely estimated direct effects on rents for this regulation scenario, but home values fall increasingly with distance to the CBD corresponding to a monocentric city world, consistent with the results in Section 5.2. These price effects are driven by the marginal effect of allowing multi-family homes. Considering these results with the results from boundaries where only density changes suggest that allowing multi-family homes in combination with relaxing density is a crucial combination of regulations to lower prices in the suburbs. Figure B.9 shows that boundaries where height and density change together affect the supply of high density buildings primarily. This corresponds to the previous finding of such boundaries being located in denser town centers. Like the main results in Section 5.2, rents decrease in mature suburbs and the inner core with no corresponding changes in house prices.

Figure 11 shows the indirect effect by town type for owners. The effect of density on house prices in mature suburbs is unambiguously negative for both high and gentle neighborhood density and across boundary types. We find the largest negative effects in mature suburbs for gentle density at boundaries where height and density change together. Notably, we do not find precisely estimated negative effects for homeowners in other town types except mature suburbs. This finding pared with our previous results implies that while mature suburbs have one of the largest potentials in increasing supply and lowering prices, this is likely to come at the cost of homeowners' perceived neighborhood quality. Figure B.11 shows the corresponding indirect effects for renters. Negative impacts of residential density in mature suburbs are absent among renters. Instead, we find negative impacts of residential density in developing suburbs across all boundary types. This result is puzzling because we do not find strong price or supply effects in these areas. A potential explanation comes from the sorting of renters into developing suburbs. These might be renters similar to homeowners in their preferences since they choose to live in low-density areas.

7. Other Local Barriers to Reducing Housing Costs

7.1 Local Town Governance and Land Regulations

Local governments set zoning laws and their stringency at the municipalities (town) level.[30] In addition to making zoning laws, municipalities also review all new housing projects, especially those that have aspects that are not permitted by-right under the local zoning code. There are four forms of local governance in Massachusetts. These include the Mayoral system (40.87% of our sample of properties), Town Manager system (7.26%), Open Town Meeting (OTM, 18.93%), and Representative Town Meeting (RTM, 32.94%), with the latter two being the most common in smaller towns and the first two being typically adopted by larger municipalities. See Figure B.13 for a map of local forms of governance in the sample. Each of these local governance structures have different approval and voting processes for new construction. For example, in OTM, any local voter can attend and vote in zoning matters, while voters select representatives to attend town meetings in RTM, Council, and Mayor system.

Einstein et al. (2019) use meeting minutes from local government meetings in the Greater Boston Area and find that individuals who are older, male, longtime residents and homeowners are significantly more likely to participate in housing and development policy meetings and oppose new housing construction. Recently, Hankinson and Magazinnik (2020) and Mast (2020) have found that switching from OTM to a more representative town governance structure reduces the overall supply of housing, especially the supply of multi-family housing. The intuition behind this result is that in OTM, powerful constituencies with higher participation (along the lines of Einstein et al. (2019))

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[30] This is the norm in most Eastern and Midwestern states of the U.S. In Western and Southern U.S. states, zoning laws are set at the county level (Rybczynski (2008)).

are able to push through new housing that is concentrated in already dense areas. By increasing representation, these communities can prevent new projects in their neighborhoods, leading to an overall drop in housing supply. While we do not observe changes in town governance structure in our sample, we run our housing supply and price analysis separately by the town's local governance structure. These results should not be interpreted as causal to the town governance structure. Instead, this exercise illustrates the heterogeneity in the supply and price effects across different forms of local governance.

Tables 6 and 7 shows results for boundaries at which dwelling units per acre change alone or in combination with allowing multi-family housing as they are most represented across all types of towns and governance structures.[31] Table 6 shows the effects on the supply of gentle and high-density buildings relative to single-family homes. For municipalities with either OTM or Mayoral structure, we find positive effects of increasing dwelling units per acre on both gentle and high-density supply. We also find that allowing multi-family homes in combination with relaxing DUPAC regulations increases both gentle and high-density supply. However, we see much smaller and imprecise effects for towns with RTM, except for the supply of gentle density in boundaries where only density changes. This result is in line with the recent literature, finding that it is harder to build multi-unit housing in places with a more representative town structure (Hankinson and Magazinnik (2020)).

Table 7 shows the effects of regulations on prices across various town governance structures. In towns with OTM or Mayors which saw the highest increase in supply from relaxed regulation, we find that the supply effect on price dominates the demand effect at boundaries where DUPAC regulations change. For example, multi-family rents fall by 4.6% when dwelling units per acre increase by average 15.3 units under the Mayoral system. Single-family prices fall by 8.7% and 1% when DUPAC increases by average 5.1 units under OTM and mayor structure, respectively. We also find that multi-family rents fall by 2.5% when dwelling units per acre increase by average 6.3 units under the RTM system. Additionally, we find indirect effects of DUPAC regulation away from the boundary for single-family residents in the RTM and Mayoral governance structures,

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[31] We omit the Town Manager system due to its low sample size.

but not the OTM system with no precise effects on multi-family rents. A 1% increase in neighborhood gentle-density reduces single-family house prices by 0.34% and 0.13% for RTM and Mayoral systems, respectively. As the literature suggests, the OTM system concentrates the supply of multi-family housing in small areas, limiting the scope of negative density spillovers for single-family residents. The result that there is little indirect price effect for OTM towns, even though there is a supply effect, provides more evidence that the negative spillover effects dominate the supply effects away from the boundary, at least in this setting.

Similarly, along borders where both multi-family and dwelling units per acre regulations are relaxed, price results are less pronounced for multi-family rents (though still negative) than single-family prices across all governance structures. In all three cases, the fall in single-family prices is driven by relaxing multi-family regulation and not DUPAC regulation. The fall in single-family prices at the border is 8.7% for OTM, 7.0% for RTM, and 4.3% for Mayor system.[32] Away from the border, preferences for density of all types of density are negative throughout, particularly so for single-family home prices, reinforcing our previous findings that homeowners dislike density. Again, the effect sizes are more extensive for towns with Mayors and RTM than those with an Open Town Meeting structure. We conclude that the type of town governance structure is strongly related to the effectiveness of a given land-use regulation. These effects go beyond capturing heterogeneity between towns closer to the central business district and different types of suburbs. The heterogeneity in governance structures is not fully explained by distance to the city center (Figure B.13). Understanding these effects has important policy implications because relaxing regulations will have a different impact when channeled through different forms of town governance.

7.2 Inclusionary Zoning and Land Regulations

Relaxing zoning regulations is just one tool available for policymakers who are seeking to expand the supply of housing. Inclusionary zoning like Massachusetts' Comprehensive Permit Act (Chapter 40B) is one such example. At its core, the Chapter 40B law

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[32] The effect is calculated for relaxing multi-family regulation (0 to 1 change) when the average DUPAC is 4.0, 4.7, and 15.6 units, respectively.

allows for different types of housing to be built, and built more densely, than they would otherwise be allowed, so long as they are granted approval from the state. To examine how Chapter 40B effects the housing affordability this paper studies the effect zoning regulation changes have on the supply of Chapter 40B properties. We test if inclusionary zoning is a substitute or complement to relaxed land-use regulations using Equation 4 where $C = 0.5$ miles.[33] Results are presented in Table 8 for boundaries where all three key regulations change as these are the only boundaries where we find precise effects. This is not surprising, given that Chapter 40B buildings are concentrated near the city center (Figure B.5) where this type of boundary is also found (Figure 1).

When multi-family construction is not allowed, the supply of all Chapter 40B buildings increases by 1.6 percentage points. If multi-family construction is allowed, the supply of *multi-family* Chapter 40B increases by 1.8 percentage points. Thus, in the places where multi-family construction is not allowed, Chapter 40B incentivizes the construction of affordable housing, but only for single-family type of buildings. The added incentive and a legal avenue to overcome local opposition and regulations likely makes it easier to build multi-family Chapter 40B buildings, and so in multi-family buildings, Chapter 40B acts as a compliment to relaxing zoning regulations. When multi-family housing is allowed and height and DUPAC restrictions are lower, the supply of all Chapter 40B buildings increases. In particular, the supply of affordable *multi-family* buildings increases by 2.1 to 25.2 percentage points.[34] Thus, Chapter 40B acts as a complement to more lax land regulation. This helps explain why many of the Chapter 40B properties located in Greater Boston are found in areas where multi-family housing already is present, as shown in B.5.

Given the estimates from Table 8, the total probability for a multi-family 40B building to be built is 28.9 percentage points if we sum over all the joint effects when all three regulations change. As a comparison, Fisher (2007) finds that for 1999-2005 time pe-

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[33] We use a wider bandwidth for these regressions since there are only 522 Chapter 40B buildings in 86 towns, and even fewer around regulation boundaries.

[34] The effect of relaxing DUPAC by the average 17.4 units change across the border is 2.1percentage points. The effect of relaxing height by the average 2.1 floor change across the border is 25.2 percentage points.

riod, 44% of the 369 40B applications were actually built.[35]. The 28.9 percentage points estimate represents an upper bound of approval rates, and in many areas this approval probability is likely to be close to zero given that in many municipalities we observe no Chapter 40B buildings even though most do not meet the 10% affordability threshold. Given this probability, to increase the current multi-family 40B building stock by 50% to 141 buildings, there would need to be an estimated 488 building applications (3.5 times more). Since it is unlikely that developers bring forward such a large number of applications, for inclusionary policies like Chapter 40B to make a significant dent in affordability, the approval probability would need to increase significantly, especially in areas where the land-use regulations are relatively low and building multi-family housing is relatively easier, given the complementary nature of land-use regulations and inclusionary zoning.

8. Conclusion

Housing has become increasingly unaffordable across Northern American cities. This paper highlights which zoning regulations in which locations and local governance structures might provide the most fruitful path to increase the supply of multi-family housing and reduce house prices and rents. It also examines how effective inclusionary zoning policies can increase the supply of affordable units. We find that relaxing density (DUPAC) restrictions alone and in combination with relaxing maximum height restrictions and allowing multi-family homes are the most effective ways of increasing the supply of multi-family buildings and reducing multi-family rents and single-family home prices. The fall in prices from relaxed regulations comes from two sources: directly from the change in regulation, which changes the types of housing built in an area, and indirectly through changes in neighborhood density. Based on the estimates, relaxing density restrictions alone will result in a modest increase in new units and a modest reduction in rents and house prices. This is especially true in less dense suburban communities, where demand for housing is less intense, and an increase in housing supply would significantly impact prices. However, as the estimates suggest, single-family homeowners

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[35] The remaining 205 applications were either not approved, approved but appealed, or approved ans not built

dislike higher neighborhood density in such suburban towns, so the fall in rents and house prices would occur alongside a measurable dislike and possible opposition for the changing neighborhood density.

Allowing for multi-family zoning alone is less likely to increase the supply of rental properties and lower rent costs. Thus, the recent reforms to multi-family zoning in other U.S. metro areas may not be the best course of action in Greater Boston. Allowing multi-family zoning and greater density or greater heights and density would, however, help with increasing supply and reducing housing costs. In addition, results studying the heterogeneity effects across towns with different types of local governance structure indicate that it is essential to keep these factors in mind when making policy decisions since the impact of relaxing regulations both in terms of price effects and in terms of the welfare consequences and equity is filtered through local governance.

In addition, there is the question of the role inclusionary zoning policies play in promoting affordable housing. We find that if Greater Boston were to rely solely on policies such as Chapter 40B to increase housing affordability, far more building applications would need to be submitted, or a more significant share would need to be approved. In addition, Chapter 40B buildings also face significant local opposition, as any zoning reform would. Finally, this paper finds that while lowering housing costs either through zoning reforms or inclusionary zoning policies may help first-time home-buyers and lower-income renters, it comes at the expense of—and therefore likely generate substantial political opposition from—current homeowners.

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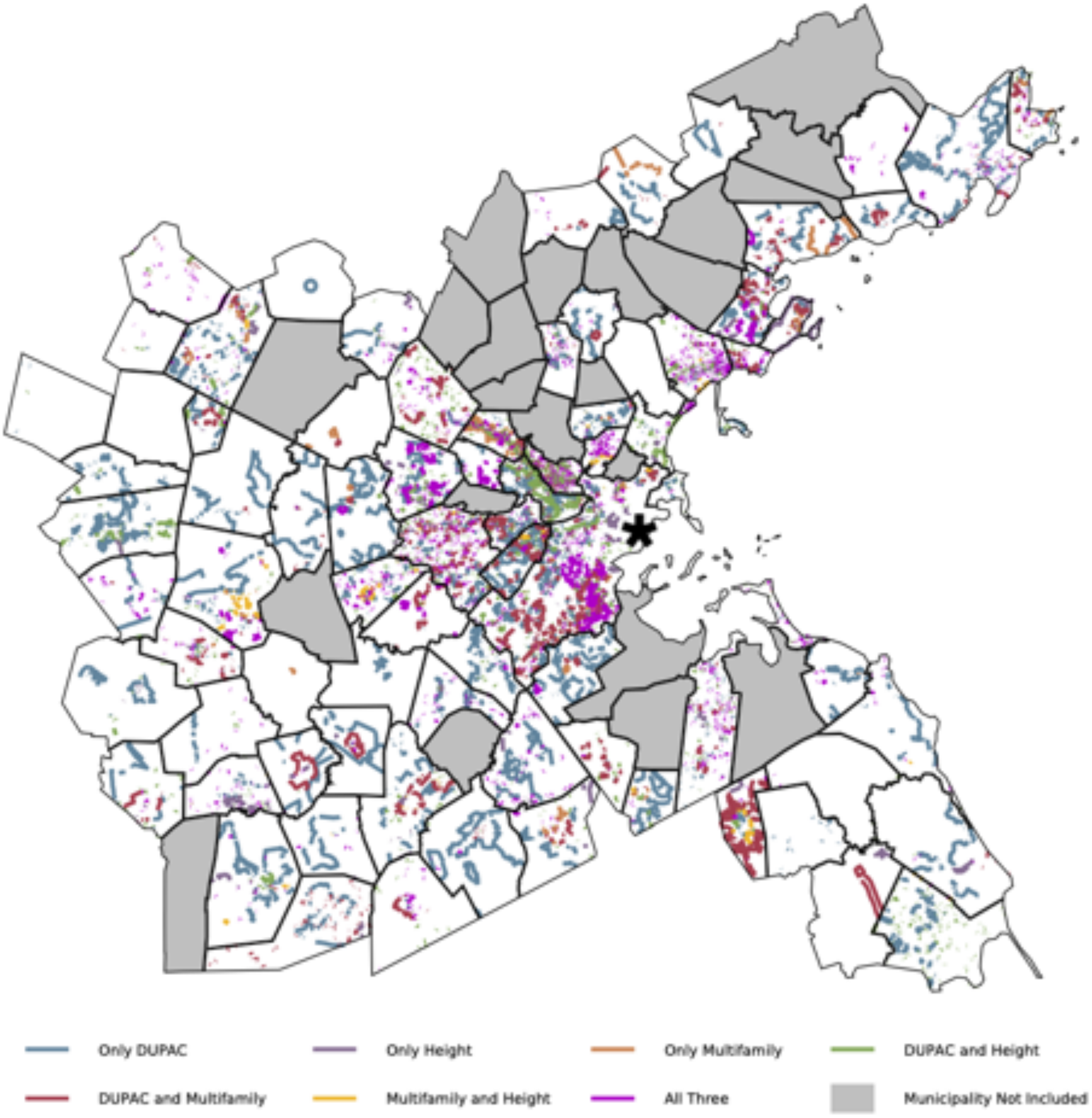
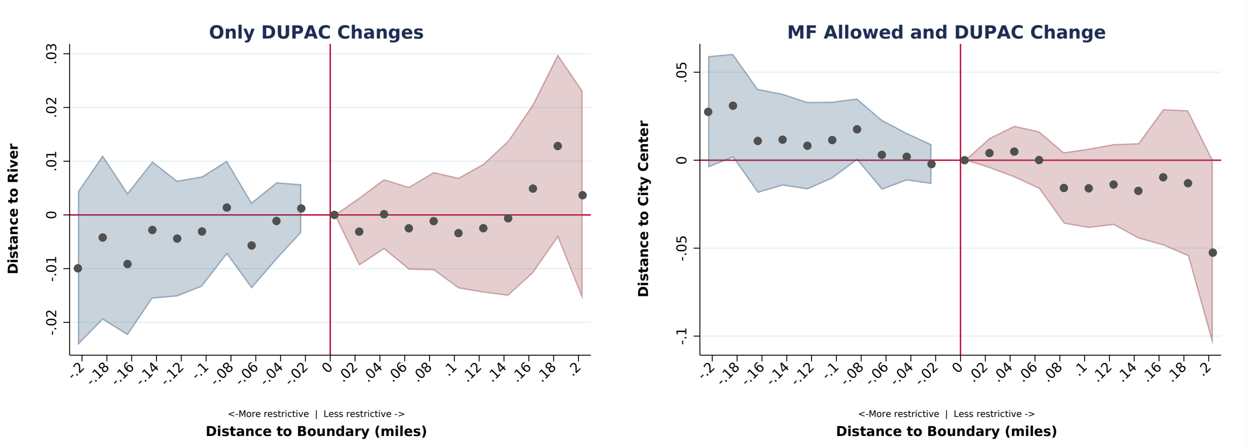
Figure 1: Admissible Boundaries with Land-Use Regulation Changes

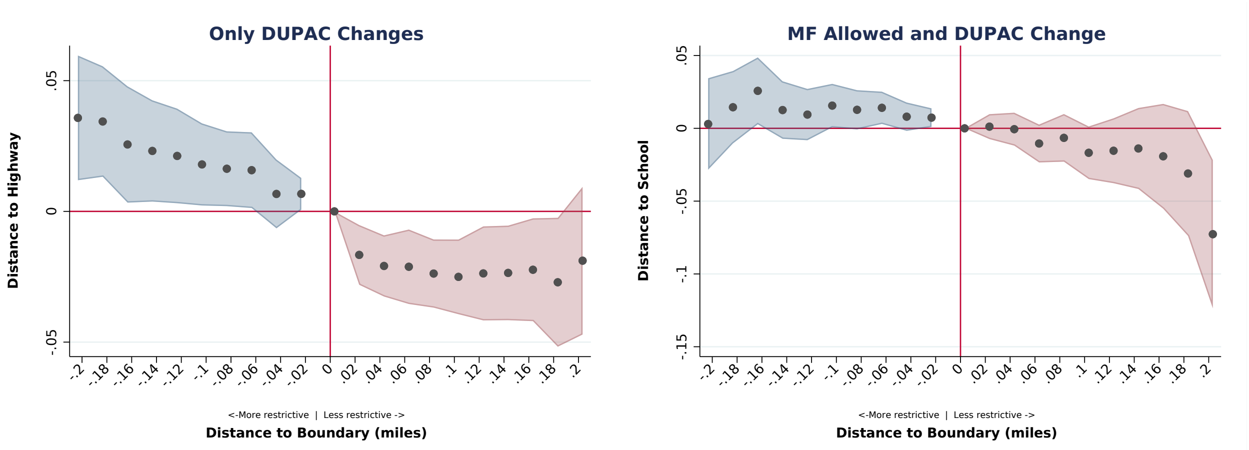


Note: This map shows the boundaries where multi-family (MF) regulation, maximum height restrictions, and dwelling units per acre (DUPAC) changes either by themselves or in a combination. These do not include regulations boundaries that overlap with major roads or geographic features. The base maps for these boundaries can be found in Appendix Figures B.2, B.3, and B.4. * denotes city of Boston.

