Local Barriers to Housing Density and Reducing Costs*

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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 within towns and school attendance areas in the Greater Boston Area, we obtain causal estimates for the effect of 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, allowing multi-family zoning or relaxing height regulations alone does not have any significant impact on increasing the number of units built and reducing rents. 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 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 major 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. In the past decade, only 82 new building permits were issued for every 100 net new households in the Greater Boston Area. 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 well as community opposition, particularly those that limit multi-family housing, on both rents and house prices, and the supply of different types of housing, including different types of multi-family housing.

Oregon, California, and Minneapolis have famously allowed for multi-family zoning in most or all of their jurisdictions recently (Economist, 2021). Additionally, the literature has looked at the effect of a single regulation on supply and prices.[1] 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, all of which when restricted, negatively affect multi-family housing supply.

On the one hand, land-use regulation can be considered rent-seeking on behalf of current owners and on the other hand, relaxing regulations can add negative externalities, especially if residents have negative willingness to pay for higher density. There are often competing interests between current homeowners and new home buyers as well as renters when promoting housing affordability. We study how the interactions of

[1] 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)

these regulations affect the trade-offs to building single-family houses, usually owned, or multi-family housing (usually rented); and in turn affects rents and housing prices. We break down the effect on housing costs into direct effects that capture how relaxing regulations changes the type, size or number of units and indirect effects that capture how relaxing regulations changes 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 U.S. are made at the local town level and different forms of local governance affects how effective relaxing land-use regulations is. Greater Boston has many advantageous features for studying the role of local zoning laws and local governance 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 (2020)).[2] 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.

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 provide 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 with the goal of understanding whether the inclusionary zoning policy acts as a substitute for relaxing land regulations to increase housing affordability.

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

Using a regression discontinuity design framework around land-use regulation boundaries, 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 type of town governance. Given that most spatial regression discontinuity boundaries that study the effect 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 have any significant impact on 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 find larger falls in housing costs from land-use reform in and around the central business district, as expected, and in established suburbs farther from 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 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 Sasser 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.[3] 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 be a substitute for relaxing land-use regulations.[4] 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

[3] 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 other programs that are targeted towards very low-income households (Diamond and McQuade (2019)).

[4] 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).

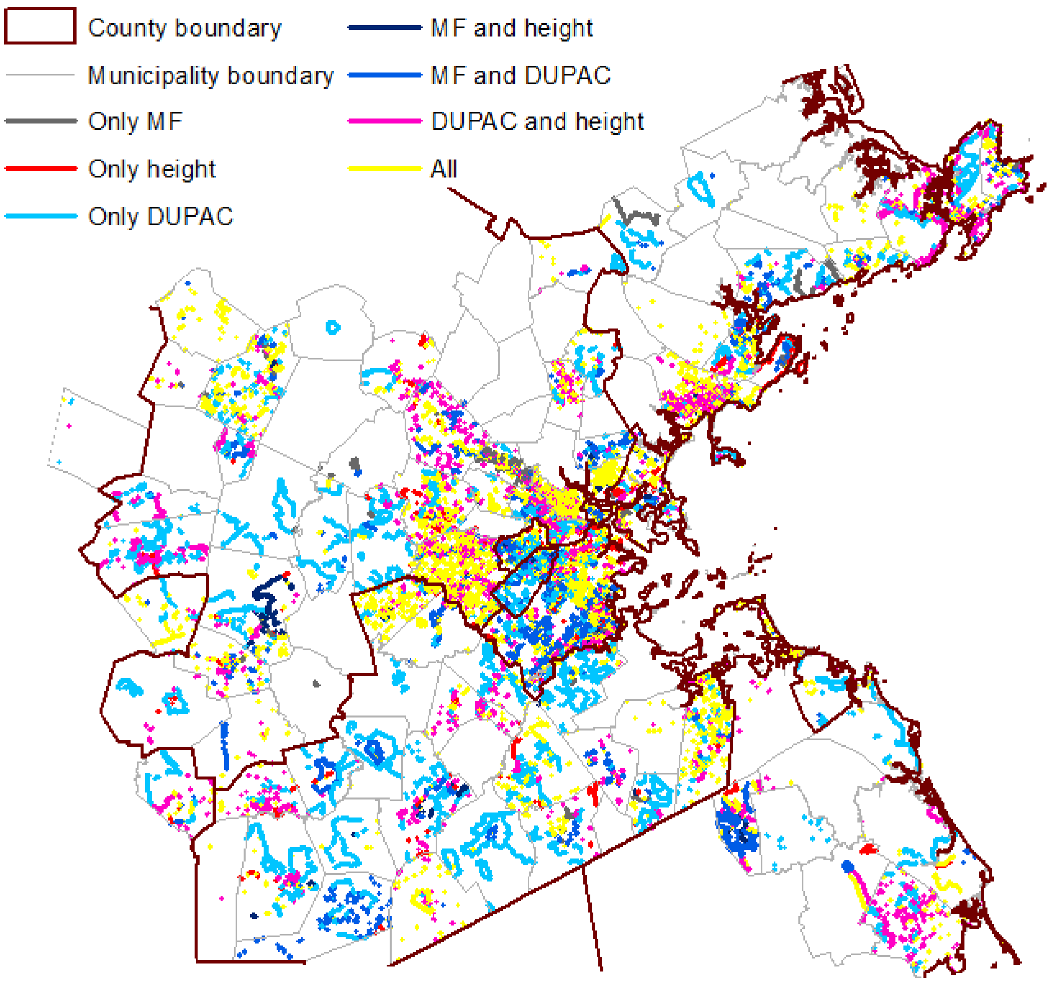
Local land-use and governance policies preventing new home construction not only affect the housing supply and prices but can also have negative spillover effects on geographic mobility, local labor markets, and growth (Ganong and Shoag (2017)). Restrictive land-use regulations have been shown to slow 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 (Chetty and Hendren (2018)). 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

2.1 Zoning Regulation

We focus on three land-use regulations that affect the building of multi-family units. These are whether multi-family housing is or is not allowed, maximum height restrictions, and dwelling units allowed per acre (DUPAC). Figure 1 shows how the three regulations vary across 101 municipalities in the Greater Boston area. While all three regulations have relatively straightforward definitions, the actual implementation and interaction of these regulations can be complex. Below we provide details.

Figure 1: Admissible Boundaries with Land-Use Regulation Changes



Note: This map shows the boundaries where multi-family regulation, maximum height restrictions, and density 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 A.2,A.3, and A.4.

2.1.1 Multi-Family Zoning

This zoning regulates whether multifamily housing is a permitted use "by-right", by special permit, or not allowed (single-family zoning) on a particular lot.[5] Given that our pri-

[5]If a regulation is by-right, it is expressly defined in the local zoning code. If a regulation is by special permit, it means that a developer must request special approval from a local zoning board regardless of how high or how densely they are proposing to build (MAPC 2020). Note that we combine multi-family allowed by-right with special permit and compare the effect of this policy against the policy where multi-

mary interest is studying local barriers limiting multi-family and affordable housing, the choice to include multi-family zoning is natural. This 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 A.2, there is considerable with-in and across town variation in the zoning of this policy.

2.1.2 Building Heights Restrictions

Building heights restrictions indicate the maximum allowable building height in feet of the built structure. Often, even if multi-family zoning is allowed either by-right or special permit, municipalities often limit the 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 the housing near the economic centers. Figure A.3 shows how the building heights restrictions vary across the Greater Boston Area.

2.1.3 Dwelling Units per Acre

Dwelling units per acre (DuPac) limit **density and the total number of units** being built in a region. DuPac is calculated by counting the number of lots that could be constructed on an acre after taking into account minimum lot size requirements[6] 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 from *maximum dwelling units*. Construction of this measure allows a standardized comparison of density across different types of developments and minimum lot sizes. Figure A.4 shows how the DuPac restrictions vary across the Greater Boston Area.

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.