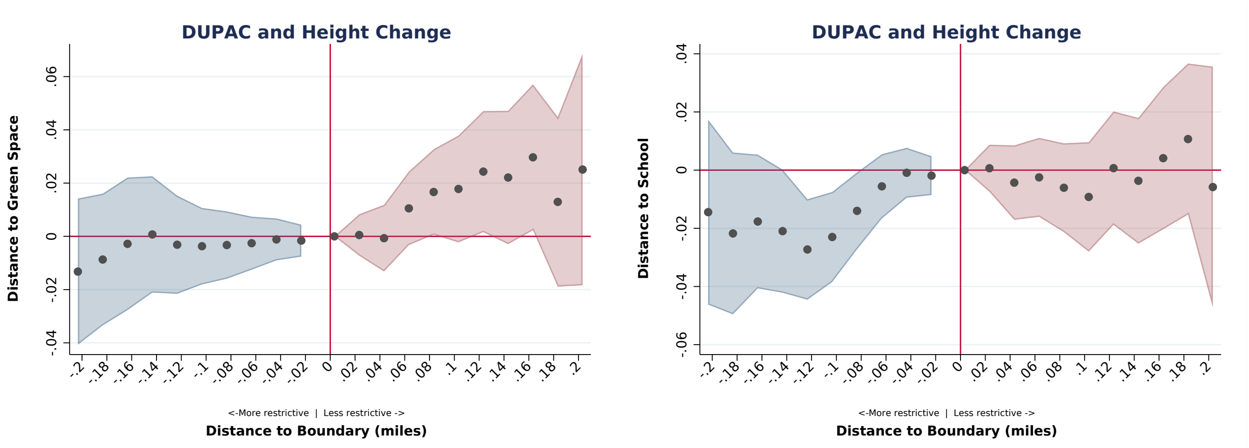
Figure 2: Amenities at Regulation Boundaries



(a) River/Lake RD estimate = 0.001, (t stat = 0.52)
(b) Center RD estimate = -0.002, (t stat = -0.39)



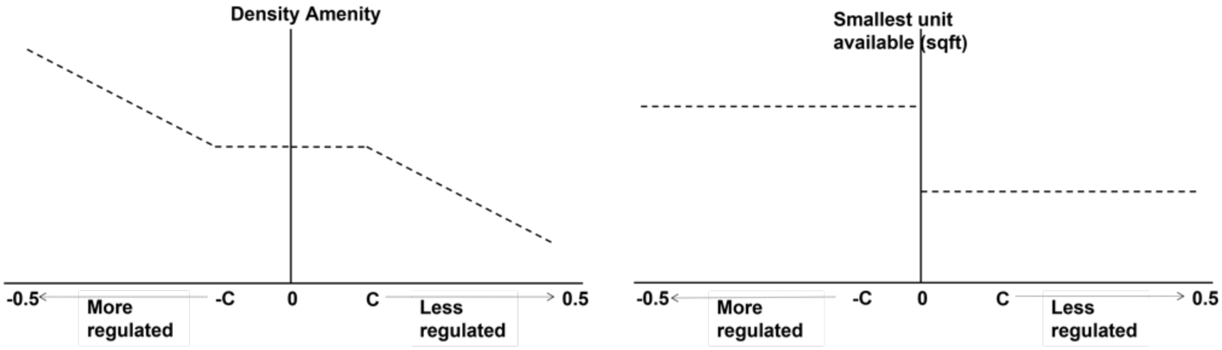
(c) Road RD estimate = 0.007, (t stat = 2.16)
(d) School RD estimate = -0.007, (t stat = 2.25)



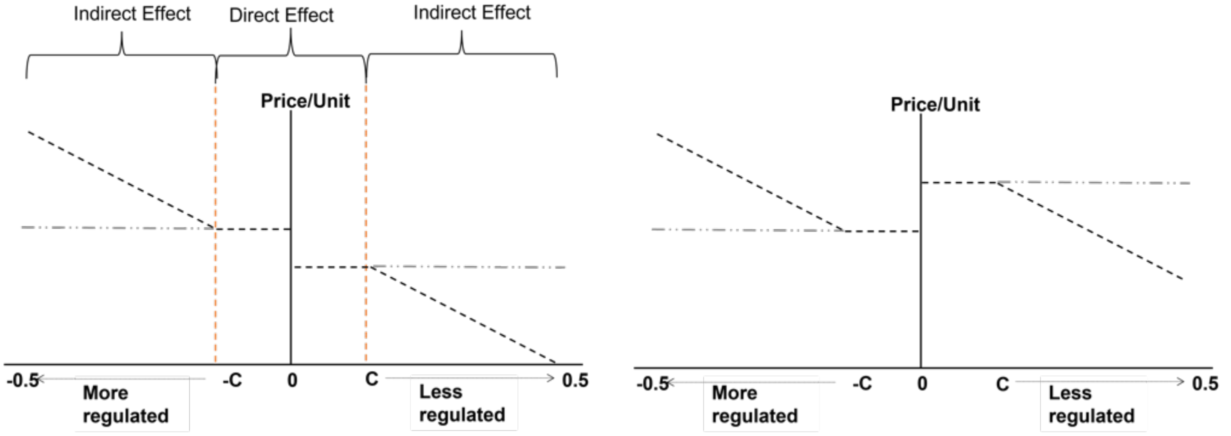
(e) Open Space RD estimate = -0.002, (t stat = -0.52)
(f) School RD estimate = -0.002, (t stat = -0.56)

Note: Plots are created by regressing distance to amenities on boundary fixed effects and distance to boundary (bins of 0.02 miles). Coefficients on distance bins are plotted. Negative distances indicate more regulated side. Bin closest to boundary on less regulated side (0-0.02 miles) is normalized to 0. 95% confidence intervals are shown. DUPAC is Dwelling units per acre and MF is multi-family zoning.

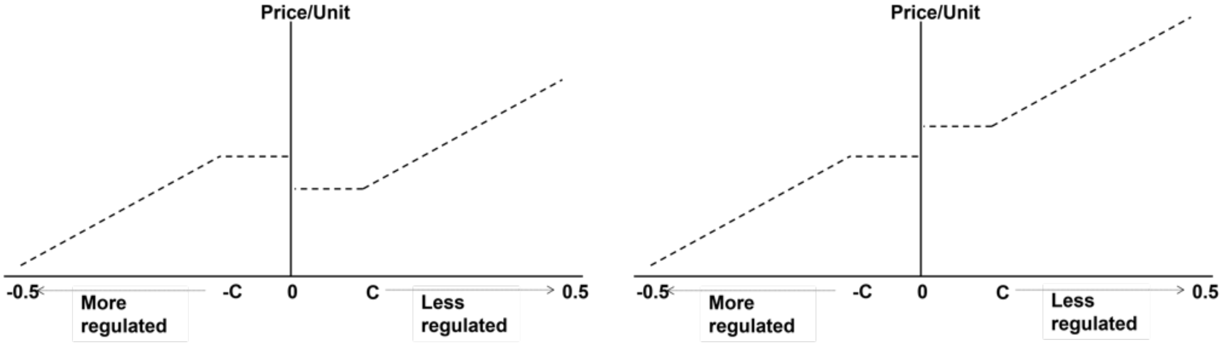
Figure 3: Price Effects at the Regulation Boundary



(a) Density Amenity (b) Smallest available unit



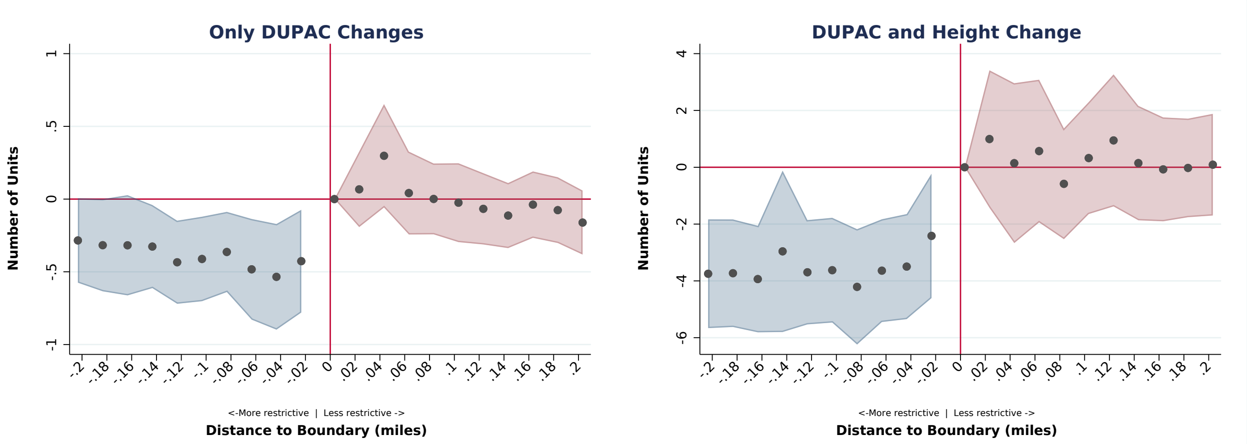
(c) Supply dominates & (no) dislike for density (d) Demand dominates & (no) dislike for density



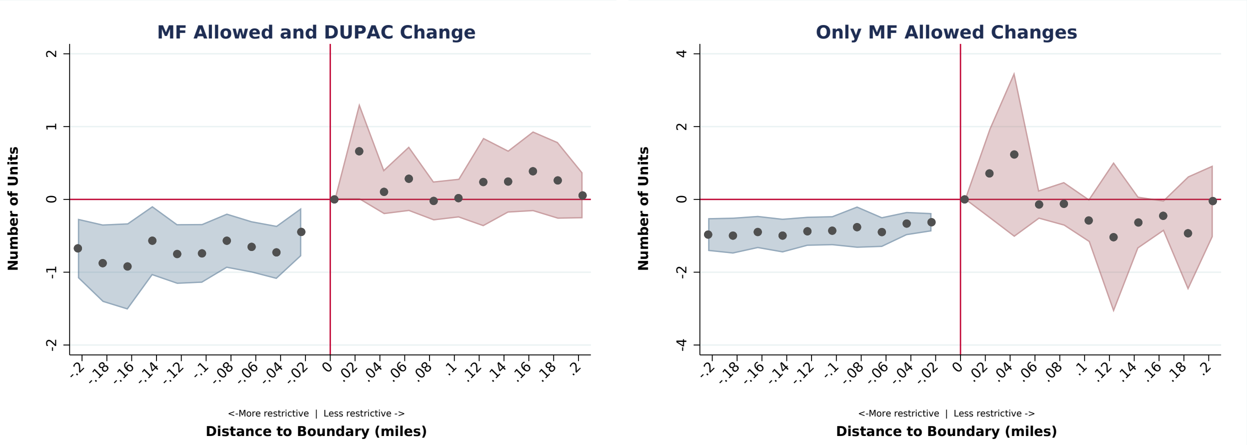
(e) Supply dominates & (no) preference for density (f) Demand dominates & preference for density

Note: This theoretical figure shows how amenities (a) and supply (smallest unit available (b)) change across regulation boundaries. Subfigures (c)-(f) illustrate how price per unit changes across regulation boundaries.

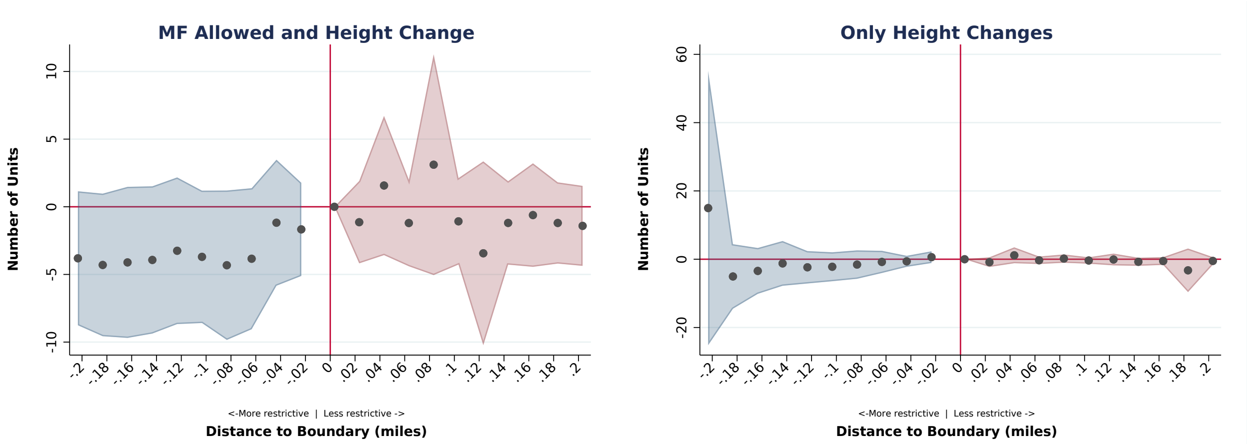
Figure 4: Effect of Regulations on Supply of Number of Units



(a) RD estimate = -0.427, (t statistic = -2.37) (b) RD estimate = -2.415, (t statistic = -2.17)



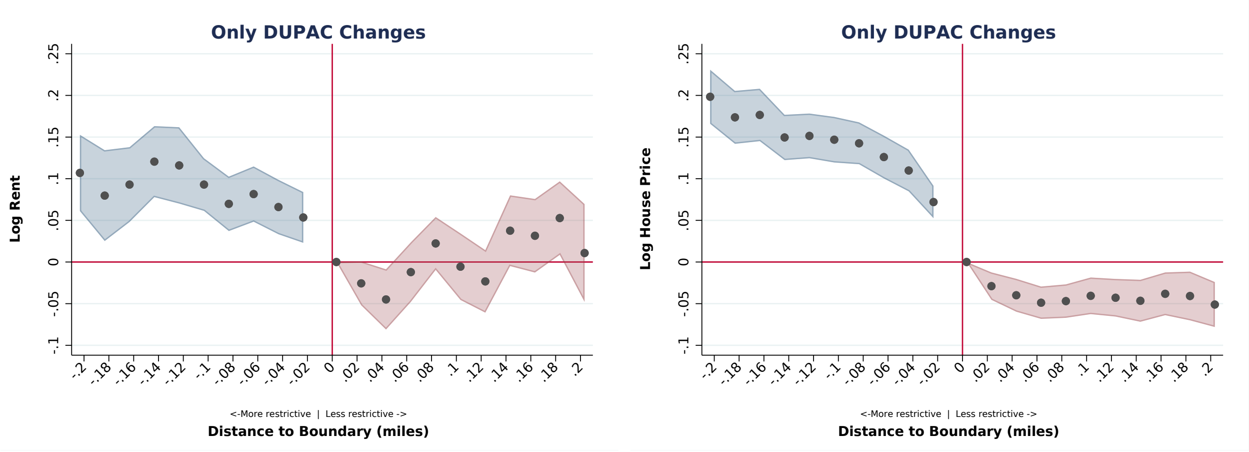
(c) RD estimate = -0.447, (t statistic = -2.65) (d) RD estimate = -0.626, (t statistic = -4.90)



(e) RD estimate = -1.669, (t statistic = -0.97) (f) RD estimate = 0.601, (t statistic = 0.69)

Note: Plots are created by regressing number of units on boundary fixed effects and distance to boundary (bins of 0.02 miles). Coefficients on distance bins are plotted. All buildings are built after 1918. Negative distances indicate the more regulated side. The bin closest to boundary on the less regulated side (0-0.02 miles) is normalized to 0. 95% confidence intervals are shown. Dwelling units per acre is DUPAC and multi-family allowed is MF. Standard errors are clustered at the boundary level.

Figure 5: Effects of Only DUPAC Regulation on Rents and Owner Costs of Housing

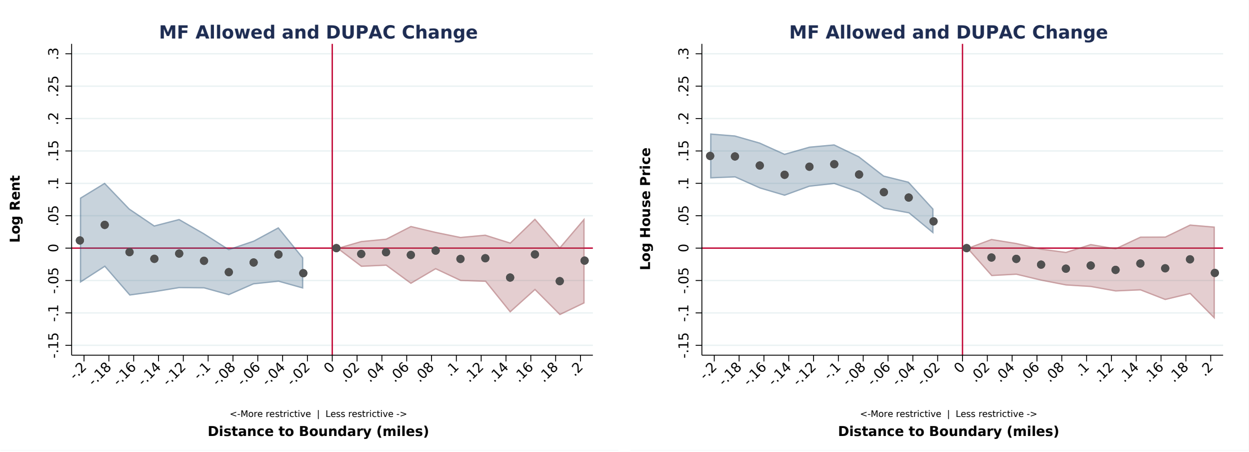


(a) RD estimate = -0.054, (t statistic = 3.44)

(b) RD estimate = -0.072, (t statistic = 7.27)

Note: Plots are created by regressing log prices on boundary fixed effects, year fixed effects [2010-2018], and bins of distance to boundary (bins of 0.02 miles). Coefficients on the distance bins are plotted. Negative distances indicate the more regulated side of a boundary. The bin closest to the boundary on the less regulated side (0-0.02 miles) is normalized to 0. 95% confidence intervals are shown. Left panel indicates the effect on monthly rental prices for multi-family buildings. Right panel indicates the effect on monthly owner cost of housing for single-family houses. The unit on DUPAC (dwelling units per acre) is in 1 housing unit. Standard errors are clustered at the boundary level.