2.1.4 Interaction of Zoning Laws

While these three regulations and their effects on single-family supply and prices is well documented, it is not well understood how these zoning laws interact with each other and affect the landscape of residential buildings. Furthermore, it is also not well-understood how the interaction of these regulations affect the supply differently for single versus multi-family housing and prices for renters versus owners.[7] In this paper, we take the three salient zoning rules discussed above and study not only their effect individually but also together. For instance, even if multi-family zoning is allowed, how does maximum building heights restrictions interact with maximum DuPac restrictions and affect whether the multi-family housing is below or above 9 units. Thus, broadly speaking, we have the following scenarios of the interaction of the three zoning laws. First, all three zoning laws change at a boundary segment. Second, only one of the three zoning laws changes at the boundary segment. Third, two zoning laws change but the

family is now allowed.

[6] 43,560 square feet/Minimum lot size

[7] Brueckner and Singh (2020) study building heights restrictions, (Kulka, 2020) studies the effects of minimum lot size restrictions in isolation.

other remains the same. With the combination of these three scenarios, we're able to identify the effects of each of these laws individually as well and the effects from their multiple combinations. Table 1 shows all the possible regulation zoning scenarios we study. Most of the analysis focuses on scenarios 3, 5, and 6 since most of these the most common in the Greater Boston Area.

2.2 Inclusionary Zoning and Chapter 40B

Many states and cities in the U.S. have inclusionary zoning policies that provide different incentives to developers to build affordable housing units.[8] 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. This is mostly used as a zoning tool to build single-family or multi-family units with more lax building heights, more units per acre (DuPac), and relaxing other zoning restrictions. While this policy enacted in 1969 is meant to increase the stock of affordable housing, by one calculation, only 55% of the project applications between 1995-2005 had obtained building permits by the first quarter of 2007 (Fisher, 2007). In addition, there are only 581 Chapter 40B buildings in the entire Greater Boston Area. Chapter 40B can be used to either build single family houses for ownership (roughly 50% of the sample), the remaining units are for renting in multi-unit housing.[9]

In this paper, we study how the Chapter 40B program interacts with the three key zoning regulations–multi-family housing allowed, building heights restrictions, and DuPac restrictions to study whether these this inclusionary zoning policy is a complement or substitute for more relaxed zoning regulations. One should note that Chapter 40B is not a fool-proof program as these projects face massive community opposition, many approvals are repealed in courts and the litigation process can be lengthy, reducing the incentives for developers to use this program (Greenberg, 2021).

[8] Such as NYC's 421-a property tax exemption.

[9] Furthermore, there is an additional stipulation in Chapter 40B that if a town has less than 10% affordable units out of all it's built units (subsidy housing inventory (SHI)), then the zoning process is easier. At present, the mean town SHI is 5.6%.

3. Data

3.1 Land-Use Zoning Data

The data on parcel level land-use zoning regulations comes from the maps compiled by the Metropolitan Area Planning Council's (MAPC) for their Zoning Atlas project of the Greater Boston area. The Zoning Atlas was constructed between 2010-2020 and provides a snapshot of zoning regulations at that time. However, most of the zoning regulations were set in place during the mid-20th century (the first height regulations were put in place in Boston in 1918, with the first comprehensive zoning regulations were adopted in 1956) with few zoning changes afterwards and almost always in the direction of more restrictive zoning.[10]

With the interest in studying how zoning regulations impact the markets of single-family and multi-family housing deferentially, we focus on multi-family allowed, maximum height, and maximum dwelling units per acre (DUPAC). These were also chosen because they are the most widely implemented across municipalities in Massachusetts and elsewhere in the U.S. The Zoning Atlas also includes a few other quantitative and narrative information on bylaws and ordinances that may influence the underlying zoning regulations, and ultimately, the approval of multi-family housing projects, but we do not include these in our analysis to reduce complexity. MAPC's Zoning Atlas dictates our sample of 'Greater Boston' municipalities, as we are restricted to at most the 101 cities and towns included in this data.

3.2 Housing Market and Price Data

The data on housing units and characteristics [2010-2018] come from the Warren Group that collects tax assessment records across towns. This provides us with the universe of all residential and mixed-use buildings in the Greater Boston area. Figure B.1 plots

[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 very small amounts of land. Annually, there are around 5 rezonings that take place.

the total single-family and multi-family units from Warren group data against the units from ACS. Warren Group provides us information on type of building (single-family, 2-3 units, 4-8 unit, 9-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.[11]

3.2.1 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 0.3 miles of our regulations boundaries which are, on average, 0.1 miles long, we do not have enough sales data for the 2010-2018 for our analysis. Second, we believe that the assessed values in our sample closely mirror the sales values. Since we compare the effects of regulation change on house prices with changes in rents, we need to convert house prices into comparable rental values. Following the procedure laid out by BLS (Katz et al., 2017), we use 6.29% of house assessed value to get the annual owner cost of housing.

3.2.2 Multi-Family Rents

Unit or building level rental data for multi-family units is particularly difficult to find, especially historical rental data. CoStar provides the historical rental information for many buildings with 5 or more units. CoStar uses websites like Apartment.com (which it owns) as well as field visits and survey to get market rental data. In addition, CoStar provides detailed data on multi-family building characteristics like CoStar rating, number of units, market and sub market segments, distance to closest transit stop, number of elevators and floors, floor and lot size, build year etc. For the buildings that have CoStar market rent available [2010-2018], we use it directly. The distribution of CoStar market rent is in red in Figure B.3 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

[11] Condos buildings with greater than one unit get assigned as multi-family. The type of multi-family (2-3 unit or 4-plus units) depends on the number of units in the condo building. If a condo buildings has only one unit, we exclude it from our analysis.

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 B.3. From CoStar we get data on 18,536 building-year observations. As can be seen from the Figure B.3 panel (a), CoStar's rental distribution leans towards the higher-end rental market. Two capture the entire distribution of rents for the remainder of 112,992 buildings, in particular multi-family buildings with 2-4 units, we proceed in two steps.

First, we use the BLS 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 B.3 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.[12] The ACS imputed rent distribution is plotted in blue in Figure B.3 panel (b). Since BLS imputation matches the ACS rental distribution better than the imputed ACS rent distribution, we use BLS imputed rent for the non-CoStar buildings.[13]

3.3 School Attendance Boundaries

Another data component that influences the final sample of which Greater Boston municipalities we inlude in the analysis are the school attendance areas. The quality and types of schooling available is an important factor influencing household decisions on where to live and thus where they demand housing. We use the 2016 elementary school level attendance area boundaries from the National Center for Education Statistics' (NCES) School Attendance Boundary Survey (SABS) for this purpose. 15 of 101 municipalities for which we had zoning data had no school attendance boundary information present in SABS, even though they use attendance areas to dictate school enrollment.[14] We exclude these 15 towns and the final sample of 86 towns is displayed in Figure A.1 in the Appendix.

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

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

[14] Eight towns with missing SABS boundaries were kept because they use an open enrollment model.

3.4 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. The data on different local town governance forms comes from Massachusetts's Municipal forms of Governance.

4. Empirical Framework and Model

To study how the land-use regulations affect different types of housing, number of units, multi-family rents, and single-family house prices, we discuss our methodology in Section 4.1 and discuss various channels of the effects in Section 4.2.

4.1 Regulation Boundary Discontinuity Design

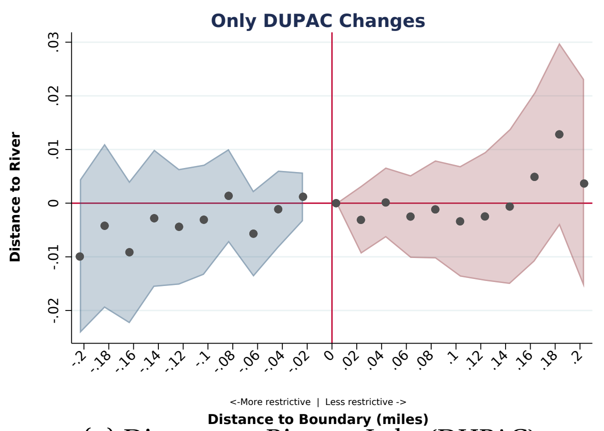
To study the causal effects of land-use regulations on land use regulations on the prices and the supply of all types of housing, we need to address endogeneity concerns. The price of housing and rents is correlated with quality of that location, including the unobserved or latent location quality. Thus, for causal price effects, we need a source of variation that is orthogonal to the unobserved location amenities. Boundary discontinuity design around the land-use zoning regulation boundaries, under the certain conditions, serves this criteria. 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 the location does not change and public amenities and municipal services are continuous along the boundaries.
3. The shape and location of the land-use zoning boundaries in not endogenous to location.

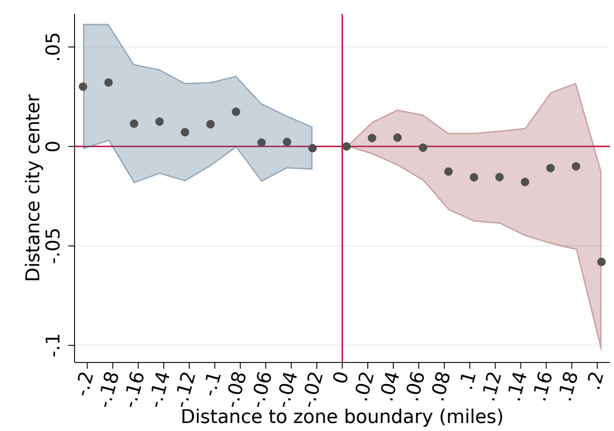
To see that the regulation boundaries affect both the number of units built and the type of buildings built (single-family, 2-3 unit buildings, or larger apartment complexes with 4 units or more) across the regulation boundaries see Section 5.1, Figure 4 and Table 4.

Below, we discuss assumptions (2) and (3).

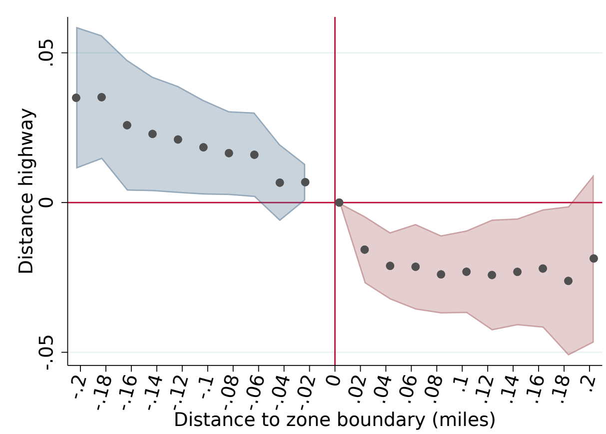
Figure 2: Amenities at Regulation Boundaries



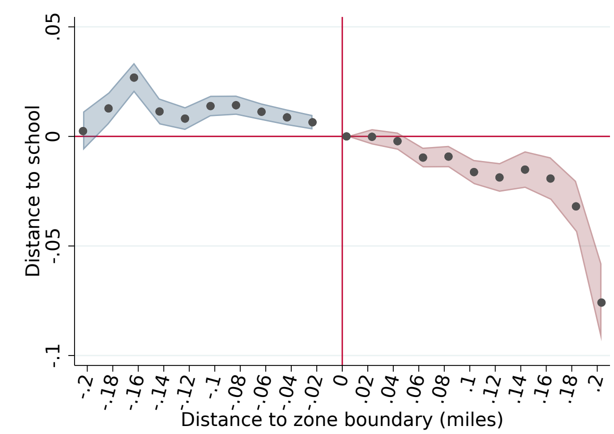
(a) Distance to River or Lake (DUPAC)



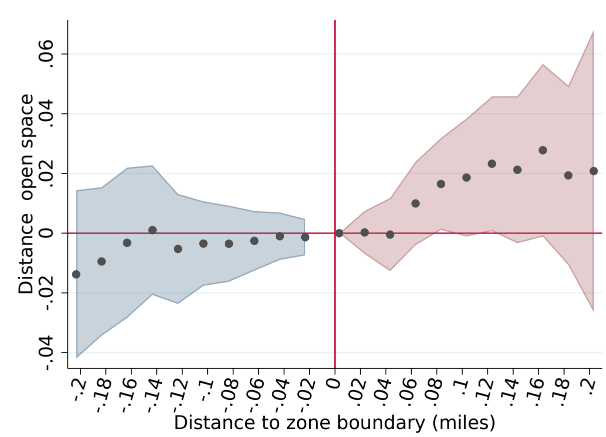
(b) Distance to Center (MF + DUPAC)



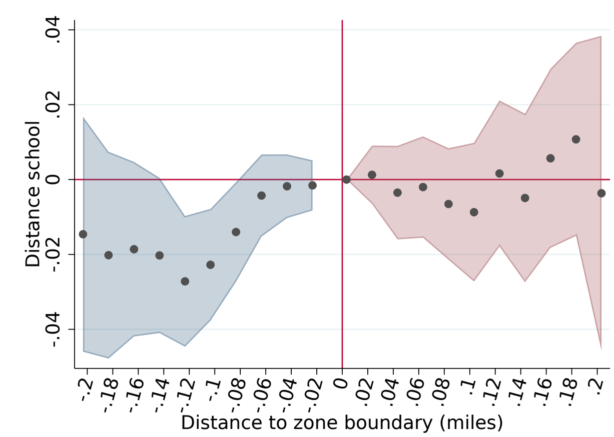
(c) Distance to Road (DUPAC)



(d) Distance to School (MF + DUPAC)



(e) Distance to Open Space (Height + DUPAC)



(f) Distance to School (Height + DUPAC)

Note: Plots are created by regressing distance to various amenities 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 to -0.02 miles to the boundary) is normalized to 0. 95% confidence intervals are shown. DUPAC is Density units per acre and MF is multi-family zoning boundaries.

4.1.1 Continuous amenities along the 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 boundaries, we restrict our across regulation boundary comparisons to within each town individually. For many households, school quality is a primary location amenity 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 are may coincide with major roads or geographic features. To account for this and to 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.

We ensure continuity of location amenities across boundaries, other than the change in regulation itself, by comparing buildings that are within 0.3 miles on either side of the admissible boundaries within towns and school attendance zones. The maximum bandwidth of 0.3 miles is chosen because beyond this, distance to neighborhood amenities changes across the border.[15] Figure 2 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 figure, 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.

Table 2: 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		0.120		0.025		0.018	
	(0.106)		(0.028)		(0.024)		(0.009)	
H				0.005				0.004
				(0.011)				(0.007)
DU		0.001	-0.003	0.001		0.000	0.000	0.005
		(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	6,649	67,788	38,346	25,511	4,387	53,695	26,521	14,313
$\mathbb{E}(y)$	0.469	0.396	0.340	0.330	0.276	0.397	0.176	0.388

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. 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.

4.1.2 Exogeneity of the zoning boundaries

While we ensure that observed and unobserved amenities of a location do not vary across the land-use regulation boundaries, another potential concern is that these boundaries could be shaped around the existing historic building structure of the Greater Boston Area. The city of Boston and Cambridge first adopted maximum height restrictions in 1918.[16] Neighboring suburban towns of Brockton, Brookline, and Newton followed suit and adopted maximum height restrictions in early 1920s.cite. In 1956, Boston passed the Enabling Act to establish Zoning Commission of Boston and adopted the first

[15] 0.3 miles is the maximum bandwidth. In most of the analysis, smaller bandwidth is used. See Section 5.4 for optimal bandwidth selection.

[16] Bobrowski (2002),Hillard (2020),**?**,**?**,Neilson (1934),MacArthur (2019)

comprehensive zoning code in the area. Neighboring towns also adopted a comprehensive zoning code in the mid-late 1950s.[17].