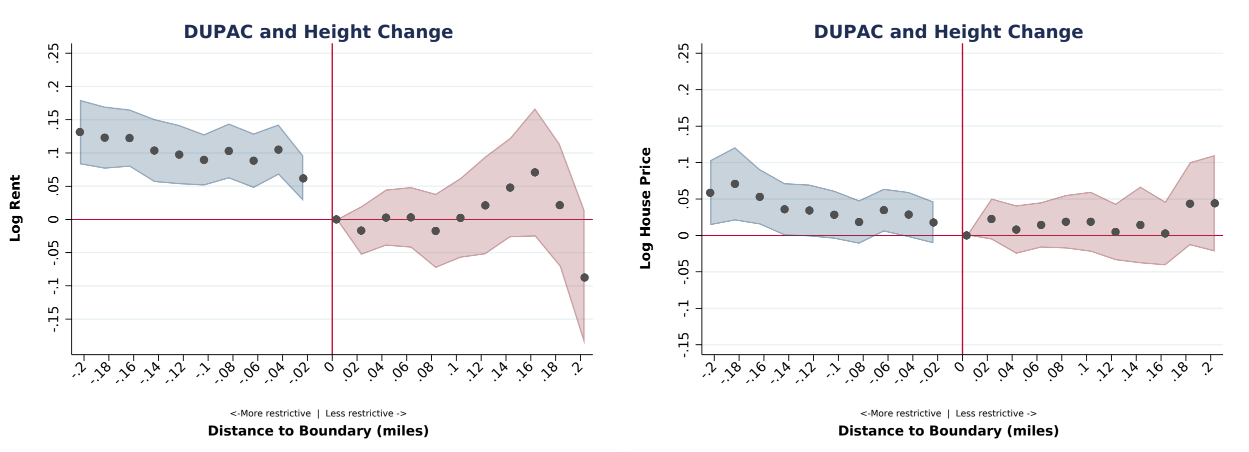
Figure 6: Effects of Two Regulation Changes on Rents and Owner Costs of Housing



(a) RD estimate= -0.039, (t statistic = -3.16)

(b) RD estimate = 0.041, (t statistic = 4.19)

Change in DUPAC and Multi-Family Regulation Boundaries



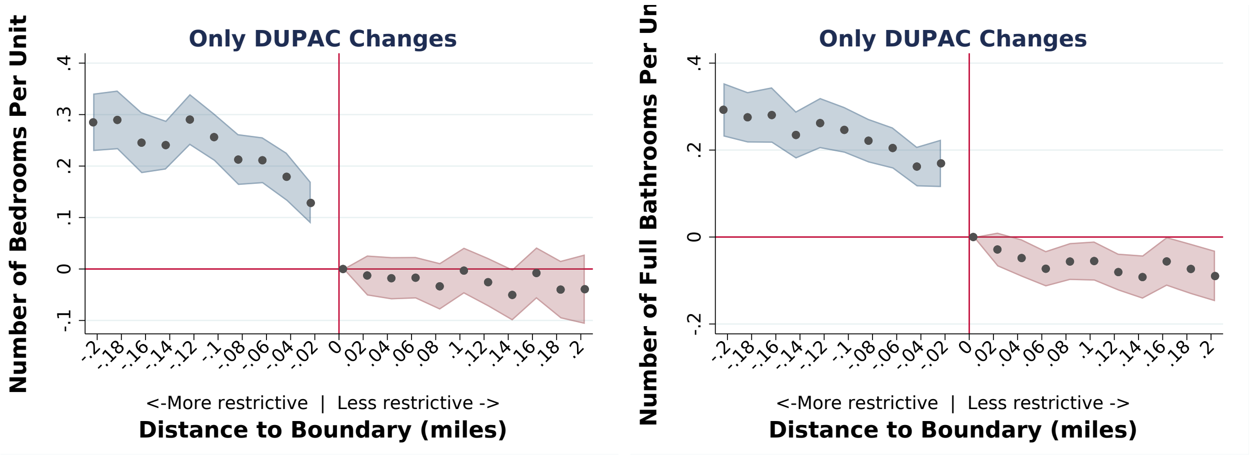
(c) RD estimate= 0.062, (t statistic = 3.53)

(d) RD estimate = 0.018, (t statistic = 1.21)

Change in DUPAC and Height Regulation Boundaries

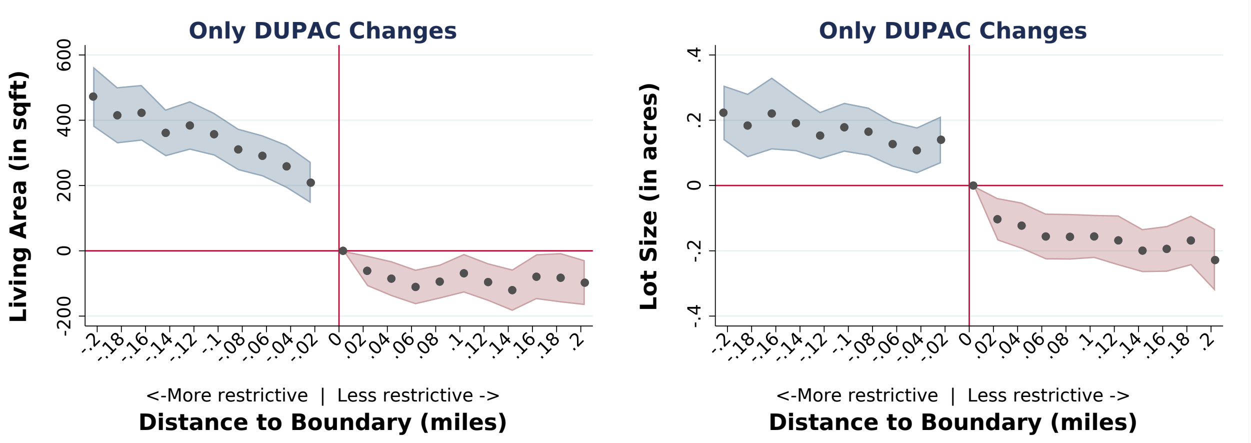
Note: Plots are created by regressing log prices on boundary fixed effects, year fixed effects [2010-2018], and bins of distance to the boundary (bins of 0.02 miles). Coefficients on the distance bins are plotted. Negative distances indicate the more regulated side of a boundary. The bin closest to the boundary on the less regulated side (0-0.02 miles) is normalized to 0. 95% confidence intervals are shown. Left panel indicates the effect on monthly rental prices for multi-family buildings. Right panel indicates the effect on monthly owner cost of housing for single-family houses. The unit on height is in 10 feet and DUPAC (dwelling units per acre) is in 1 housing unit. Standard errors are clustered at the boundary level.

Figure 7: Housing Characteristics at Regulation Boundaries: Only DUPAC Boundaries



(a) Bedrooms RD estimate = 0.128 , (t stat = 6.18)

(b) Bathrooms RD estimate = 0.17, (t stat = 6.08)

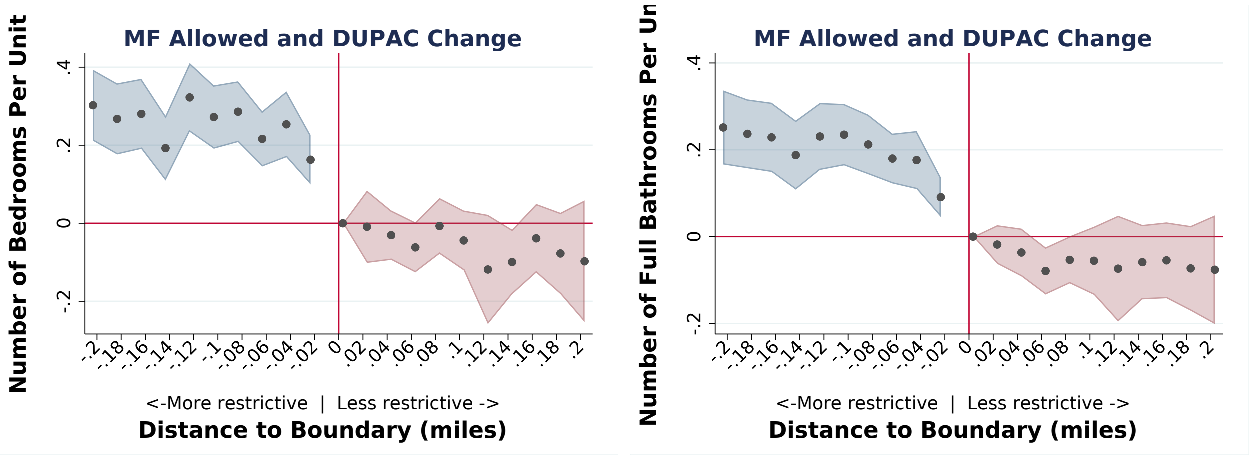


(c) Living Area RD estimate = 208.9, (t stat = 6.47)

(d) Lot Size RD estimate = 0.140, (t stat = 3.83)

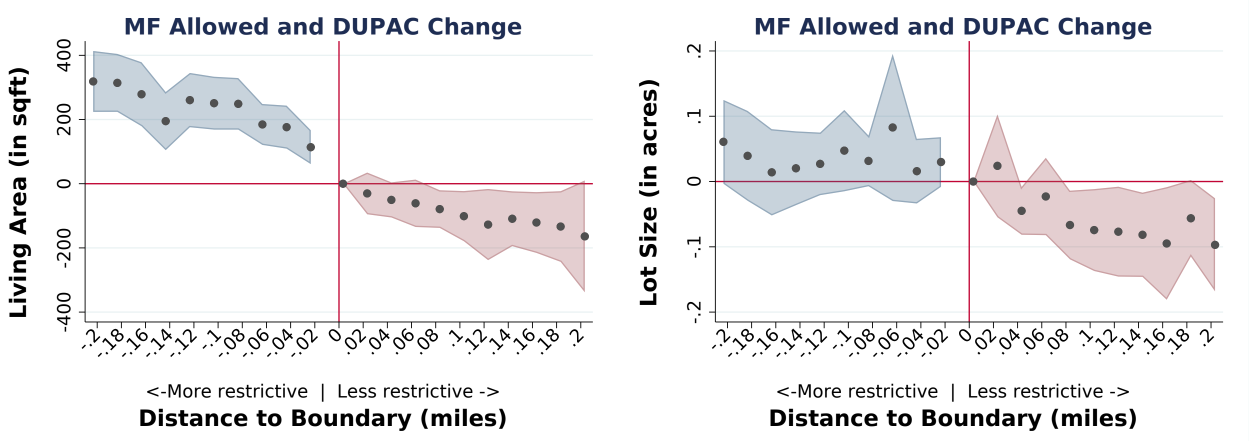
Note: This figure plots building characteristics across regulation boundaries. Plots are created by regressing unit characteristics on boundary fixed effects and distance to boundary (bins of 0.02 miles). Coefficients on distance bins are plotted. Negative distances indicate more regulated side. Bin closest to boundary on less regulated side (0- 0.02 miles) is normalized to 0. 95% confidence intervals are shown. DUPAC is Dwelling units per acre and MF is multi-family zoning.

Figure 8: Housing Characteristics at Regulation Boundaries: DUPAC & MF change



(a) Bedrooms RD estimate = 0.163, (t stat = 5.04)

(b) Bathrooms RD estimate = 0.091, (t stat = 3.90)

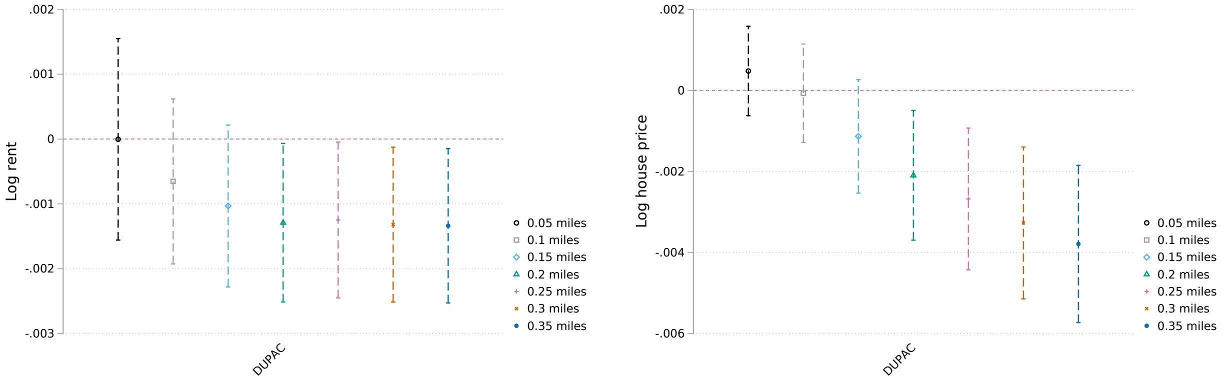


(c) Living Area RD estimate = 113.8, (t stat = 4.23)

(d) Lot Size RD estimate = 0.03, (t stat = 1.54)

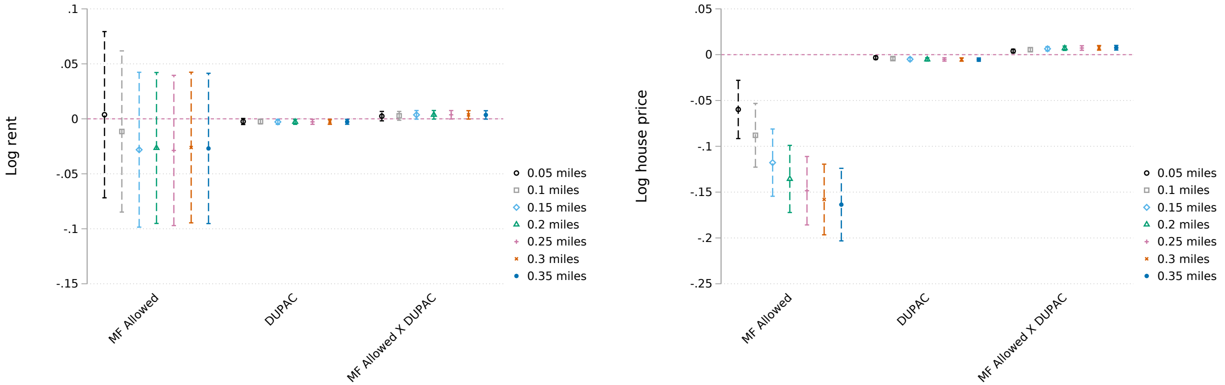
Note: This figure plots building characteristics across regulation boundaries. Plots are created by regressing unit characteristics on boundary fixed effects and distance to boundary (bins of 0.02 miles). Coefficients on distance bins are plotted. Negative distances indicate more regulated side. Bin closest to boundary on less regulated side (0-0.02 miles) is normalized to 0. 95% confidence intervals are shown. DUPAC is Dwelling units per acre and MF is multi-family zoning.

Figure 9: Price Effects across Various Distance Bandwidths



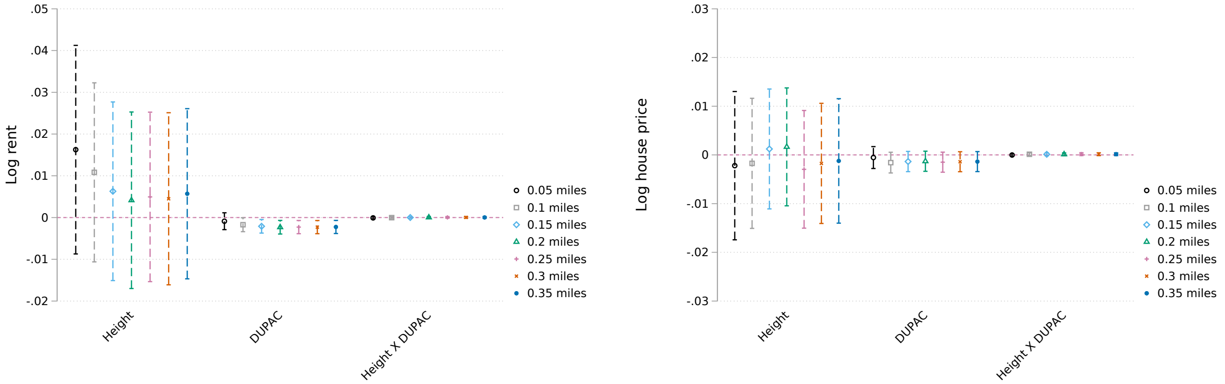
(a) (b)

Change in DUPAC Regulation Boundaries



(c) (d)

Change in DUPAC and Multi-Family Regulation Boundaries

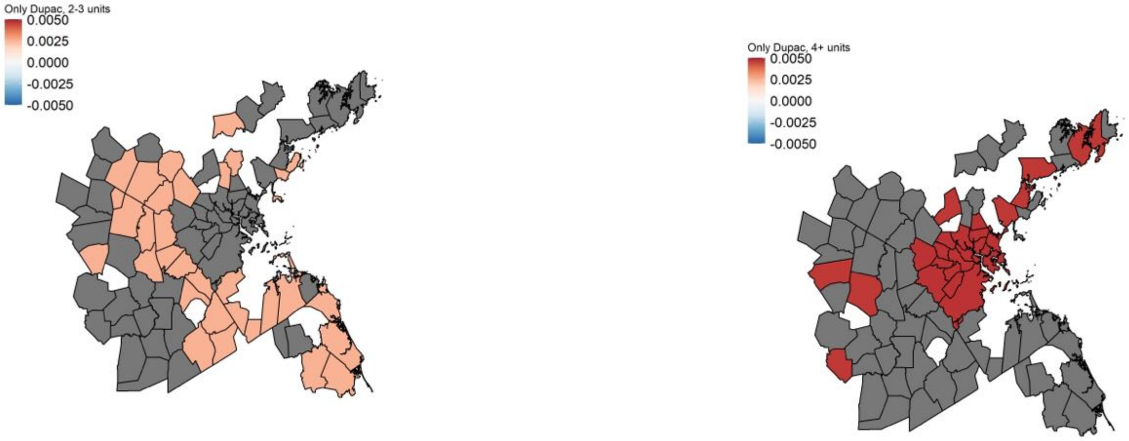


(e) (f)

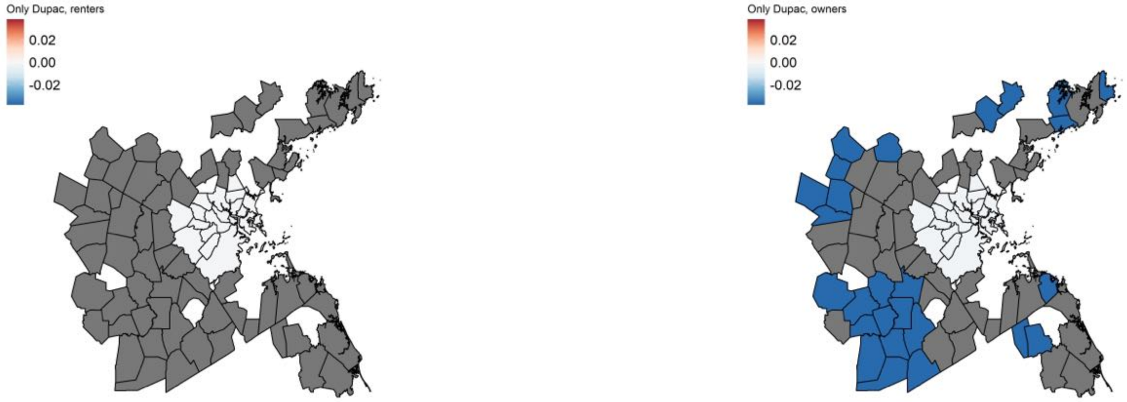
Change in DUPAC and Height Regulation Boundaries

Note: This figure plots coefficient on multi-family (MF), height, and dwelling units per acre (DUPAC) when the regulation RD boundary varies from 0.05-0.35 miles. Coefficients for log monthly rents are plotted left (a,c,e). Coefficients for log monthly owner cost of housing are plotted right (b,d,f). The unit on height is in 10 feet and DUPAC is in 1 housing unit. Standard errors are clustered at the boundary level.