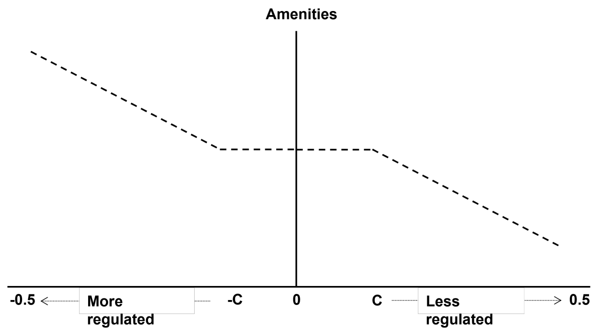
To address this concern, we study whether the type of buildings built (either 2-3 unit apartments or 4 or more unit apartments versus single-family buildings) before either 1918 or 1956 (two prominent years for zoning code adoption) do not differ across the present-day regulation boundaries. We use the linear probability model (LPM) laid out in Section 4.3 (equation 1). Table 2 shows the results from the LPM for buildings built before 1956 (see Table A1 in Appendix for buildings built before 1918). As can be seen from the table, the type of building built (single-family versus multi-family) do not vary in any statistically significant ways across the four key land-use regulation scenarios.

4.2 Mechanisms from Supply and Price Effects

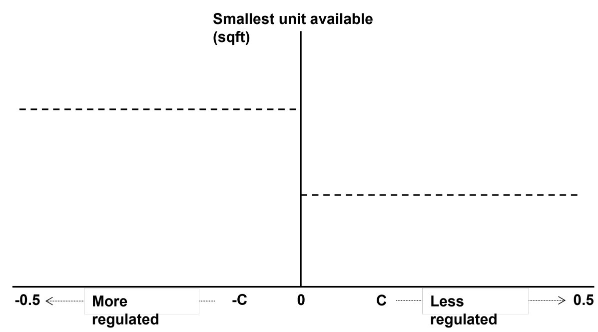
There are four key mechanisms that would result in price changes across boundary when the type of land-use regulation changes. First, within the *direct effects*, there is the supply effect where increase in supply from relaxed land-use regulation would lower prices (movement along the demand curve) assuming no shifts in demand. Second, within the *direct effects*, there is the demand effect where increase in supply from relaxed land-use regulation would increase prices if the shift in demand outweighs the increase in supply from the relaxed regulation. This is potentially likely in locations near downtown where land-use regulation are more relaxed, on average, but high demand is not met with sufficient supply and could occur both 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, 2020). Third, home-owners experience a *direct effect* of relaxing land use regulation 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 which increases the future sale value of the land. Fourth, there is an *indirect effect* from relaxed regulation if households dislike higher density and relaxing the regulation increases the supply of housing. In this case, the indirect effect of relaxing land-use regulation on

[17]Willmington adopted comprehensive zoning code in 1955; Cambridge in 1962.

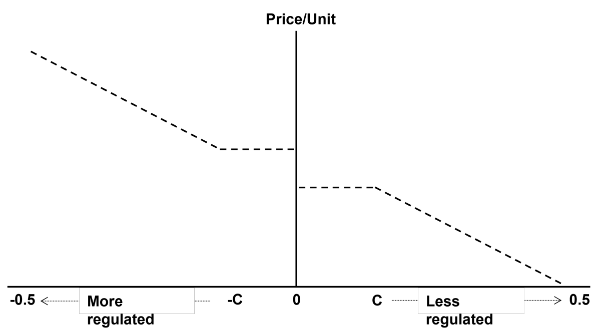
Figure 3: Different Effects at the Regulation Boundary



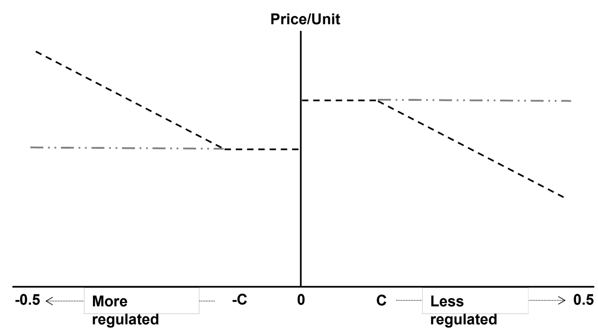
(a) Amenities



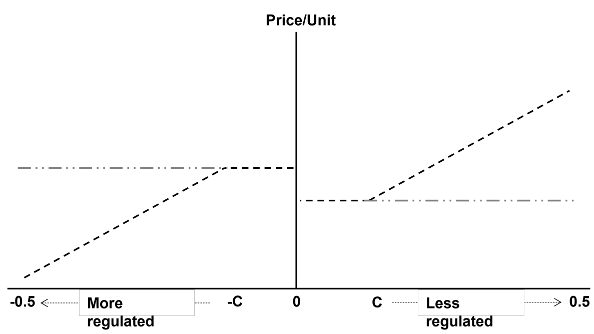
(b) Smallest available unit



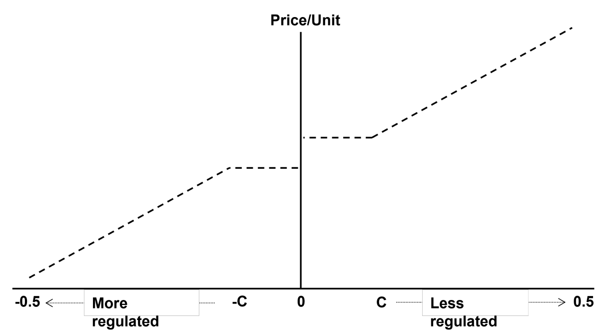
(c) Supply dominates & dislike for density



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



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



(f) Demand dominates & preference for density

Note: This 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.

house prices is negative i.e. higher density would reduce prices.

Boundary discontinuities are commonly used to elicit the willingness to pay for characteristics that change discontinuously at boundaries, such as education (Black, 1999). If housing supply is fixed across the boundary, neighborhood demand is perfectly elastic, and other observed and unobserved neighborhood amenities are continuous, then the difference in price across the boundary can be interpreted as the willingness to pay for the changing characteristic.

Land use regulations primarily affect prices through housing supply (direct effect) though they also affect neighborhood composition and density by changing the types of available housing (indirect effect). In places with relaxed land use regulation, a higher number of smaller and cheaper units are available than in places with strict regulation. This supply effect lowers the per unit price of housing unless the demand for smaller units is so big that it dominates the supply effect. Figure 3 illustrates different scenarios to highlight which effects we are able to identify and when.

Figures 3a and 3b illustrate that right at the boundary amenities are continuous however the type of housing, in particular the smallest unit available (in the case of density, in the case of height this would be the most floors etc.) drops as relaxed density regulations imply a smaller minimum size. Therefore, at the boundary, price per unit shifts, because regulations change the type and size of housing, even though amenities in the area remain the same.

Close to the boundary where there is a density spillover from the more relaxed side of a boundary to more restricted side, the direct effect on price per unit can be estimated. As you move away from the boundary, the effect density has on prices comes from both direct and indirect effects, which cannot be separated in general. However, Figures 3c to 3f highlight in which cases we can make statements about the direct and indirect effects. C represents the cutoff value for our direct effect estimates and the distance from the boundary at which our indirect effect estimates begin.

Figures 3c and 3d show cases in which households have a dislike for density so prices fall as density increases (i.e. towards the less regulated side) and Figures 3e and 3f show the opposite case. If the supply effect dominates (Figure 3c) and lowers prices and the indirect is also negative, we cannot distinguish whether the indirect effect captures a willingness to pay for density or the overall supply effect. Similarly, when the demand effect dominates and density is preferred (Figure 3f) we face the same issue.

If the indirect and direct effects have different signs, i.e. Figures 3d and 3e, we are able to make statements about preferences for density compared to the direct effect of regulation. These figures also show the cases in which there is no preference for density, so 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 also informative about preferences for density. We further discuss these cases when discussing our results. Next, we turn to our empirical specification.