Figure 10: Only DUPAC Regulation: Effects on Supply and Prices across Space



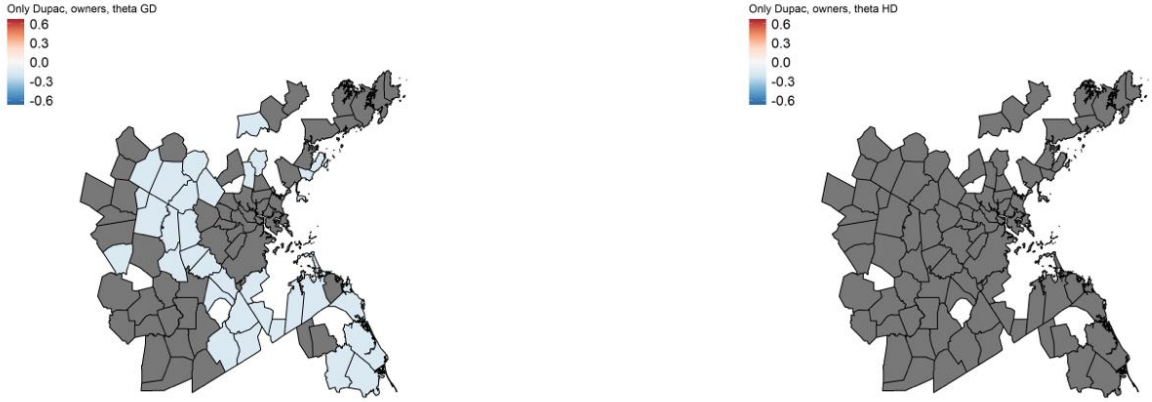
(a) Supply effect



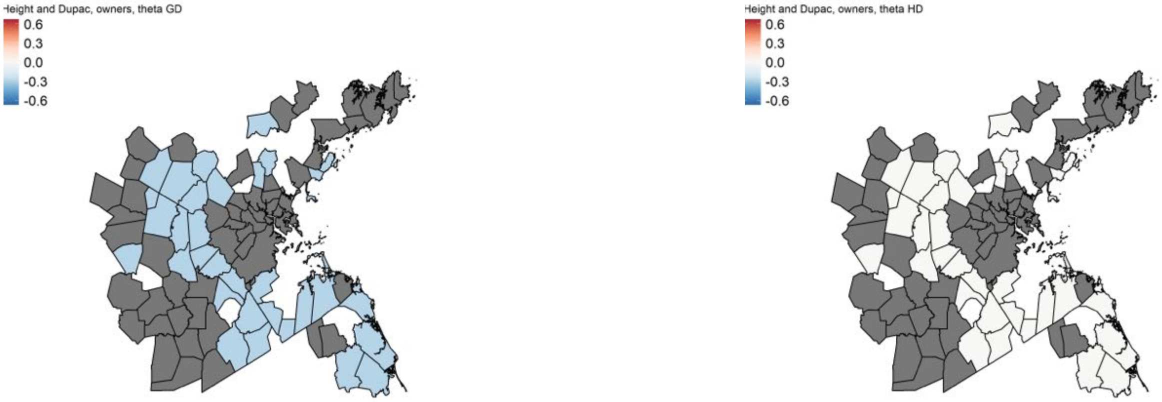
(b) Direct effect

Note: These figures highlight the effects of only DUPAC regulation on the supply of type of building (2-3 units on top left and 4 or more units on top right) and housing costs (log monthly rents for multi-family units on bottom left and log monthly owner cost of housing for single-family houses on bottom right) across space. DUPAC is dwelling units per acre. Grey areas represent no statistically significant results.

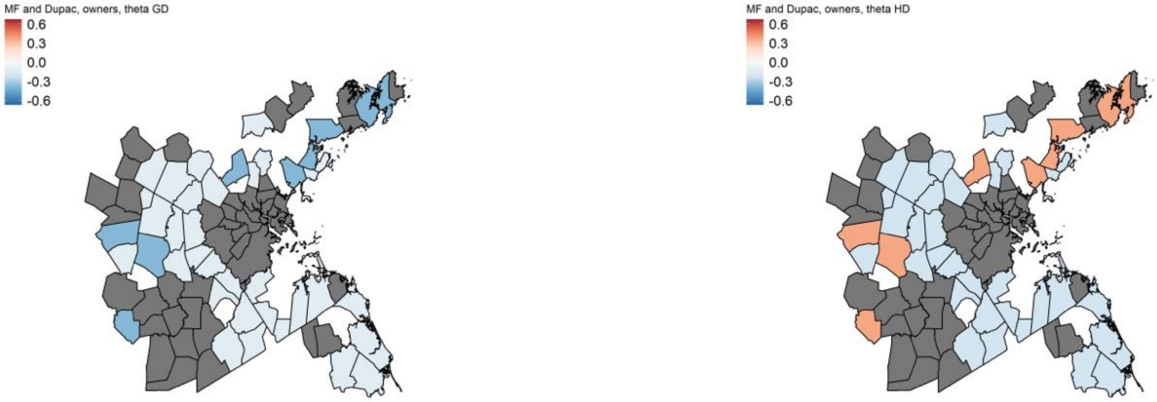
Figure 11: Indirect Effects of Gentle and High Density on Owners



(a) Boundaries where only DUPAC changes



(b) Boundaries where DUPAC and Height change



(c) Boundaries where DUPAC and MF allowed change

Note: These figures plots coefficients of the indirect price effects of only DUPAC (dwelling units per acre), DUPAC and Height, and DUPAC and Multi-Family (MF) regulations on log monthly owner cost of housing for single-family houses for increases in gentle-density (2-3 units) or high-density (four or more units) in 0.1 radius around the house on left and right, respectively. Grey areas represent no statistically significant results.

Table 1: Interaction of Various Zoning Regulation Scenarios

Regulation Scenarios	Multi-Family Changes	Height Changes	DUPAC Changes	Rent (% Obs.) (Multi-Family)	Prices (% Obs.) (Single-Family)
Scenario 1	X			-	3.0
Scenario 2		X		2.8	2.6
Scenario 3			X	30.8	55.5
Scenario 4	X	X		1.0	1.5
Scenario 5	X		X	22.0	20.2
Scenario 6		X	X	24.0	8.4
Scenario 7	X	X	X	19.4	8.8

Note: This table represents the interaction of various zoning regulation scenarios as well as the percentage of rents and house price observations under each of these scenarios. DUPAC is maximum dwelling units per acre.

Table 2: Type of Housing Built Before 1918

	2-3 units (Gentle Density)				**4+ units (High Density)**			
	Only MF	Only DU	MF & DU	H & DU	Only MF	Only DU	MF & DU	H & DU
MF allowed	0.016		0.114***		0.007		0.043*	
	(0.092)		(0.032)		(0.048)		(0.017)	
Height (H)				0.011				0.010
				(0.013)				(0.010)
DUPAC (DU)		-0.000	0.001	0.001		-0.000	0.001	0.005***
		(0.001)	(0.002)	(0.001)		(0.001)	(0.001)	(0.001)
MFXDU			-0.005*				-0.003*	
			(0.002)				(0.001)	
HXDU				-0.000				0.000
				(0.000)				(0.000)
N	2,918	29,485	17,833	16,821	1,373	19,054	10,440	8,461
R^2	0.374	0.296	0.294	0.237	0.323	0.369	0.208	0.378
$\mathbb{E}(y)$	0.566	0.397	0.436	0.568	0.078	0.067	0.037	0.141

Note: This table presents the results from a linear probability model where dependant variable value of 0 is a single family house and value of 1 is either a 2-3 unit building or 4 or more unit building 0-0.3 miles on either side of the boundary. All buildings are built before 1918. Only MF are boundaries where only multi-family (MF) regulation changes and only DU are boundaries where only dwelling units per acre (DUPAC) regulation changes. MF & DU and H & DU are boundaries where MF and DUPAC both change and height and DUPAC both change, respectively. The unit on height is in 10 feet and DUPAC is in 1 housing unit. Standard errors are clustered at the boundary level.

Table 3: Regulations and Their Effects on Supply and Prices

		Δ Single Regulation			Δ Multiple Regulation		
		MF	H	DU	MF & DU	MF &H	DU & H
Supply		–	–	↑	↑	–	↑
Prices	Supply/Demand	–	–	↓	↓	–	↓
	Option Value (SF)	↑	↑	↑	↑	↑	↑
	Spillovers	↓	–	↓	↓	↓	↓

Note: This figure illustrates how supply and prices change under various combination of regulation scenarios. MF is multi-family, H is maximum height, and DU is dwelling units per acre (DUPAC) regulation boundaries. MF & DU, MF & H, and DU & H are boundaries where MF and DUPAC both change, MF and H both change, and H and DUPAC both change, respectively.

Table 4: Supply: Types of Housing across Regulation Boundaries (Built after 1918)

	2-3 units (Gentle Density)				**4+ units (High Density)**			
	Only MF	Only DU	MF & DU	H & DU	Only MF	Only DU	MF & DU	H & DU
MF allowed	0.418***		0.044*		0.033		0.002	
	(0.073)		(0.021)		(0.017)		(0.009)	
Height (H)				-0.011				-0.007
				(0.010)				(0.007)
DUPAC (DU)		0.002**	-0.008**	-0.002		0.001**	0.000	0.004*
		(0.001)	(0.003)	(0.002)		(0.000)	(0.001)	(0.002)
MFXDU			0.012***				0.002*	
			(0.002)				(0.001)	
HXDU				0.0003*				-0.000
				(0.0001)				(0.000)
N	5,838	92,046	35,194	13,101	5,006	87,697	30,129	9,878
R^2	0.457	0.397	0.371	0.509	0.405	0.490	0.271	0.522
$\mathbb{E}(y)$	0.157	0.061	0.159	0.290	0.017	0.012	0.015	0.067

Note: This table presents the results from a linear probability model where dependant variable value of 0 is a single family house and value of 1 is either a 2-3 unit building or 4 or more unit building 0-0.3 miles on either side of the boundary. All buildings are built after 1918. Only MF are boundaries where only multi-family (MF) regulation changes and only DU are boundaries where only dwelling units per acre (DUPAC) regulation changes. MF & DU and H & DU are boundaries where MF and DUPAC both change and height and DUPAC both change, respectively. The unit on height is in 10 feet and DUPAC is in 1 housing unit. Standard errors are clustered at the boundary level.

Table 5: Price Effects Away from Regulation Boundaries

	Only MF	Only DUPAC	MF & DUPAC	DUPAC & Height	All
			Multi-Family (rents)		
θ^{HD}	-	0.168	0.092	-0.100	-0.137
		(0.119)	(0.141)	(0.093)	(0.134)
θ^{GD}	-	-0.101*	-0.059	0.040	-0.060
		(0.051)	(0.041)	(0.047)	(0.061)
N		43,993	31,391	35,347	30,114
$\mathbb{E}(y)$		\$1,049	\$971	\$1,017	\$943
$\mathbb{E}(\theta^{HD})$		0.054	0.043	0.079	0.058
$\mathbb{E}(\theta^{GD})$		0.388	0.465	0.532	0.555
			Single-Family (owner cost of housing)		
θ^{HD}	-0.495	-0.103	-0.102	-0.097	-0.051
	(0.250)	(0.092)	(0.060)	(0.056)	(0.095)
θ^{GD}	0.159	-0.166***	-0.213***	-0.056	-0.213***
	(0.102)	(0.038)	(0.048)	(0.043)	(0.062)
N	20,517	446,515	147,523	63,495	63,695
$\mathbb{E}(y)$	\$2,710	\$2,519	\$2,256	\$2,321	\$2,494
$\mathbb{E}(\theta^{HD})$	0.010	0.001	0.010	0.023	0.016
$\mathbb{E}(\theta^{GD})$	0.061	0.053	0.104	0.192	0.150

Note: This table shows the coefficients on share of high density (4 + units) buildings (θ^{HD}) and share of gentle density (2-3 units) buildings (θ^{GD}) within 0.1 mile radius around a house across different regulation boundaries from Equation 6 for buildings 0.1-0.3 miles on either side of the regulation boundaries. Top panel presents results where dependent variable is log monthly rents. For bottom panel it is log monthly owner cost of housing. Standard errors are clustered at the boundary level. MF is multi-family. DUPAC is dwelling units per acre. All is boundary where MF, DUPAC, and Height regulations all change. The unit on height is in 10 feet and DUPAC is in 1 housing unit. Standard errors are clustered at the boundary level.

Table 6: Town Governance Heterogeneity: Supply

		OTM		RTM		Mayor	
		2-3	4+	2-3	4+	2-3	4+
Only DU	DU	0.016***	0.008*	0.001***	0.000	0.002	0.006***
		(0.004)	(0.004)	(0.000)	(0.000)	(0.003)	(0.002)
	N	22,937	22,681	11,223	11,116	11,981	11,618
MF X DU	MF	-0.069**	-0.028***	0.048	-0.017	0.207**	0.119*
		(0.028)	(0.011)	(0.056)	(0.018)	(0.086)	(0.056)
	DU	-0.034***	-0.008*	0.020	-0.020	0.005	0.006*
		(0.012)	(.004)	(0.029)	(0.014)	(0.004)	(0.003)
	MF X DU	0.036***	0.009***	-0.004	0.019	-0.004	-0.001
		(0.009)	(0.004)	(0.026)	(0.012)	(0.004)	(0.003)
	N	4,849	4,686	3,734	3,623	4,351	3,904

Note: This table presents results from Equation 4 for different forms of local government: open town meetings (OTM), representative town meetings (RTM), or mayoral system (Mayor). Dependent variable is an indicator for supply of different types of buildings. We control for boundary fixed effects. Standard errors are clustered at the boundary level. MF is multi-family regulation. DU is dwelling units per acre (DUPAC). The unit on DUPAC is in 1 housing unit.

Table 7: Town Governance Heterogeneity: Price Effects

		OTM		RTM		Mayor	
		MF	SF	MF	SF	MF	SF
	DU	-0.008	-0.017***	0.004***	-0.001	-0.003***	-0.002*
		(0.004)	(0.004)	(0.001)	(0.001)	(0.001)	(0.001)
Only DU	N	19,537	324,427	15,969	211,798	119,211	275,067
	θ^{GD}	-0.246	-0.033	0.011	-0.344***	-0.073	-0.133***
		(0.113)	(0.047)	(0.107)	(0.103)	(0.063)	(0.051)
	θ^{HD}	-0.237	-0.082	-0.126	-0.337	0.199	-0.310**
		(0.211)	(0.100)	(0.288)	(0.211)	(0.120)	(0.116)
	N	7,251	156,638	4,121	100,858	23,848	102,691
	MF	-0.105	-0.199***	-0.004	-0.131***	-0.014	-0.183***
		(0.104)	(0.054)	(0.070)	(0.032)	(0.047)	(0.032)
MF X DU	DU	-0.009	-0.025	0.029	-0.012	-0.002	-0.007***
		(0.017)	(0.017)	(0.020)	(0.017)	(0.001)	(0.001)
	MF X DU	0.015	0.028	-0.029	0.013	0.003	0.009***
		(0.018)	(0.014)	(0.019)	(0.014)	(0.003)	(0.002)
	N	8,268	85,280	10,100	77,119	108,846	161,811
	θ^{GD}	-0.109	-0.107*	0.086	-0.201***	-0.046	-0.197***
		(0.157)	(0.047)	(0.102)	(0.065)	(0.043)	(0.079)
	θ^{HD}	-0.281**	-0.142*	0.314	-0.136	0.320	-0.133
		(0.113)	(0.068)	(0.226)	(0.146)	(0.218)	(0.108)
	N	2,785	37,176	3,305	32,550	22,128	52,254

Note: This table presents results from Equation 4 & 6 for different forms of local government: open town meetings (OTM), representative town meetings (RTM), or mayoral system (Mayor). Dependent variable is log of either monthly owner cost of housing (single-family) or monthly rent (multi-family (MF)). We control for boundary fixed effects. We also use year fixed effects. Standard errors are clustered at the boundary level. MF is multi-family regulation. DU is dwelling units per acre (DUPAC). The unit on DUPAC is in 1 housing unit.

Table 8: Land Regulation and Inclusionary Zoning (Chapter 40B)

	MF	H	DU	MF X H	MF X DU	H X DU	MF X H X DU	R^2	E(y), N
All	-0.336*	0.005	0.000	0.080*	0.008*	-0.0005*	-0.001*		0.004
	(0.158)	(0.004)	(0.000)	(0.036)	(0.004)	(0.00002)	(0.001)	0.418	6,392
MF	-0.827***	0.017	0.002	0.209***	0.019***	-0.001***	-0.004***		0.006
	(0.168)	(0.010)	(0.001)	(0.043)	(0.005)	(0.000)	(0.001)	0.819	3,770

Note: This table presents the results from Equation 4 for buildings 0-0.5 miles around the border. The dependent variable is an indicator whether a property was built using Massachusetts' Chapter 40B inclusionary zoning policy to override local zoning rules. We control for boundary fixed effects. Standard errors are clustered at the boundary level. Results presented here are for boundaries where all regulations change at the same time. "All" indicates any building built using Chapter 40B's comprehensive permitting procedure while "MF" indicates multi-family buildings built using this procedure. Each column shows the effect of a different zoning policy on the supply of properties built using Chapter 40B. MF indicates multi-family. DU is dwelling units per acre and H is height. The unit on height is in 10 feet and DUPAC is in 1 housing unit. Standard errors are clustered at the boundary level.

ONLINE APPENDIX

A. Data Appendix

A.1 Rent Imputation

For the buildings that have CoStar market rent available [18,536 buildings from 2010-2018], we use it directly. For the remaining 112,992 buildings, we impute rent using CoStar characteristics, Warren Group data and ACS block group characteristics. The distribution of CoStar market rent is in red in Figure A.1 panel (a) plotted against the 2018 ACS block-group level rent (yellow). For the buildings that have detailed CoStar data, we impute rent using a linear regression model using the detailed characteristics from CoStar, Warren Group, and ACS block group characteristics and CoStar data on market rent. This distribution is plotted in green in Figure A.1. From CoStar, we get data on 18,536 building-year observations. As can be seen from the Figure A.1 panel (a), CoStar's rental distribution leans towards the higher-end rental market. To capture the entire distribution of rents for the remainder of 112,992 buildings, particularly multi-family buildings with two-four units, we proceed in two steps.

First, we use the BEA imputation of 6.29% of the assessed value for *all* multi-family buildings. This distribution is plotted in pink against the 2018 ACS rent distribution (yellow) in Figure A.1 panel (b). Second, we impute rent using a linear regression model using the characteristics Warren Group and ACS block group characteristics and CoStar data on market rent.[1] The ACS imputed rent distribution is plotted in blue in Figure A.1 panel (b). Since BEA imputation matches the ACS rental distribution better than the imputed ACS rent distribution, we use BEA imputed rent for the non-CoStar buildings.[2]

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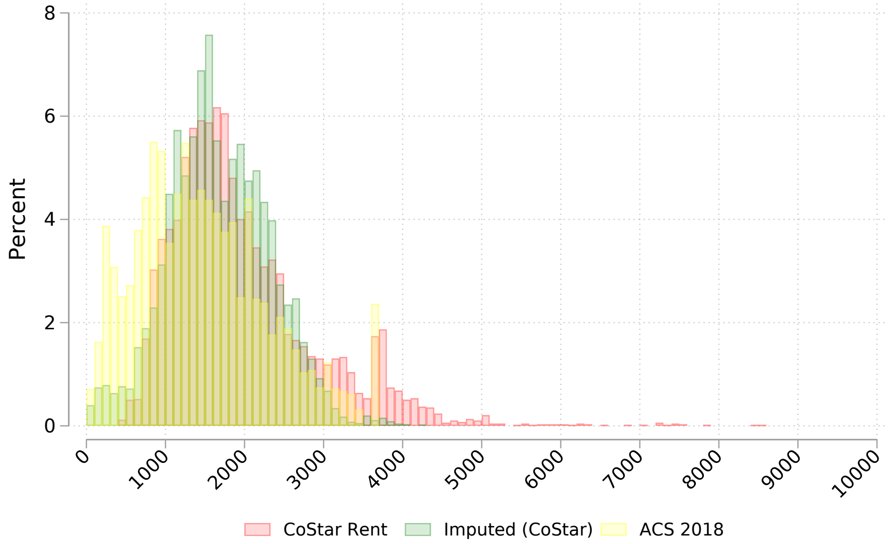
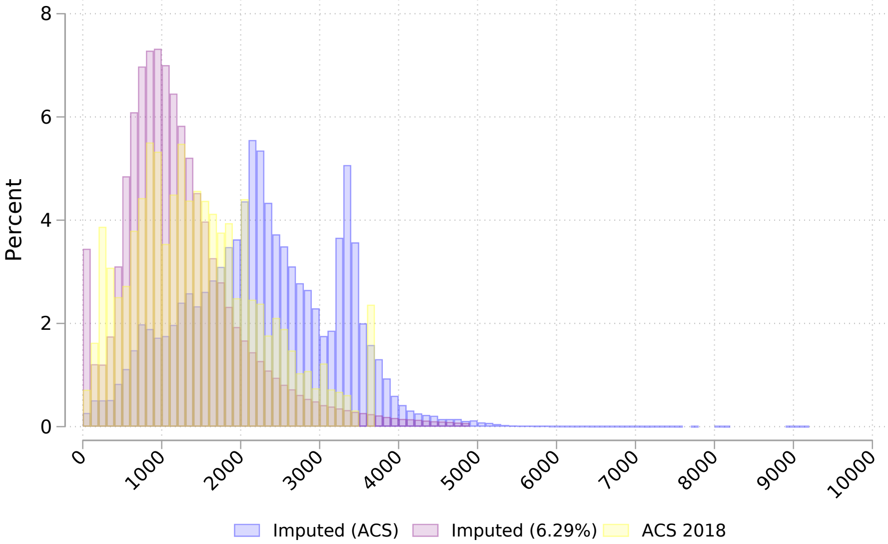
[1] These buildings do not have detailed CoStar building characteristic data.