4.3 Empirical Specification

We use a spatial regression discontinuity design 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 (distances to the boundary) and discuss sensitivity with respect to the chosen bandwidth. To estimate the direct effect of the regulation, we use the parsimonious regression specification given by Equation 1

$$Y_{ht} = \rho_0 + \rho_1 1\{\text{Regulation}_h\} + f_h(\text{dist}) + \lambda_h^{seg} + \tau_t + \epsilon_{ht} \tag{1}$$

where Y_h is log owner cost of housing for single family homes and rent for multi-family houses. Alternatively, we estimate linear probability models where Y_h is an indicator for either 2-3 unit building relative to single-family homes or an indciator for 4 or more unit building relative to single-family homes. Regulation_h is either change in DUPAC, change in maximum height, multi-family allowed (0/1 dummy), or combination of these three regulations. $f_s(\text{dist})$ is a linear function in distance estimated separately on either side of the boundary, λ_h^{seg} is the boundary fixed effect 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 relaxed regulation and the fact that relaxed regulation changes the type of housing that is built. Since house characteristics are endogenous to the regulation, we do not control for them in this regression. In the appendix we also show results for a version in which we control for the year a given house was built. We do this recognizing that structures built at different times can vary in quality and style in ways that are completely unrelated to the zoning regulation. 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

We use a linear probability version of Equation 1 to study the effects of land use regulation on housing supply. For our linear probability model specification, we focus on buildings built after 1918 or 1956, to important dates in the history of land use regulation in Boston (see Section 3.1). Buildings built prior to these years were not subject to the regulation and could therefore look quite different and bias our supply results. We also use these dates to analyze endogeneity of the regulations in section 4.1.2.

Lastly, we use the boundary RD design to estimate the indirect effects of land use regulations on house prices and rents. These manifest through changes in neighborhood density that households have a valuation for. We are going to consider two measures of neighborhood density that we call gentle density and high density. Gentle density, θ_{GD}, is given by the fraction of 2-3 unit buildings in a 0.1 mile radius of a given property h. High density, θ_{HD}, is given by the fraction of 4+ unit buildings in a 0.1 miles radius of property h. We estimate the spillovers of density using the following equation.

$$Y_{ht} = \rho_0 + \rho_1 1\{\text{Regulation}_h\} + \rho_2 \theta_h^{HD} + \rho_3 \theta_h^{GD} + \rho_4 x_h + f_h(\text{dist}) + \lambda_h^{seg} + \tau_t + \epsilon_{ht} \tag{2}$$

x_h is a vector of unit level characteristics, such as year built, lot size, building area, number of bedrooms, etc. In contrast to our broad stance taken on the direct effect of the land use regulation, estimating the indirect effect requires controlling for a rich set of unit level attributes that affect prices. ρ_2 and ρ_3 are the coefficients of interest. 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 0.1 miles from the boundary.

Again, we show robustness with respect to bandwidth choice.

It is important to mention two caveats at this point. First, at present, we cannot distinguish between the effect of density itself or changes in neighborhood quality that follow from changes in residential density. Second, in general, we cannot distinguish between a distaste for density and a supply effect of relaxed regulation - both leading to negative signs on ρ_2 and ρ_3. 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, means that we can assess the importance of preferences for density relative since we expect direct effects to not change with distance but indirect effects should change as density continues to change away from the boundary. Before turning to results we discuss how different types of regulations and their combinations should affect supply of housing and prices based on their effects on density.

4.4 Differential Effects of Regulations on Supply and Prices

All regulations don't have the same effects on the supply of multi-family housing and therefore on prices. Before we dive into our results related to the effect of regulation on housing supply, 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 targeting density directly is dwelling units per acre while allowing multi-family housing and height regulations affect the size and type of housing conditional on an areas density. Consequently, we expect DUPAC and interactions of DUPAC with other regulations to be the only regulations that increase units directly.

The predictions we make for price changes follow from our predictions on supply. Regulations that do not impact supply, are not expected to lower prices through a supply effect. For single family homes, relaxing any regulation increases the option value. Finally, the effect of spillovers is specific to our definition of spillovers as coming from the share of 2-3 or 4+ unit homes within a 0.1 miles radius. Therefore, regulations that

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.

affect the type of housing or units should affect this share. The only regulation that affects neither the type of housing nor density is height and therefore we expect there to be no spillover effects at boundaries where only height changes. We now turn to our results on supply.

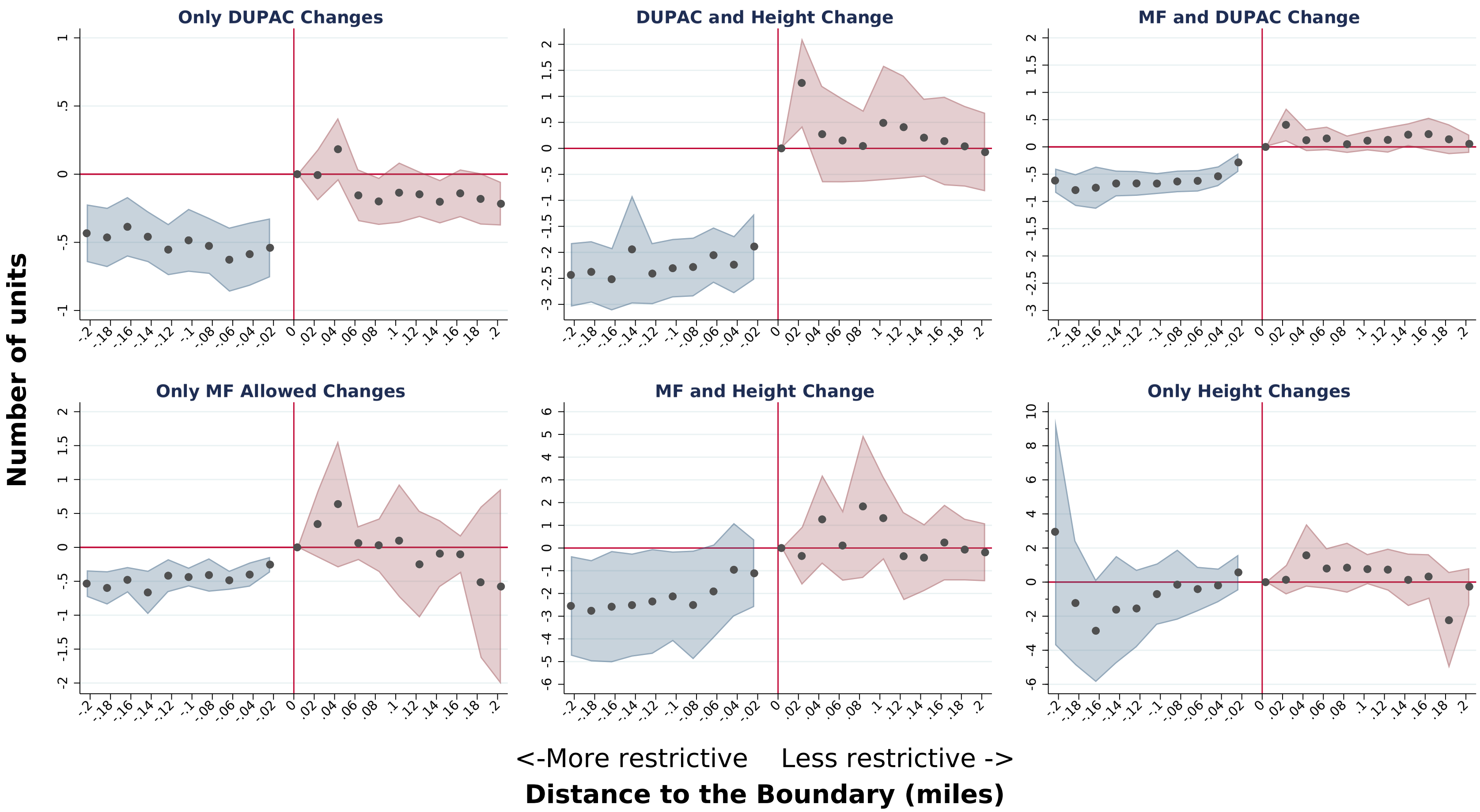
5. Results

5.1 Supply

We argue that different land use regulations differ in their effect on the supply of housing (see 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 dwelling units per acre. Allowing multi-family zoning changes the type of housing and relaxing height restrictions change the size of the unit, however, unless the number of allowable units to be built per acre (DUPAC) changes, relaxing multi-family zoning or height restrictions does not increase the supply of housing.