[2] Baseline results use CoStar actual market rent data and BEA imputation for the remainder. For robustness, we also use CoStar actual and imputed rent data along with BEA imputation, but results don't change significantly compared to the baseline rental measure.

Figure A.1: Rent Imputation for Multi-Family Houses



(a) CoStar Imputation



(b) BEA and ACS Imputation

Note: Panel (a) plots the rental data from CoStar against the imputed rental values using CoStar variables and against the ACS (2018) rental distribution. Panel (b) plots the ACS (2018) rental distribution data against the ACS variables, and the 6.29% BEA estimation.

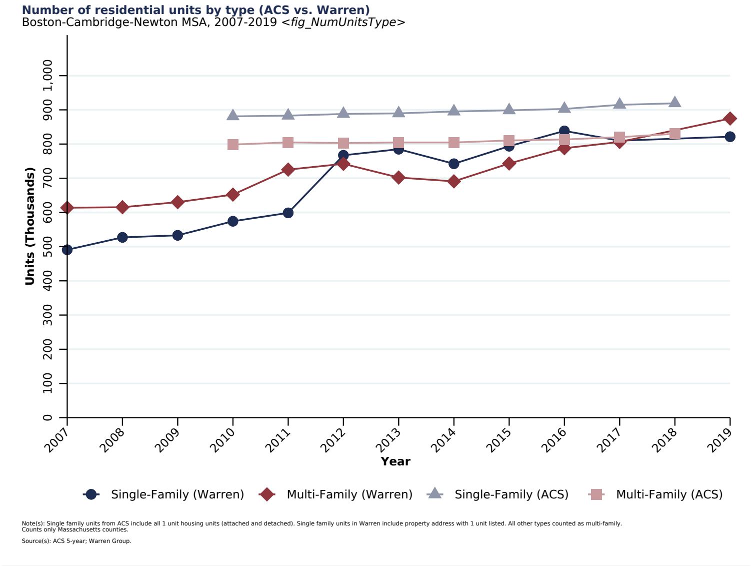
A.2 Regulations and Supply: Neighborhood Level

In addition using a linear probability model to study the effect of land-use regulations on supply, we also run regressions at neighborhood level. A neighborhood is a 0.1X0.1 or 0.1X0.3 or 0.1X0.5 mile box on either side of the boundary (see Figure A.4). In each box, neighborhood density is measured as share of total gentle or high density lots, unit-level density (total units /total lots), or area-level density (total building area /total lot area). The empirical model is given by Equation 4. Qualitatively, these results are similar to the results presented in Table 4 and Figure 4. Note that this is not chosen to be the primary specification because about half of our boundaries 0.1 miles or smaller. Use of this specification, thus, results in dropping off of about half of the boundaries.

A.3 Distance to Nearby Boundaries

Identifying the direct effect of the zoning regulation in a boundary RD framework depends on other factors not varying discontinuously at the boundary (e.g., Figure 2). In terms of the indirect effect, a possible confounding factor is that it might be capturing changes in residential density from other nearby zoning regulation boundaries. Figures A.5 shows a histogram of the distance to the closest, 2nd closest, and 3rd nearest boundaries in our sample. The 2nd closest boundary is, on average, 0.376 miles. The third closest boundary is 0.464 miles away. This may seem concerning since we estimate indirect effects at 0.1-0.3 miles from the boundary. Figure **??** shows how the share of single-family, gentle-density and high-density homes in a 0.1 mile radius evolves over space away from the boundary. Since we show that boundaries lead to sharp changes in the type and number of homes, if our estimates of indirect effects were driven by proximity to the next regulation boundary, we would expect to see large gradients in the shares away from the boundary. On the contrary, we see that the share of different types of homes is quite flat up until 0.2 miles from the boundary (which includes homes up until 0.25 miles from the boundary). Therefore, we are reassured that indirect effects are driven by the density of homes induced by this zoning regulation and not the next closest one.

Figure A.2: Total Units by Housing Type: Warren and ACS Data


Number of residential units by type (ACS vs. Warren)

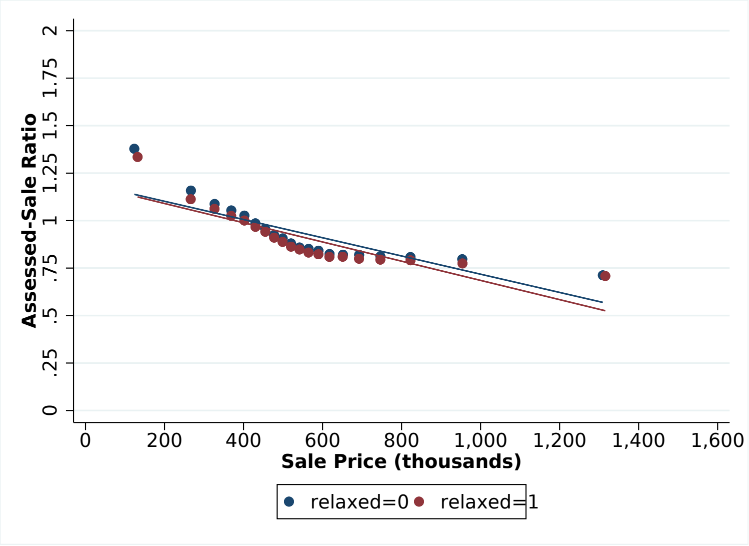
Boston-Cambridge-Newton MSA, 2007-2019 <*fig_NumUnitsType*>

Note(s): Single family units from ACS include all 1 unit housing units (attached and detached). Single family units in Warren include property address with 1 unit listed. All other types counted as multi-family. Counts only Massachusetts counties.

Source(s): ACS 5-year; Warren Group.

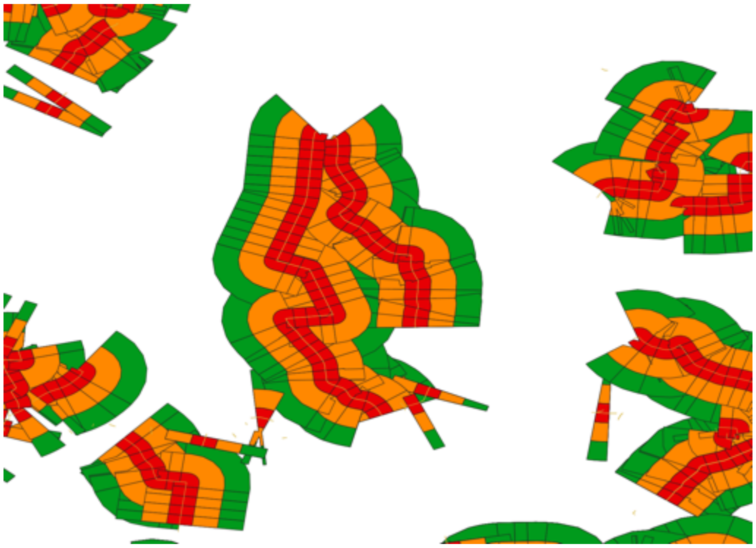
Notes: Single family units from ACS include all 1 unit housing units (attached and detached). Single family units in Warren include property addresses with 1 unit listed. All other types counted as multi-family. Counts only Massachusetts counties.

Figure A.3: Sales and Assessed Values for Single-Family Houses



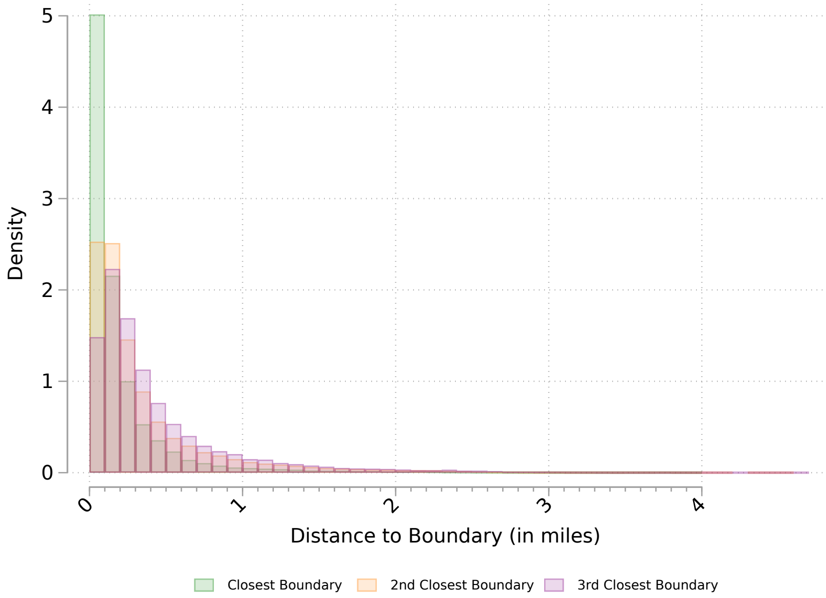
Note: Plots assessed-sales ratio against sale prices for single-family houses sold 2010-2018 in Greater Boston Area for houses on relaxed (relaxed=1) and restricted (relaxed=0) side of the regulation boundary. Town fixed effects are included.

Figure A.4: Example Construction of Neighborhood Density



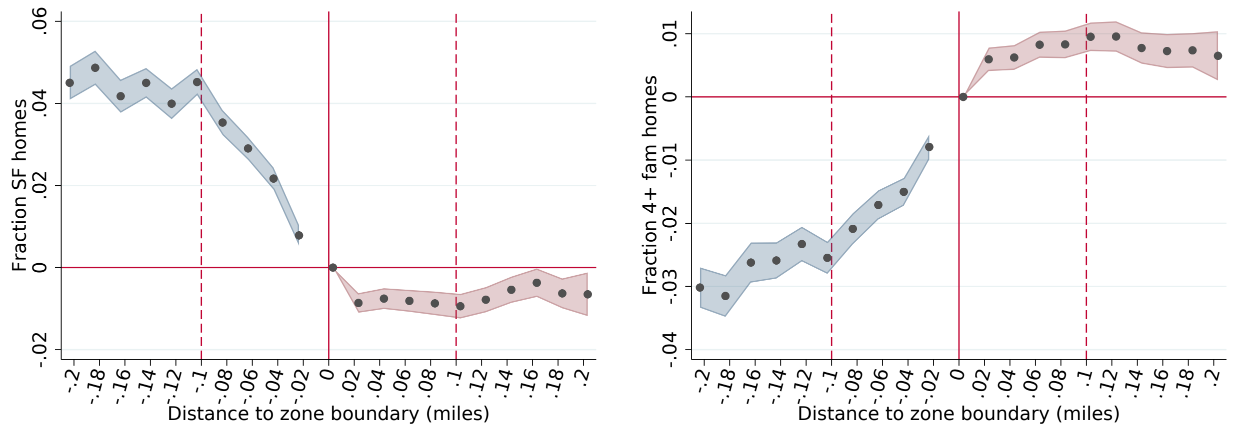
Note: This figure plots a sample of boundaries and the construction of neighborhood density around these boundaries. Red indicates 0.1X0.1 mile boxes around the boundary. Orange indicates 0.1X0.3 mile and green indicates 0.1X0.5 mile.

Figure A.5: Building Distance to Nearby Boundaries



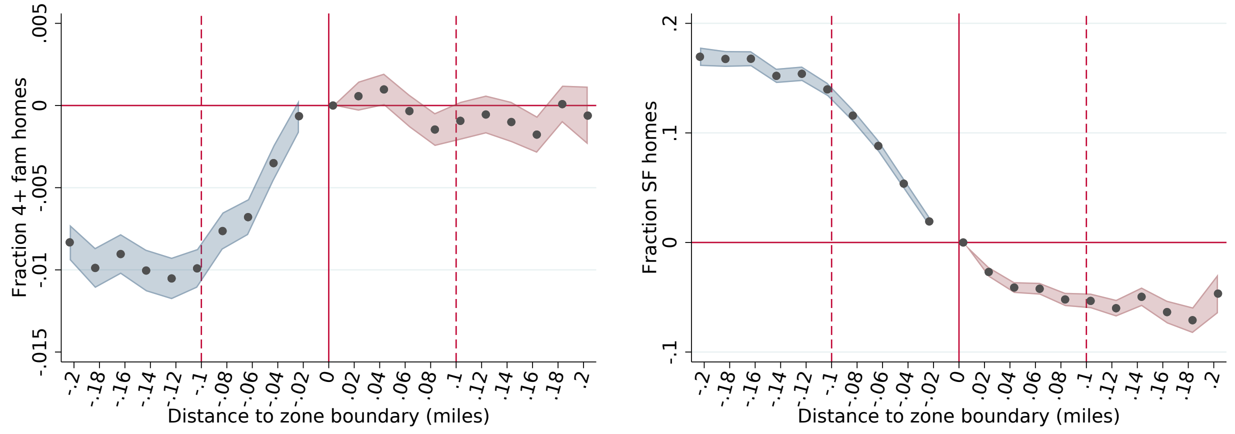
Note: This figure plots the distance to the first, second, and third nearest boundaries for all buildings in the sample.

Figure A.6: Shares of Single Family, Gentle Density, and High Density Homes



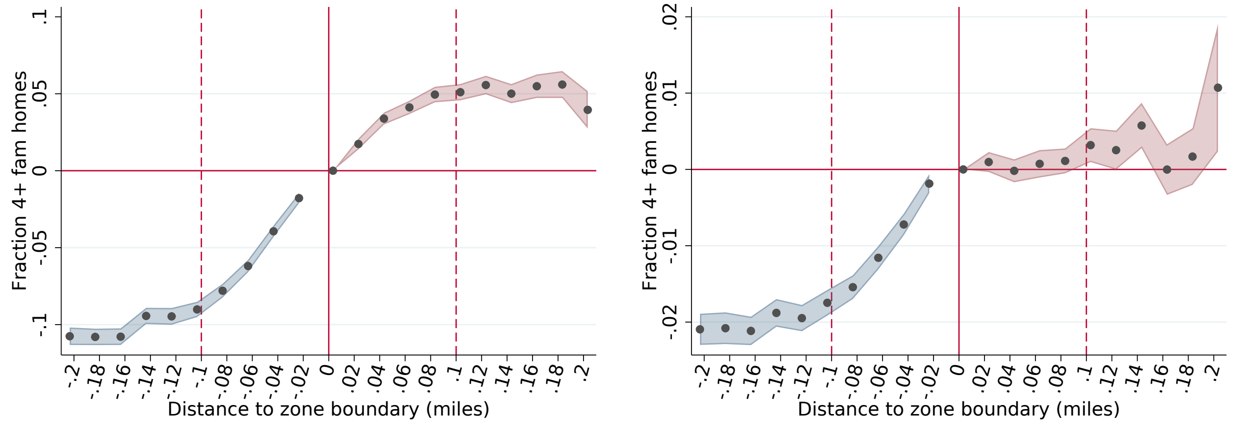
(a) SF (Dupac)

(b) Gentle Density (Dupac)



(c) High Density (Dupac)

(d) SF (MF + Dupac)



(e) Gentle Density (MF + Dupac)

(f) High Density (MF + Dupac)

Note: This figure plots the share of single-family, gentle-density (2-3 unit), and high-density (4+ units) homes along the boundary. Shares are calculated as the fraction of homes of a given type within an 0.1 mile radius around every property. Plots are created by regressing shares on boundary fixed effects, and bins of distance to the boundary (bins of 0.02 miles). Coefficients on the distance bins are plotted. Negative distances indicate the more regulated side of a boundary. The bin closest to the boundary on the less regulated side (0-0.02 miles to the boundary) is normalized to 0. 95% confidence intervals are shown.

B. Additional Tables and Figures

Table A1: Type of Housing Built Before 1956

	2-3 units (Gentle Density)				**4+ units (High Density)**			
	Only MF	Only DU	MF & DU	H & DU	Only MF	Only DU	MF & DU	H & DU
MF	0.233*		0.117*		0.026		0.019*	
	(0.105)		(0.028)		(0.023)		(0.009)	
H				0.004				0.003
				(0.011)				(0.007)
DU		0.001	-0.004	0.001		0.000	0.001	0.004***
		(0.001)	(0.002)	(0.001)		(0.000)	(0.001)	(0.001)
MFXDU			0.002				-0.001	
			(0.002)				(0.001)	
HXDU				-0.000				-0.000
				(0.000)				(0.000)
N	6,653	67,656	38,323	25,281	4,388	53,614	26,535	14,234
R^2	0.470	0.396	0.340	0.332	0.280	0.399	0.177	0.386
$\mathbb{E}(y)$	0.361	0.236	0.323	0.498	0.031	0.036	0.022	0.108

Note: This table presents the results from a linear probability model where dependant variable value of 0 is a single family house and value of 1 is either a 2-3 unit building or 4 or more unit building 0-0.3 miles around the boundary. All buildings are built before 1956. Only MF are boundaries where only multi-family (MF) regulation changes and only DU are boundaries where only dwelling units per acre (DUPAC) regulation changes. MF & DU and H & DU are boundaries where MF and DUPAC both change and height and DUPAC both change, respectively. The unit on height is in 10 feet and DUPAC is in 1 housing unit. Standard errors are clustered at the boundary level.

Table A2: Supply: Types of Housing across Regulation Boundaries (Built after 1956)

	2-3 units (Gentle Density)				4+ units (High Density)			
	Only MF	Only DU	MF & DU	H & DU	Only MF	Only DU	MF & DU	H & DU
MF	0.250***		0.042*		0.066		0.011	
	(0.066)		(0.019)		(0.035)		(0.014)	
H				-0.011				0.004
				(0.011)				(0.008)
DU		0.002**	0.003	0.001		0.002*	0.000	0.003
		(0.001)	(0.003)	(0.003)		(0.001)	(0.002)	(0.002)
MFXDU			0.004				0.003*	
			(0.002)				(0.001)	
HXDU				0.000				-0.000
				(0.000)				(0.000)
N	2,103	53,875	14,704	4,641	1,991	52,957	13,946	4,189
R^2	0.384	0.274	0.318	0.510	0.574	0.487	0.410	0.650
$\mathbb{E}(y)$	0.081	0.025	0.069	0.165	0.030	0.008	0.018	0.075

Note: This table presents the results from a linear probability model where dependant variable value of 0 is a single family house and value of 1 is either a 2-3 unit building or 4 or more unit building 0-0.3 miles around the border. All buildings are built after 1956 when comprehensive zoning is adopted. Only MF are boundaries where only multi-family (MF) regulation changes and only DU are boundaries where only dwelling units per acre (DUPAC) regulation changes. MF & DU and H & DU are boundaries where MF and DUPAC both change and height and DUPAC both change, respectively. The unit on height is in 10 feet and DUPAC is in 1 housing unit. Standard errors are clustered at the boundary level.

Table A3: Effects of Regulation on Prices

	Multi-family (rents)			Single-Family (housing costs)			
	Only DU	MF & DU	DU & H	Only MF	Only DU	MF & DU	DU & H
MF allowed		-0.027		-0.040		-0.136***	
		(0.035)		(0.022)		(0.019)	
Height (H)			0.004				0.002
			(0.011)				(0.006)
DUPAC (DU)	-0.001*	-0.003*	-0.002**		-0.002*	-0.005***	-0.001
	(0.001)	(0.001)	(0.001)		(0.001)	(0.001)	(0.001)
MFXDU		0.004				0.007***	
		(0.002)				(0.001)	
HXDU			0.000				0.000
			(0.000)				(0.000)
N	174,726	125,098	135,593	49,853	771,615	304,340	129,779
$\mathbb{E}(y)$	\$1,142	\$1,017	\$1,057	\$2,446	\$2,520	\$2,228	\$2,171
R^2	0.617	0.632	0.630	0.696	0.732	0.768	0.871

Note: This table presents the results from Equation 4 where the dependent variable is either log of monthly owner cost of housing or monthly rent 0-0.2 miles around the border. Controls are boundary fixed effects and year fixed effects. Standard errors are clustered at the boundary level. Only MF are boundaries where only multi-family (MF) regulation changes and only DU are boundaries where only dwelling units per acre (DUPAC) regulation changes. MF & DU and H & DU are boundaries where MF and DUPAC both change and height and DUPAC both change, respectively. Since there are no renters on one side of a boundary where allowing multi-family homes changes, we do not show results on rents for that type of boundary. The unit on height is in 10 feet and DUPAC is in 1 housing unit. Standard errors are clustered at the boundary level.

Table A4: Effects of Regulations on Prices (with Year Built)

	Multi-family (rents)			Single-Family (housing costs)			
	Only DU	MF & DU	DU & H	Only MF	Only DU	MF & DU	DU & H
MF allowed		-0.030		-0.018		-0.093***	
		(0.027)		(0.017)		(0.014)	
Height (H)			0.006				0.001
			(0.009)				(0.006)
DUPAC (DU)	-0.001	-0.002*	-0.002***		-0.003***	-0.003***	-0.002
	(0.001)	(0.001)	(0.001)		(0.001)	(0.001)	(0.001)
MFXDU		0.003*				0.004***	
		(0.002)				(0.001)	
HXDU			0.000				0.000
			(0.000)				(0.000)
N	171,945	124,088	133,766	49,701	769,028	303,811	129,547
$\mathbb{E}(y)$	\$1,145	\$1,019	\$1,062	\$2444	\$2,515	\$2,227	\$2,168
R^2	0.659	0.690	0.713	0.782	0.807	0.825	0.894

Note: This table presents the results from Equation 4 where the dependent variable is either log of monthly owner cost of housing or monthly rent 0-0.2 miles around the border. In addition to boundary fixed effects and year fixed effects, we also control for year-built fixed effects. Standard errors are clustered at the boundary level. Only MF are boundaries where only multi-family (MF) regulation changes and only DU are boundaries where only dwelling units per acre (DUPAC) regulation changes. MF & DU and H & DU are boundaries where MF and DUPAC both change and height and DUPAC both change, respectively. Since there are no renters on one side of a boundary where allowing multi-family homes changes, we do not show results on rents for that type of boundary. The unit on height is in 10 feet and DUPAC is in 1 housing unit. Standard errors are clustered at the boundary level. Standard errors are clustered at the boundary level.

Table A5: Adoption of Zoning Laws across Towns

Town	Year	Town	Year
ARLINGTON	1924-8-30	MEDFORD	1925
BEDFORD	1928	MELROSE	1924-5-6-7-8
BELMONT	1925-6-7	MILTON	1022-6
BOSTON	1904-18-23-4-9-30-1-2-56	NATICK	1931
BROOKLINE	1922-4-8	NEEDHAM	1925-6-31
CAMBRIDGE	1924-5-6-7-8-9-30-56	NEWTON	1922-5-6-9
CHELSEA	1924	REVERE	1925-9
CONCORD	1928	SALEM	1925-7-8-9
DEDHAM	1924	SOMERVILLE	1925-9
EVERETT	1926-8	STONEHAM	1925-6-7-8-9-30-31-32
FRANKLIN	1930	SUDBURY	1931
GLOUCESTER	1926-7	SWAMPSCOTT	1924
HUDSON	1927	WAKEFIELD	1925-7-9
HULL	1931-2	WALPOLE	1925-8
LEXINGTON	1924-9	WALTHAM	1925-8-9
LINCOLN	1929	WATERTOWN	1026-7-9-30-1
LYNN	1924-5-6-9	WELLESLEY	1925
MALDEN	1923-6-32	WESTON	1928
MARBLEHEAD	1927-8-30	WESTWOOD	1929
MARLBOROUGH	1927	WINTHROP	1922-8-9
MARSHFIELD	1926	WOBURN	1925

Note: This table provides the date of first height or other types of zoning adoption across towns in Greater Boston Area. Data is from Knauss (1933).

Table A6: Price Effects Away from Regulation Boundaries: Robustness

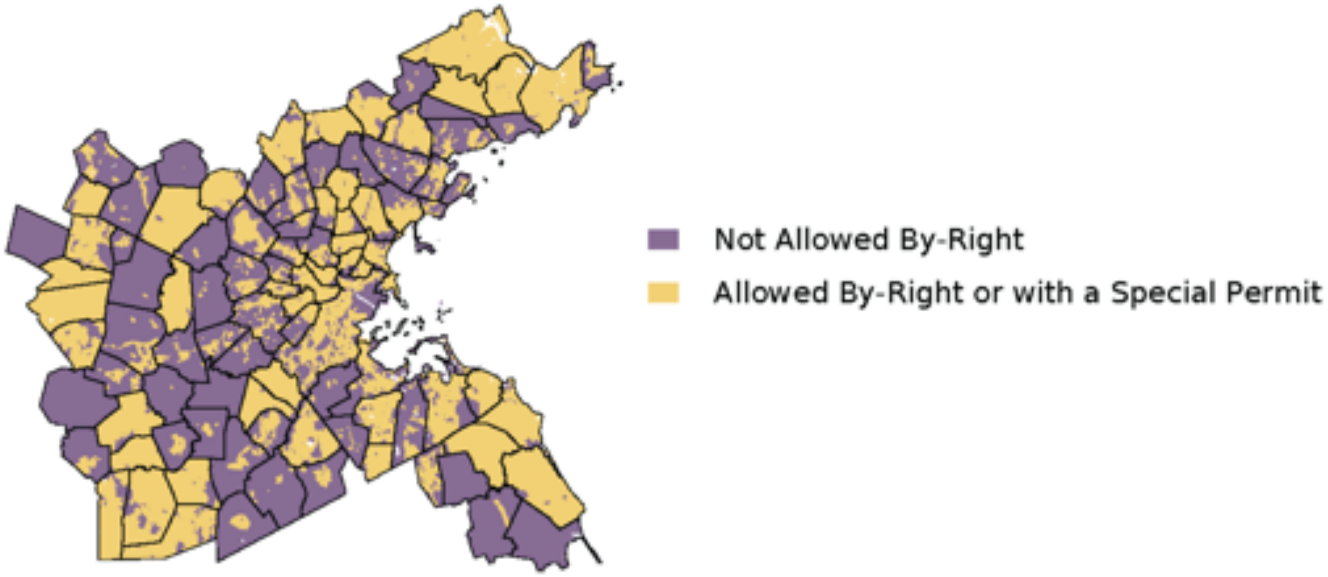
	Only MF	Only DUPAC	MF & DUPAC	DUPAC & Height	All
		Multi-Family (rents): bandwidth 0.1-0.2 miles			
θ^{HD}	-	0.225	0.127	-0.104	-0.115
		(0.151)	(0.173)	(0.112)	(0.162)
θ^{GD}	-	-0.081	-0.076	0.029	-0.033
		(0.048)	(0.047)	(0.052)	(0.072)
N		33,486	25,074	27,652	24,338
		Multi-Family (rents): bandwidth 0.1-0.35 miles			
θ^{HD}	-	0.079	0.076	-0.067	-0.145
		(0.108)	(0.145)	(0.105)	(0.132)
θ^{GD}	-	-0.102*	-0.048	0.025	-0.063
		(0.051)	(0.038)	(0.039)	(0.059)
N		46,268	33,060	36,870	31,116
		Single-Family (owner cost of housing): bandwidth 0.1-0.2 miles			
θ^{HD}	-0.274	-0.070	-0.120	0.081	-0.099
	(0.155)	(0.094)	(0.069)	(0.068)	(0.068)
θ^{GD}	0.022	-0.151***	-0.197***	-0.068	-0.197***
	(0.132)	(0.039)	(0.044)	(0.04)	(0.056)
N	15,275	289,725	98,090	44,646	42,467
		Single-Family (owner cost of housing): bandwidth 0.1-0.35 miles			
θ^{HD}	-0.364	-0.130	-0.119*	-0.111	-0.047
	(0.283)	(0.092)	(0.06)	(0.058)	(0.087)
θ^{GD}	0.131	-0.169***	-0.211***	-0.069	-0.224***
	(0.082)	(0.041)	(0.044)	(0.04)	(0.058)
N	22,386	496,837	162,598	68,595	70,288

Note: This table plots coefficient on share of high density (4 + units) buildings (θ^{HD}) and share of gentle density (2-3 units) buildings (θ^{GD}) within 0.1 mile radius around a house across different regulation boundaries from Equation 6 for buildings within either 0.1-0.2 or 0.1-0.35 miles on either side of the boundary. The preferred specification with bandwidth of 0.1-0.3 miles is in the main paper. Top panel presents results where dependent variable is log monthly rents. For bottom panel it is log monthly owner cost of housing. Standard errors are clustered at the boundary level. Only MF are boundaries where only multi-family (MF) regulation changes. Only DUPAC are boundaries where only dwelling units per acre regulation changes.

Figure B.1: Towns Included in Sample

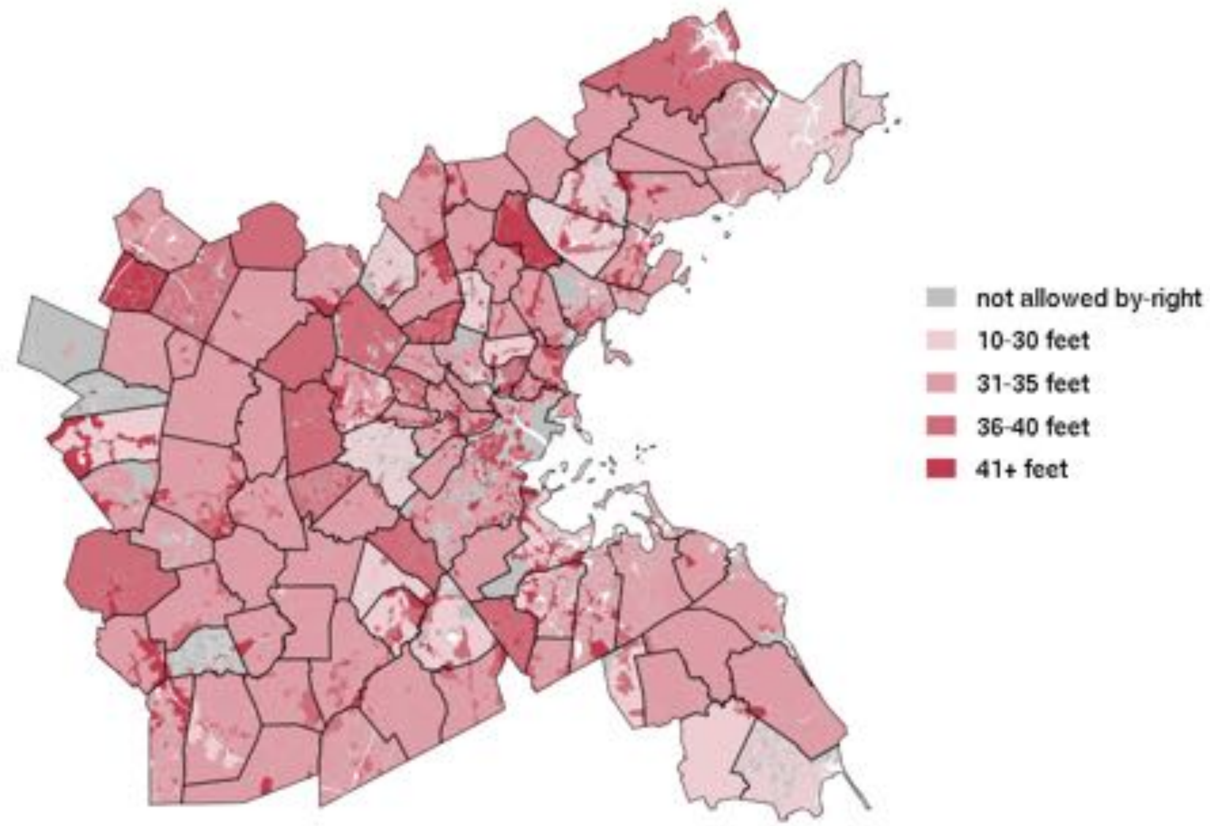
Note: Municipalities are included if they either had open enrollment school attendance policies or had elementary school attendance boundary data included in the 2016 School Attendance Boundary Survey (SABS). Municipalities were excluded if they lacked school attendance boundary data and did not have open enrollment.

Figure B.2: Multi-Family Zoning in Greater Boston Area



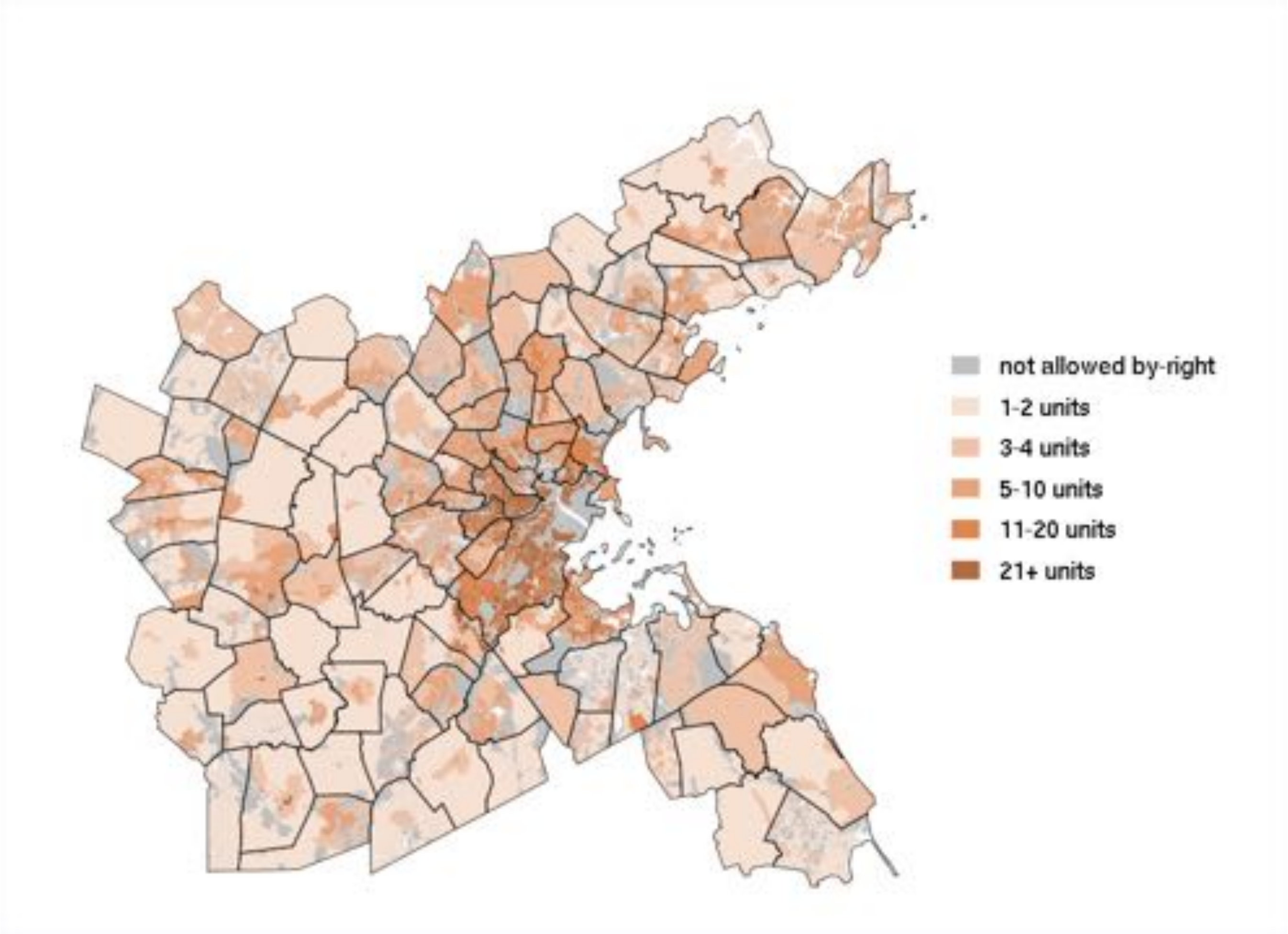
Note: This figure plots the multifamily zoning in Greater Boston Area. Allowed includes areas where multifamily construction is allowed by-right and with special-permit.