This can be seen in Figure 4, which displays the change in the number of units supplied on the more restrictive side of a regulation boundary, relative to the number supplied at the less restrictive side of the boundary (normalized to 0 0 - 0.2 miles from the boundary). As can be seen from the top row of Figure 4, relaxing DUPAC restriction alone or in combination with allowing multi-family by-right or relaxing height restriction has the largest and most significant effect on increasing supply measured through number of units built. Relaxing DUPAC restrictions alone results in a 0.48 unit increase on average per building 0.02 miles from the regulation boundary. Relaxing DUPAC and allowing multi-family housing together result in a 0.45 unit increase among buildings with .02 miles, while relaxing DUPAC and height restrictions results in a 1.52 unit increase per lot. For all of these three regulation types, the effect is persistent away from the boundary as well and precisely estimated up until 0.2 miles from the boundary. While these effect sizes may seem small, keeping in mind that the average is 1.6 units at boundaries where only DUPAC regulations change as well boundaries where DUPAC regulations change along with allowing multi-family homes, and 2.6 units at boundaries where both DUPAC and height change, the changes imply increases in the supply of units between 28-58%.

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



Note: Plots are created by regressing number of units 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. The top panel represents boundaries where only dwelling units per acre (DUPAC) either by itself, or with height changes or multi-family (MF) regulation changes. The bottom panel represents boundaries where only height changes, only multi-family (MF) regulation changes, or both change simultaneously.

As expected, we see no effects at boundaries where height changes alone, or in combination with allowing multi-family homes. Neither of these regulations is targeted at increasing residential density, therefore we shouldn't see an increase in the number of units per lot. Right at the boundary, there does seem to be an effect of a decrease in 0.5 units on the restrictive boundary side when only multi-family regulation changes. However, examining confidence intervals, it is not clear that this effect is persistent away from the boundary. This is consistent with recent examples of zoning regulatory 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” (Star Tribune, 2021). It is possible that like in the Greater Boston Area, the dwelling units per acre (DUPAC) is the key restriction in effectively increasing the supply of housing.

Another way to study changes is housing supply is by looking at the type of housing built instead of the number of units. The avenue of land-use regulation reform might be more effective in increasing the supply of certain types of multi-family housing compared to others.[18] To investigate this question we run linear probability models (equation 1) where the outcome is the type of housing (2-3 unit or 4+ unit). We focus on buildings built after the adoption of the comprehensive zoning code in 1956 (i.e. buildings that were not grandfathered in. We interpret the effects as a given regulation increasing the probability of a house being of a certain type *compared to single family housing.* Table 4 shows the results for these specifications. We find that both allowing multi-family homes and more dwelling units increases the probability of a given property being a 2-3 unit property compared to a single-family home. In particular, column 1 shows that the probability of a property being 2-3 unit doubles relative to the baseline when multi-family homes are allowed. The fact that we don't find strong effects from combinations of multi-family and dupac and height and dupac suggests to us that at those boundaries, housing is already likely to be multi-unit. We saw in the graphical depiction that

[18]This also allows us to tie supply in directly with density externalities defined as the share of a 2-3 or 4+ unit housing and therefore to calculate policy counterfactuals for indirect effects as well.

Table 4: Supply of Various Type of Housing across Regulation Boundaries

	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		0.043		0.066		0.011	
	(0.066)		(0.019)		(0.035)		(0.014)	
H				-0.011				0.006
				(0.011)				(0.009)
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	2,108	54,007	14,803	4,562	1,996	53,096	14,042	4,105
$\mathbb{E}(y)$	0.278	0.128	0.238	0.376	0.028	0.019	0.020	0.067
R^2	0.383	0.276	0.315	0.511	0.574	0.509	0.410	0.653

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. 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 number of units does change at these boundaries but we do not find an effect on the *type* of housing.

For the supply of 4+ unit properties, we continue to find a substantial effect of allowing more dwelling units per acre. Relative to the very low sample average of 0.019, allowing an additional dwelling unit per acre, increases the chances of a given property being 4+ unit by 10%. We also find a similar effect of relaxing DUPAC in places where multi-family zoning is allowed (column 7). We do not detect any effects at boundaries where height and DUPAC regulations changing together which we again attribute to the fact that, at these boundaries, properties are already multi-family and the relevant margin is the number of units (as can be seen in Figure 4) not the type of housing.

In summary, we find that relaxing allowed dwelling units alone and in combination with other regulations reliably increases the supply of units while height regulations and combinations of height with allowing multi-family have no such effect. This is in accordance with our predictions in which allowing multi-family homes without increasing density is unlikely to have an effect on supply. We also find that relaxing zoning regulations – in particular allowing more dwelling units per acre alone or in combination with allowing multi-family housing – is most effective at increasing the supply of 4+ unit homes. Simply allowing multi-family homes increases the supply of 2-3 unit homes but not the supply of 4+ unit homes. This could be both due to the fact that allowing 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 difficult. It is likely that other factors inhibit the construction of larger apartment buildings, such as construction costs, community opposition, and the availability of land. All represent additional roadblocks to building high-density types of housing that may play less of a role for gentle-density housing types.

5.2 Direct Effects: Housing Prices and Rents

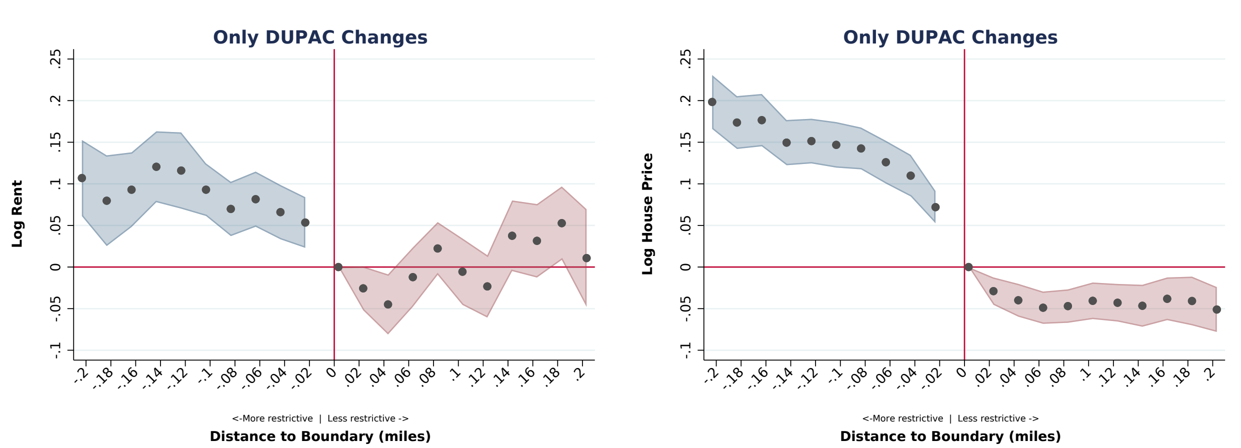
We now discuss our results for how land use regulations affect the prices of single-family homes as well as rents.[19] From this point in the paper, we will focus on regulations that interact with density (DUPAC) regulations. As seen in the previous section, other types of regulation do not have any bite in terms of adding housing which is the focus of this paper. Concretely, we focus on dwelling units per acre and combinations of DUPAC with height and allowing multi-family. In Table 1 these are Scenarios 3, 5, and 6 which amount to 77% of our multi-family and 84% of our single family home sample. Figure 1 shows that the remaining scenarios tend to be quite locally concentrated and their external validity is less convincing. While we do find some moderate effects of allowing multi-family housing on supply, this regulation affects mostly single-family homes and

[19]We exclude condos from the analysis since prices do not include the price of land and are hence not comparable to single-family home values.

we therefore don't show results going forward. Particularly, there is no sensible effect of allowing multi-family homes on rents since one side of the boundary doesn't allow rental units. We turn our attention to boundaries where all regulations change when we talk about Chapter 40B in Section 7.

Figures 5 and 6 plot the effects of regulations on prices and rents. We study the effects of regulation change across boundaries separately 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 where we normalize the first bin on the relaxed side to 0.