Figure B.3: Maximum Height Restrictions in Greater Boston Area



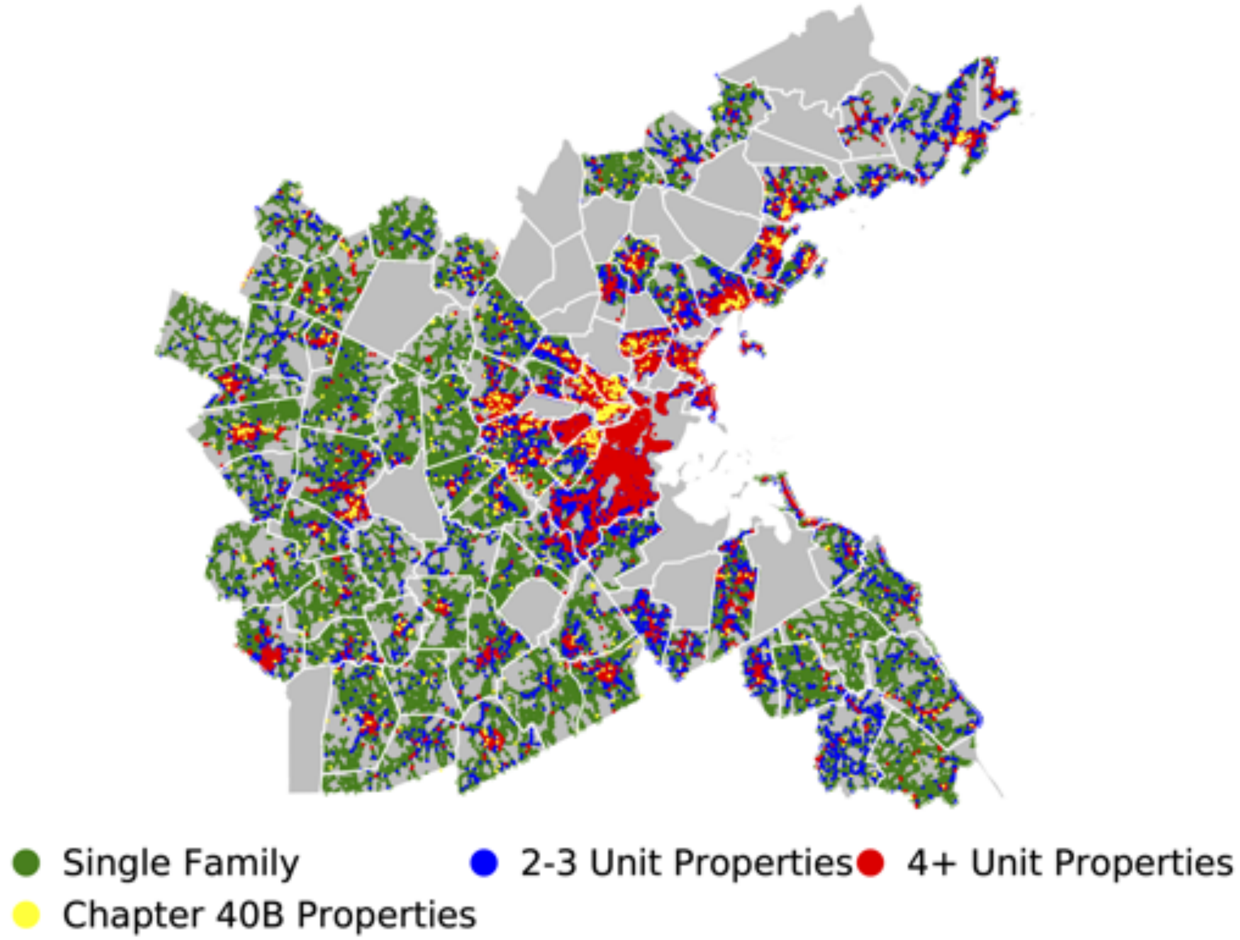
Note: This figure plots the maximum height restrictions in Greater Boston Area in feet.

Figure B.4: Maximum Density (DUPAC) Restrictions in Greater Boston Area



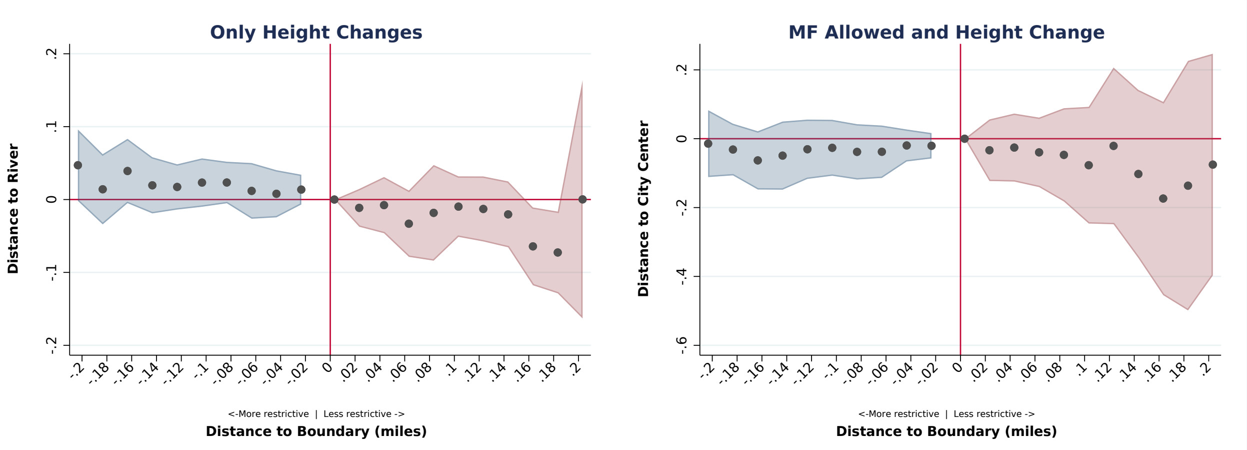
Note: This figure plots the maximum DUPAC (dweelng units per acre) restrictions in Greater Boston Area.

Figure B.5: Housing types over space



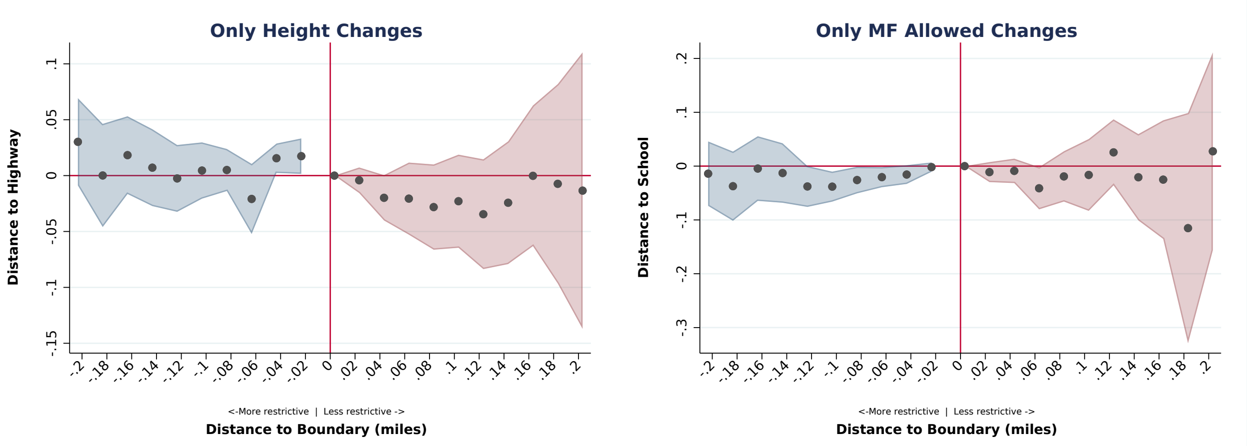
Note: Single-family properties are those classified as single-family on their 2018 tax assessment record. Two-to-three and four plus unit properties are those classified as such on their tax assessment record, or mixed use or other residential properties with two-to-three or four or more units, respectively. Chapter 40B properties are buildings built under Massachusetts inclusionary zoning law. Chapter 40B properties are magnified for better illustration. Properties shown include only those within 1 mile of a zoning boundary. Excludes municipalities that were not included in the analysis.

Figure B.6: Amenities at Regulation Boundaries (Continued)



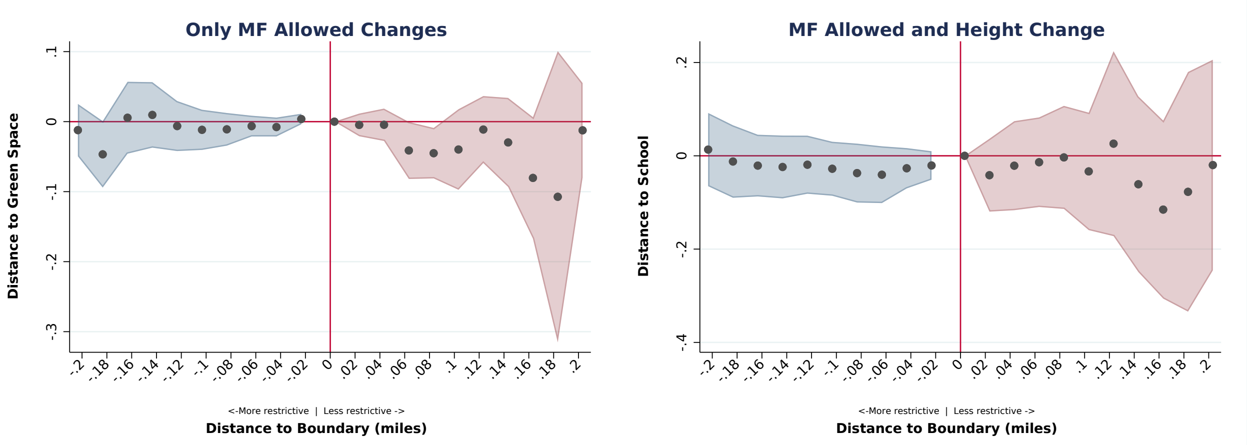
(a) River/Lake RD estimate = 0.014, (t stat = 1.32)

(b) Center RD estimate = -0.021, (t stat = -1.11)



(c) Road RD estimate = 0.017, (t stat = 2.17)

(d) School RD estimate = -0.002, (t stat = -0.43)

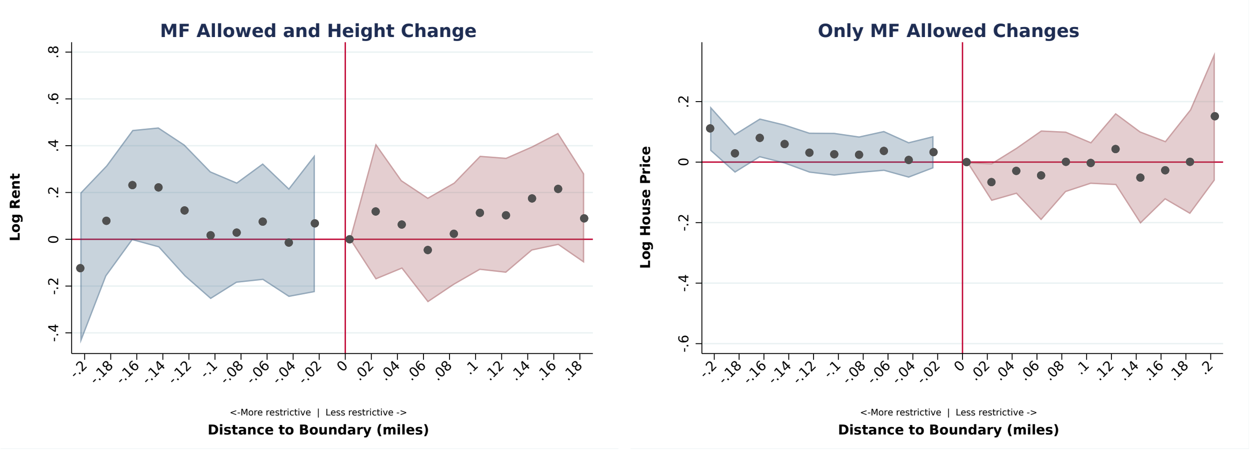


(e) Open Space RD estimate = 0.004, (t stat = 0.98)

(f) School RD estimate = -0.021, (t stat = -1.36)

Note: Plots are created by regressing distance to various amenities on boundary fixed effects and bins of distance to boundary (bins of 0.02 miles). Coefficients on distance bins are plotted. Negative distances indicate more regulated side of boundary. The bin closest to the boundary on the less regulated side (0-0.02 miles to boundary) is normalized to 0. 95% confidence intervals are shown. DUPAC is Density units per acre and MF is multi-family zoning boundaries. Standard errors are clustered at the boundary level.

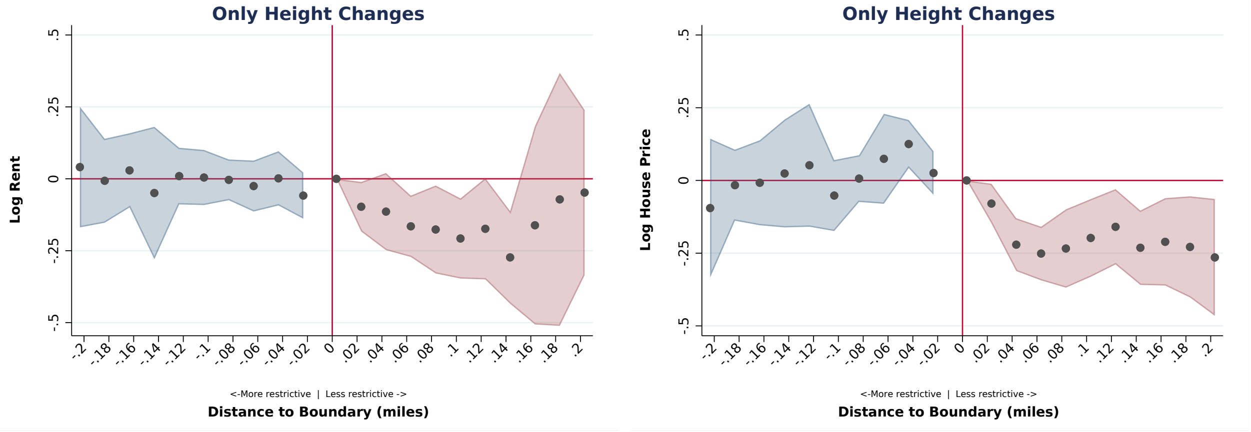
Figure B.7: Effects of Height and Multi-family Regulation on Housing Costs



(a) RD estimate= 0.068, (t statistic = 0.46)

(b) RD estimate = 0.033, (t statistic = 1.22)

Change in Only Multi-Family or Multi-Family and Height Regulation



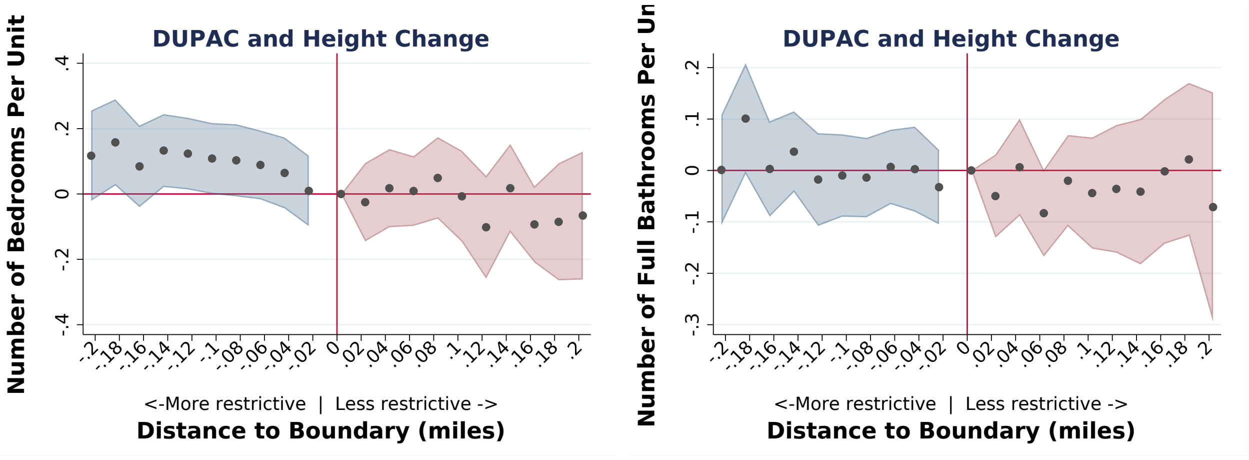
(c) RD estimate= -0.058, (t statistic = -1.44)

(d) RD estimate = 0.026, (t statistic = 0.67)

Change in Only Height Regulation Boundaries

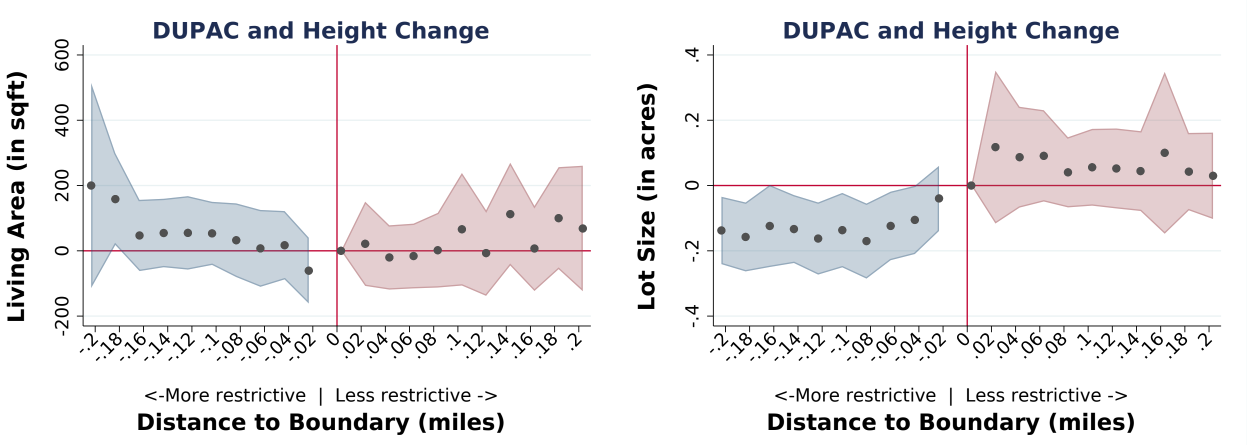
Note: Plots are created by regressing log prices on boundary fixed effects, year fixed effects [2010-2018], and bins of distance to the boundary (bins of 0.02 miles). Coefficients on the distance bins are plotted. Negative distances indicate the more regulated side of a boundary. The bin closest to the boundary on the less regulated side (0 to -0.02 miles to the boundary) is normalized to 0. 95% confidence intervals are shown. Left panel indicates the effect on monthly rental prices for multi-family buildings. Right panel indicates the effect on monthly owner cost of housing for single-family houses. The unit on height is in 10 feet. The unit on height is in 10 feet and DUPAC (dwelling units per acre) is in 1 housing unit. Standard errors are clustered at the boundary level.