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



(a) RD estimate = -0.054, (t statistic = 3.42)

(b) RD estimate = -0.073, (t statistic = 7.44)

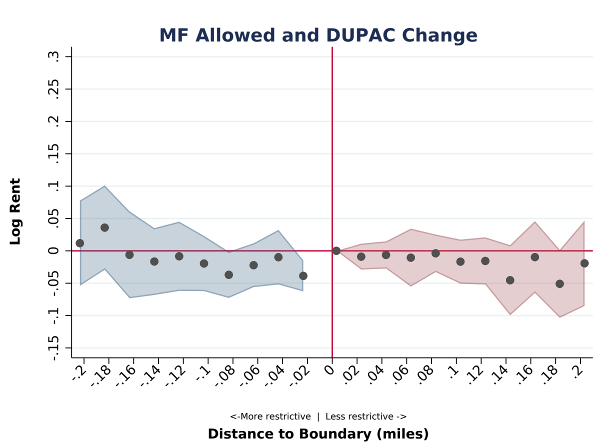
Note: Plots are created by regressing log prices on boundary fixed effects, year fixed effects [2010-2018], and bins of distance to the boundary (bins of 0.02 miles). Coefficients on the distance bins are plotted. Negative distances indicate the more regulated side of a boundary. The bin closest to the 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.

When only DUPAC regulations are relaxed, rents in multi-family properties .02 miles away from the boundary are 5.4% less on the less restrictive side compared to those on the more restrictive side. Meanwhile, the monthly housing costs for single-family property owners falls by an average of 7.3%. These effects are for the average change in regulation across boundaries where only dwelling units per acre change. Table A3 displays the per unit changes in prices which are an 0.1 percentage point decrease in rents and an 0.2 percentage point decrease in the price of single family homes. Given that for single family homes there is also an option value that increases the price when regulation is relaxed, we can draw the conclusion that the combinastion of supply and indirect effects of DUPAC regulation are stronger for single family homes than for rental units.

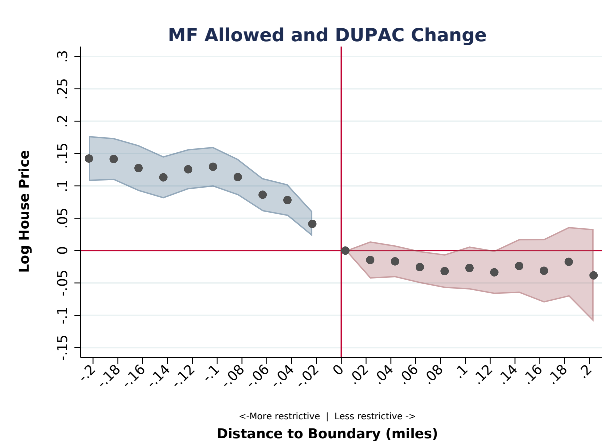
When both DUPAC is relaxed and multi-family is allowed by-right there is little change in rents across the boundary. While there is a positive effect within 0.02 miles of the boundary, graphically there is no visible discontinuity further away from the boundary. Table A3 suggests that there are negative 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 levels of density, the overall effect (which is visible in the graph) could turn positive or close to zero. House prices fall by 3.36% right at the boundary on the more relaxed side, with an increasing gap as we move further away. This is suggestive evidence of negative externalities of density that kick in away from the boundary as buildings differ on either side. The effects of individual regulations have similar signs as for rents, however the impact of allowing multi-family housing is much larger for house prices compared to rents, making it less likely that the overall effect of this combinations of regulations will be positive.

When DUPAC and height regulations change, rents fall by an average of 5.7% while there is no detectable effect on the prices of single-family homes close to 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 impact on prices) but we don't find precisely measured effects for single family home prices. Returning to Figure 1, we can see that boundaries where DUPAC and height regulations change together tend to be concentrated in town centers. These areas are typically denser urban cores with fewer single-family homes.

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

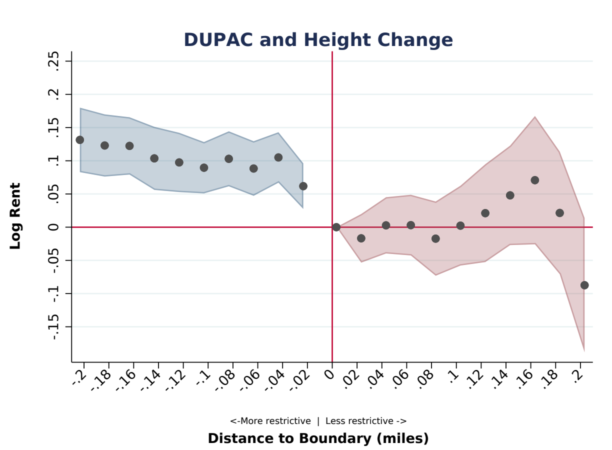


(a) RD estimate= 0.0413, (t statistic = 3.47)

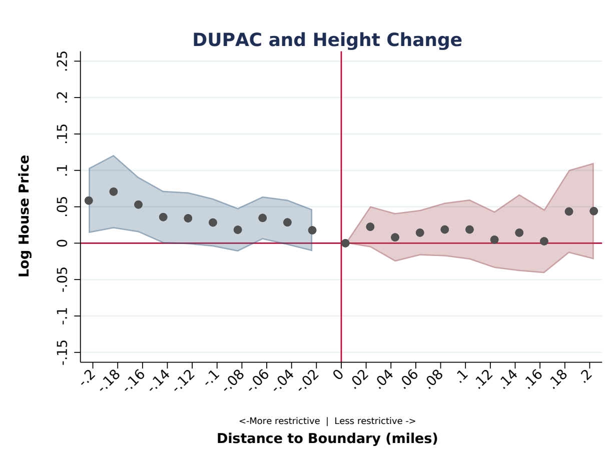


(b) RD estimate = -0.0336, (t statistic = 3.75)

(c) Change in DUPAC and Multi-Family Regulation Boundaries



(d) RD estimate= -0.057, (t statistic = 3.69)



(e) RD estimate = -0.02, (t statistic = 1.41)

(f) 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 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.

It is therefore not surprising, that we find a stronger impact of this regulation type on rents than home prices.

Earlier we showed evidence of the exogeneity of zoning regulations, in particular of the continuous height and DUPAC regulations. Nevertheless, we realize that supply could vary substantially from year to year, in particular 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 therefore bias the direct effects upwards or downwards. Table A4 shows results of equation 1 where we additionally control for year built. Comparing to Table A3, we find that when we control for the year built, there are no big differences in the effects we find 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. This could be potentially explained by increased sorting over time at zoning boundaries. Another possible explanation is that older buildings were grandfathered in and diverge in structure from newer buildings.

5.3 Taking Stock

Summing up, we find that that supply effects dominate demand effects (and the option value) for dwelling units per acre regulations both for rents as well as home prices. We find that combining DUPAC regulations with allowing multi-family homes has a strong impact on house prices but not on rents. It is possible that there is increased demand for apartments in locations with this type of regulation (evidenced by a positive interaction term of DUPAC and allowing multi-family housing), which mitigates the supply effects in this case. For a combination of DUPAC regulations with height, we find strong supply effects on rents and no effects on the prices of single family homes which we attribute mostly to where these boundaries are located within cities and towns. Comparing Figures 5b and 6b for single family homes with their equivalents for rents (Figures 5a and 6b), 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 types of housing have on surrounding properties.

Graphically, it seems that the spillovers of density are larger and negative for single-family home prices than they are for rents.