Figure B.8: Housing Characteristics at Regulation Boundaries: DUPAC & Height change



(a) Bedrooms RD estimate = 0.009, (t stat = 0.17)

(b) Bathrooms RD estimate = -0.-33, (t stat = -0.88)

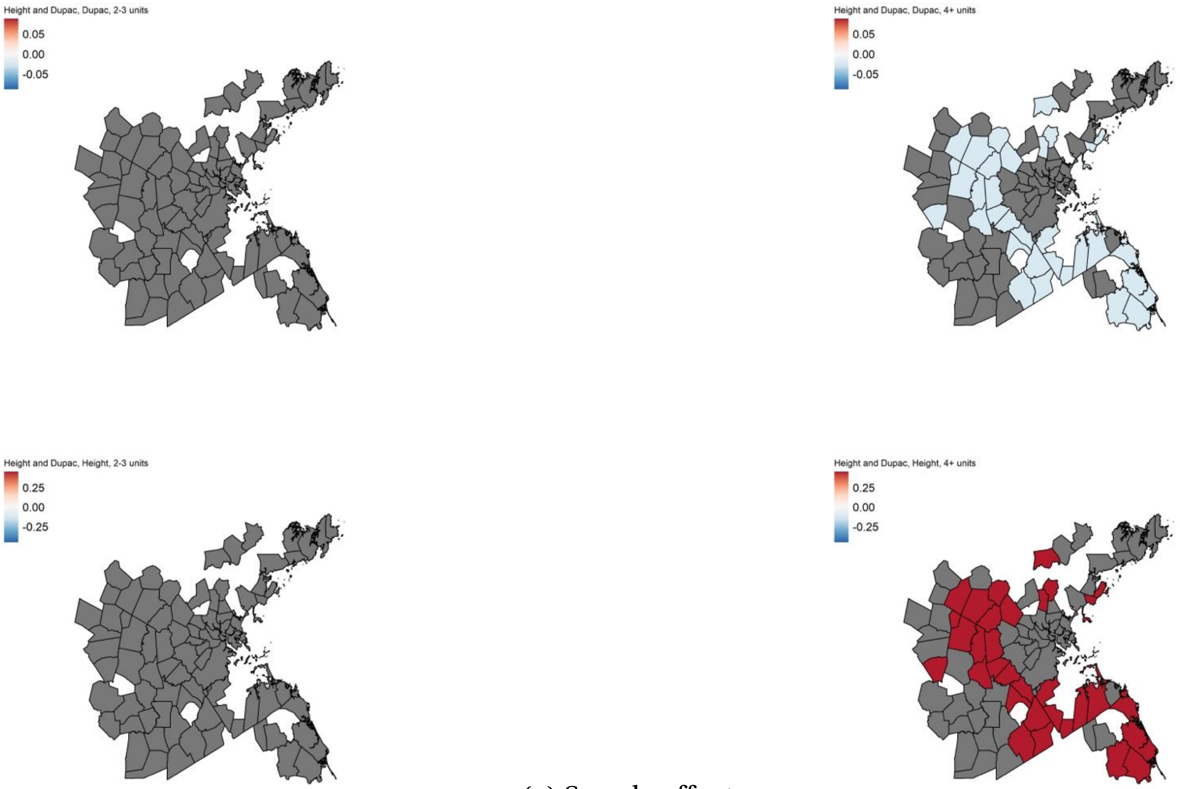


(c) Living Area RD estimate = -60.79, (t stat = -1.18)

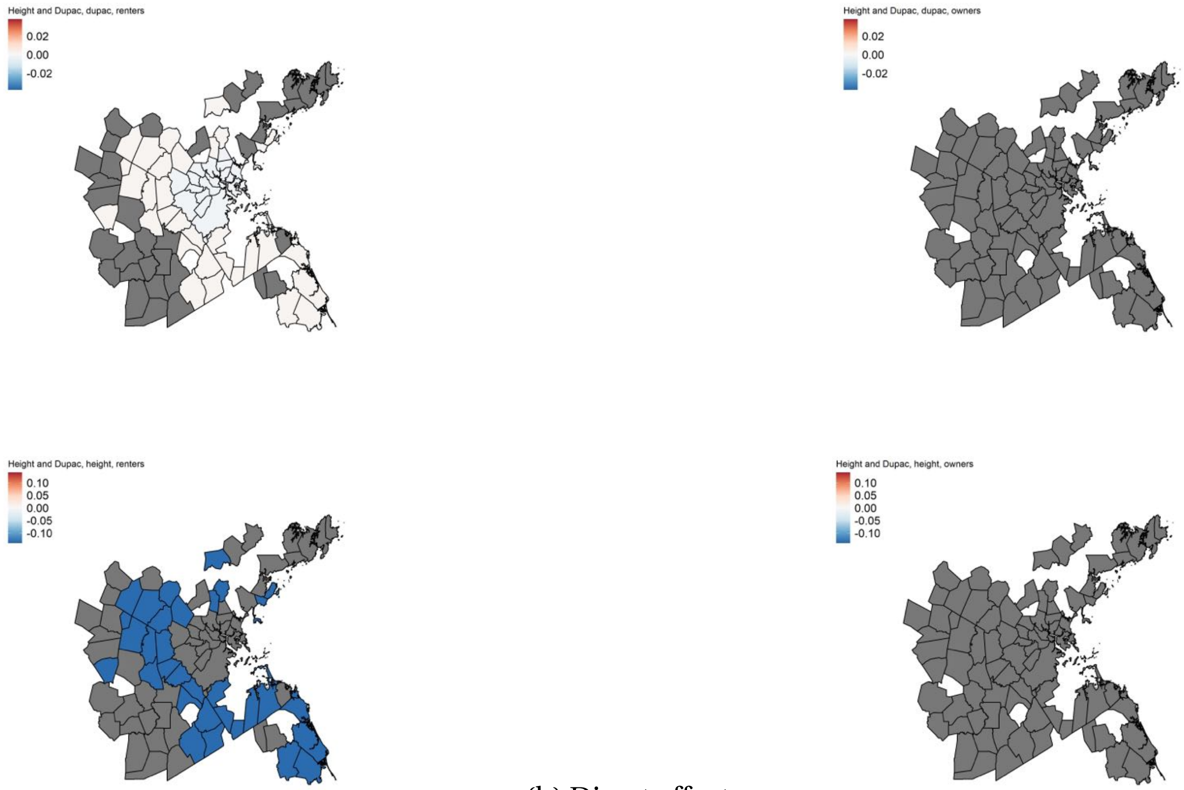
(d) Lot Size RD estimate = -0.04, (t stat = -0.78)

Note: This figure plots building characteristics across regulation boundaries. Plots are created by regressing unit characteristics on boundary fixed effects and distance to boundary (bins of 0.02 miles). Coefficients on distance bins are plotted. Negative distances indicate more regulated side. Bin closest to boundary on less regulated side (0-0.02 miles) is normalized to 0. 95% confidence intervals are shown. DUPAC is Dwelling units per acre.

Figure B.9: DUPAC and Height: Effects on Supply and Prices across Space



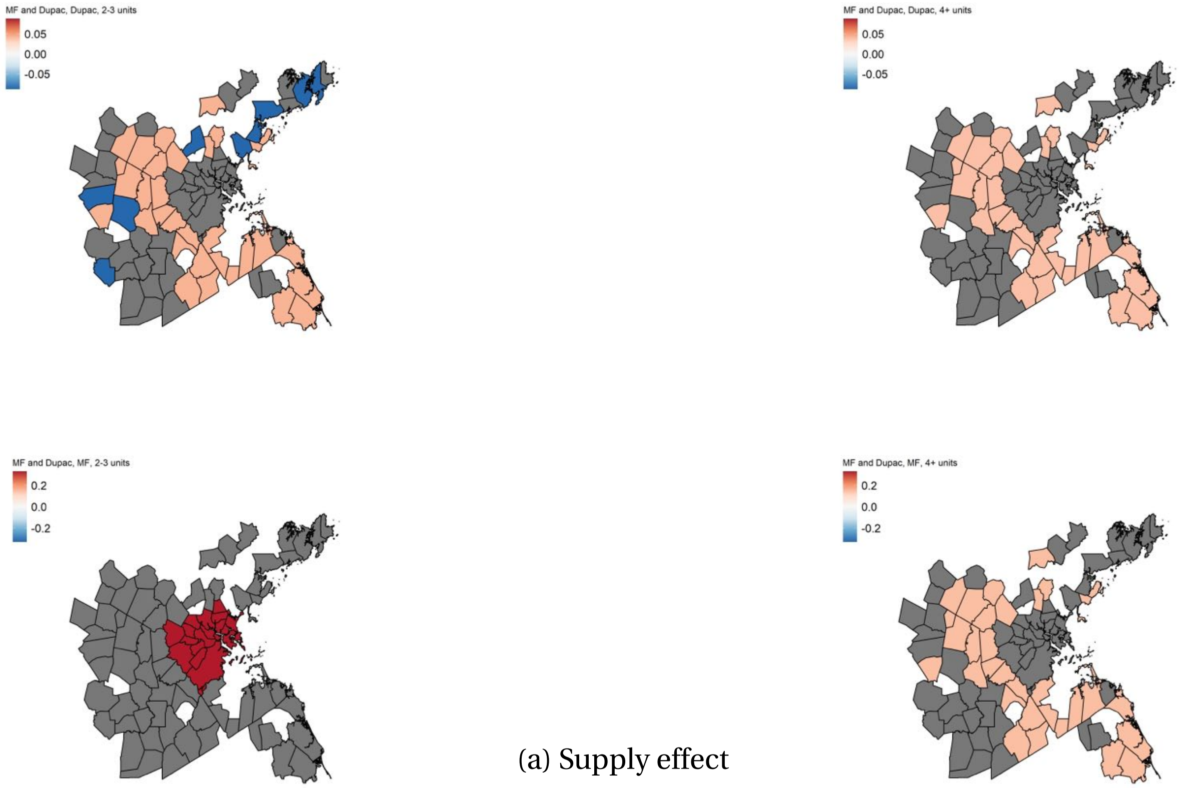
(a) Supply effect



(b) Direct effect

Note: These figures plots the coefficient on the effects of DUPAC (dwelling units per acre) and Height regulations on the supply of type of building (2-3 units on top left and 4 or more units on top right) and housing costs (log monthly rents for multi-family units on bottom left and log monthly owner cost of housing for single-family houses on bottom right) across space. Grey areas represent no statistically significant results. Standard errors are clustered at the boundary level.

Figure B.10: DUPAC and Multi-Family: Effects on Supply and Prices across Space



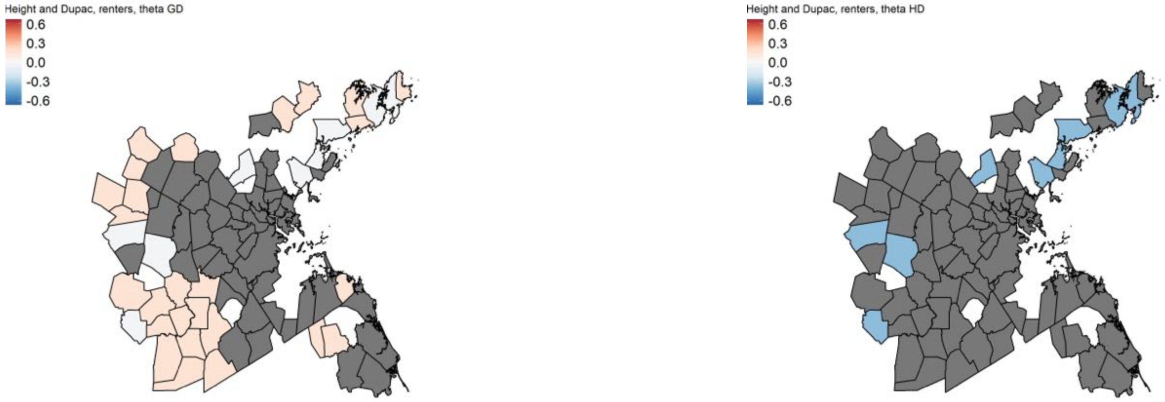
(a) Supply effect

(b) Direct effect

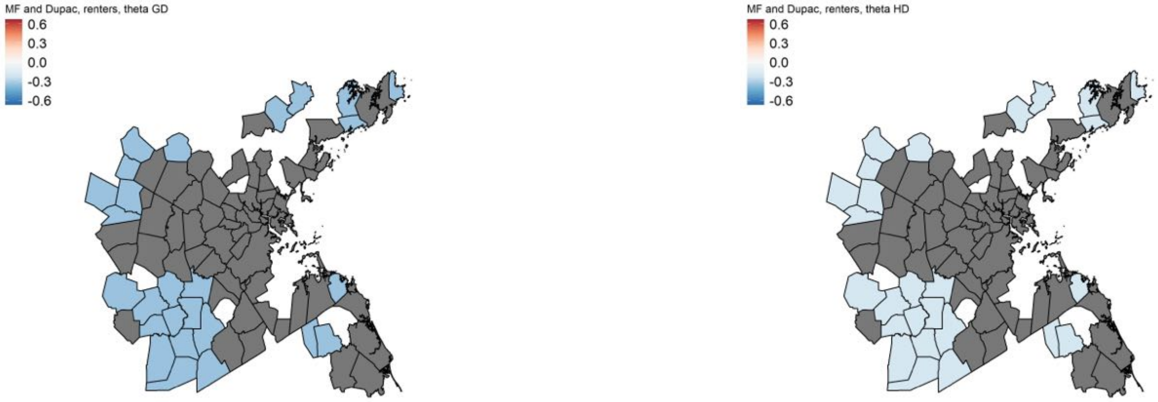
Note: These figures plots the coefficient on the effects of DUPAC (dwelling units per acre) and Multi-Family regulations on the supply of type of building (2-3 units on top left and 4 or more units on top right) and housing costs (log monthly rents for multi-family units on bottom left and log monthly owner cost of housing for single-family houses on bottom right) across space. Grey areas represent no statistically significant results. Standard errors are clustered at the boundary level.

Figure B.11: Indirect Effects of Gentle and High Density on Renters

(a) Boundaries where only DUPAC changes



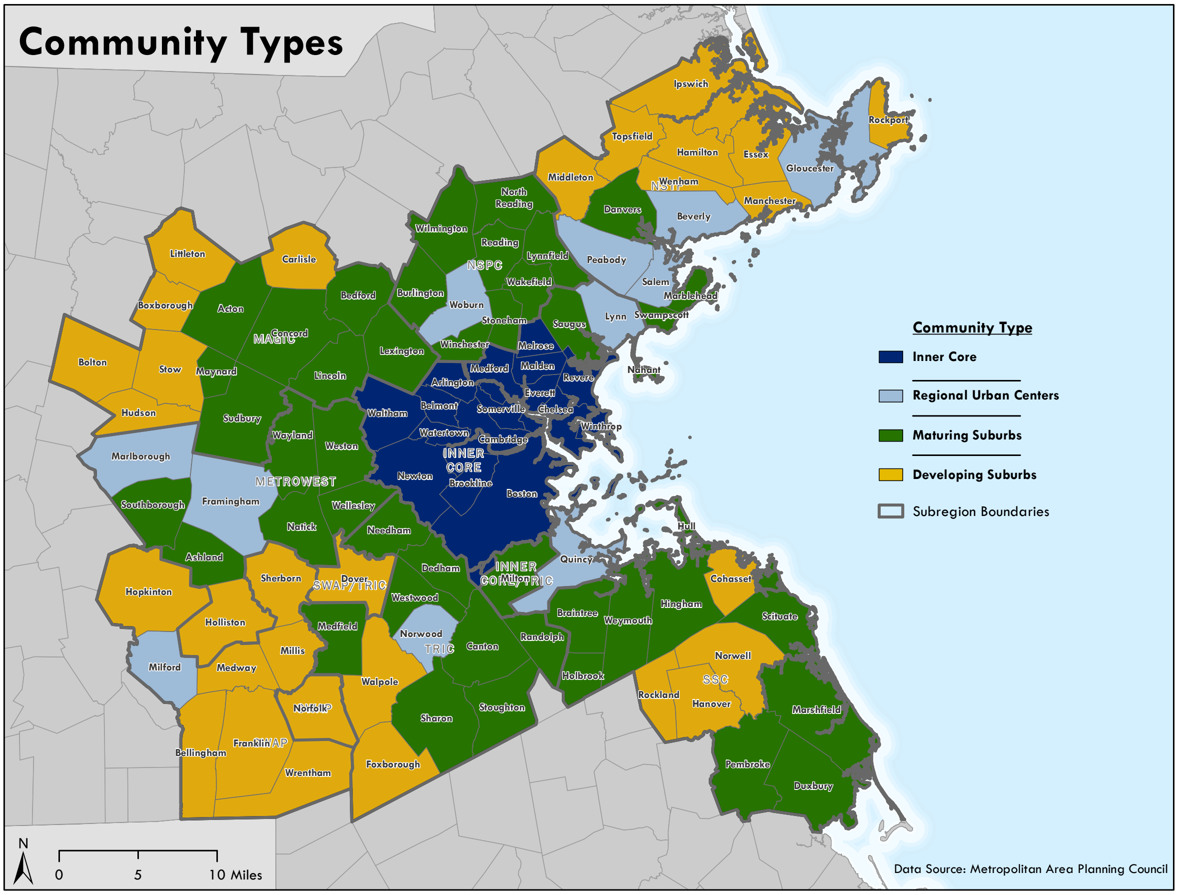
(b) Boundaries where DUPAC and Height change



(c) Boundaries where DUPAC and MF allowed change

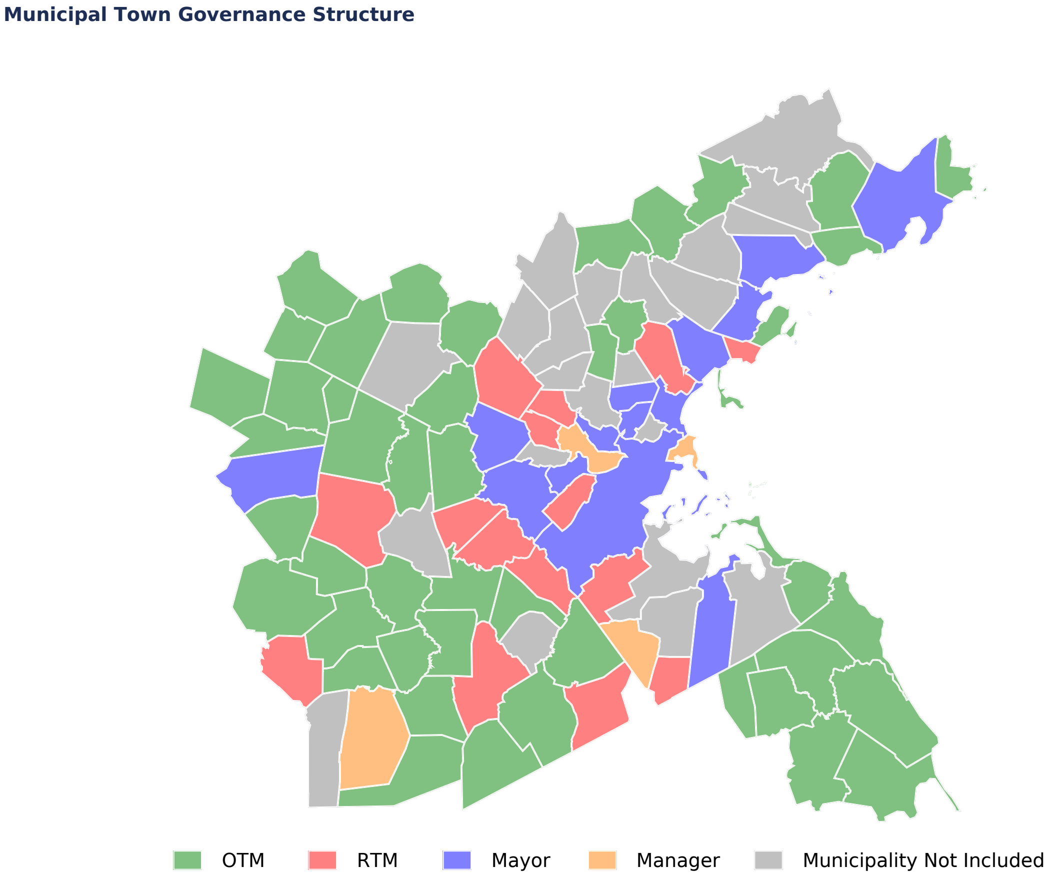
Note: These figures plots coefficients of the indirect price effects of only DUPAC (dwelling units per acre), DUPAC and Height, and DUPAC and Multi-Family (MF) regulations on log monthly rents for multi-family houses for increases in gentle-density (2-3 units) or high-density (four or more units) in 0.1 radius around the house on left and right, respectively. Grey areas represent no statistically significant results. Standard errors are clustered at the boundary level.

Figure B.12: Greater Boston Area Community Types



Notes: This figure highlights how Metropolitan Area Planning Council (MAPC) divides towns in Greater Boston Area into four distinct community types.

Figure B.13: Systems of Local Town Governance



Notes: This figure plots the different forms of local town governance in Greater Boston Area. OTM is open town meeting structure. RTM is representative town meeting structure. Other two local governance system is Mayoral and Town Manager (Manager) system.