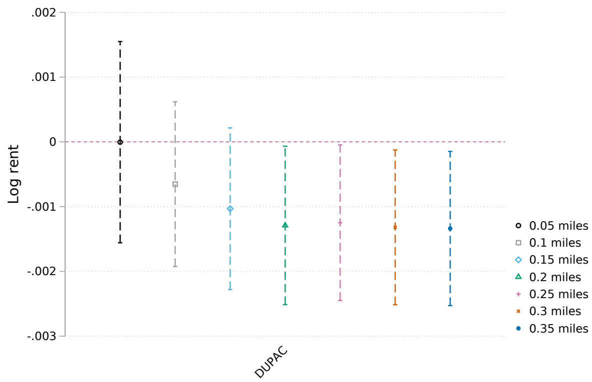
5.4 Indirect Effects: Housing Prices and Rents

So far, we studied the direct effect of regulation right at the boundary where amenities are continuous. Next, we study the indirect effect of regulation recognizing that zoning regulations – by changing density – may themselves change the quality of a neighborhood. Increasing the supply of housing through DUPAC by definition increases density, which can lower housing costs indirectly if people would prefer to live in less dense areas. This change in housing costs can be thought of as a willingness-to-pay for density, where an increase means higher density is more desirable while a decrease means it is less desirable.In our analysis, we will not be distinguishing between the effects of density per se, aka the effect of open space, and the effects of higher residential density leading to different neighborhood composition.

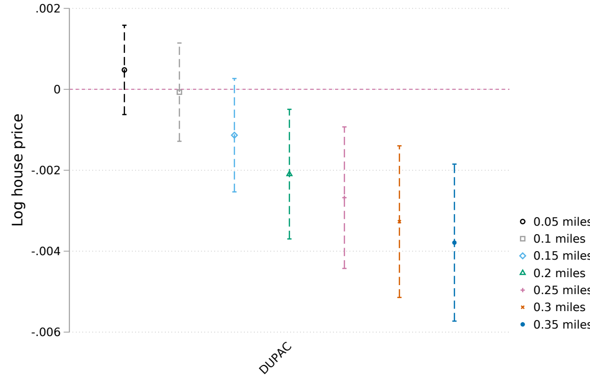
To start, we show how our direct effects from the previous section vary with the bandwidth that we choose. This analysis is more than a check of robustness with respect to bandwidth selection since distance to the boundary meaningfully alters the economic interpretation of the treatment effect of regulation by including the spillover effect of regulation the further we move from the boundary. Figure 7 plots the direct effect in the case of our three main 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 7), we find that the direct effect isn't 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. We want to highlight that this is a very small bandwidth with few properties - nevertheless this coefficient is not statistically different from the others. The stability of these coefficients also implies that there is unlikely to be a big preference for density among renters. If that were the case, then – as residential density changes away from the boundary – we would expect to see the

Figure 7: Price Effects across Various Distance Bandwidths

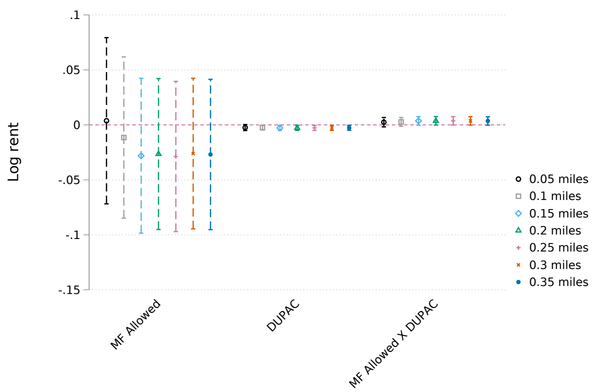


(a)

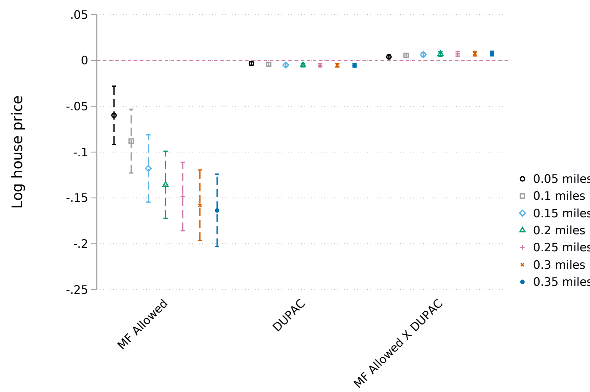


(b)

(c) Change in DUPAC Regulation Boundaries

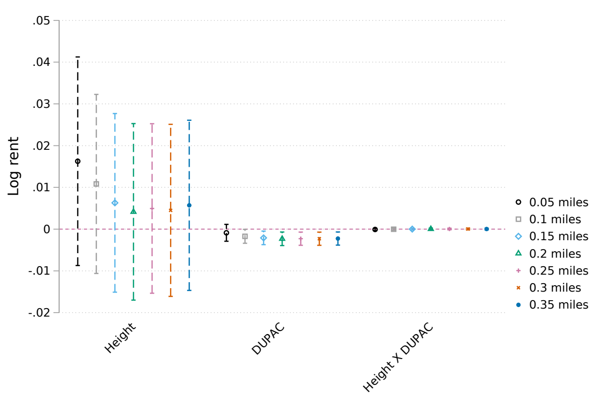


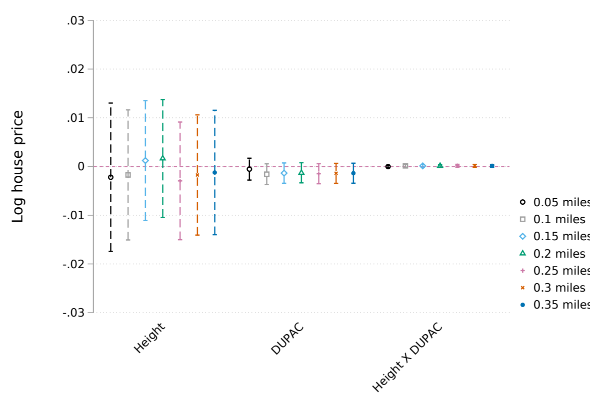
(d)



(e)

(f) Change in DUPAC and Multi-Family Regulation Boundaries





(g) Change in DUPAC and Height Regulation Boundaries

Note: This figure plots the coefficient on multi-family (MF), height, and dwelling units per acre (DUPAC) when the regulation regression discontinuity boundary varies from 0.05-0.35 miles. For each panel (a), (b), and (c), coefficients for log rents are plotted on left and coefficients for log owner cost of housing is plotted on the right.

direct effect coefficients reflect it which does not seem to be the case. Returning to our discussion of mechanisms, these plots look similar to Figure 3e in the case where there is no preference for residential density. Concluding from these figures, we conjecture that we will not be seeing strong effects on rents from estimating equation 2 (discussed below).

Results for owners are depicted in the right panels of Figure 7. Here, with the exception of boundaries where height and DUPAC regulations change together[20], the choice of bandwidth does seem to matter for the size as well as potentially the sign of the direct effect. The larger the bandwidth is, i.e. the more distance away from the boundary it covers, the larger and more negative the effect of dwelling units per acre is in Figure 7b and the effect of allowing multi-family homes in Figure 7e. This suggests that in addition to there being a supply effect, households also have a distaste for density which manifests itself at an increased distance to the boundary as density changes systematically with regulation. This case corresponds to Figure 3c. We already found significant negative direct effects of DUPAC and DUPAC in combination with allowing multi-family homes; based on these figures, we expect to also find a negative coefficient of residential density on single-family home prices.

These hypotheses are supported by Table 5 – the results from estimating equation 2. We show the effects for the share of 4+-unit homes (θ_{HD}) and 2-3 unit homes (θ_{GD}) within a 0.1 mile radius of a property for rental prices in the top panel and owner cost of housing in the bottom panel. For renters, we find a wide range of coefficient sizes and signs - almost all of them not precisely estimated. This corroborates our findings from varying the bandwidth that there is no big preference for residential density for renters and therefore the regulation impacts rents directly by increasing supply. The only statistically significant result is a 0.09% decrease in rents for a one percentage point increase in share of 2-3 unit homes.

The bottom panel shows effects of residential density on owner cost of housing and highlights the extent to which single-family homeowners might dislike living near higher density buildings. These coefficients are all negative with one exception and quite pre-

[20]These boundaries were previously shown to have no impact on price.

Table 5: Price Effects Away from Regulation Boundaries

	Only MF	Only DUPAC	MF & DUPAC	DUPAC & Height	All
Multi-Family (rents)					
θ^{HD}		0.093	0.083	-0.103	-0.160
		(0.105)	(0.142)	(0.090)	(0.132)
θ^{GD}		-0.098	-0.048	0.037	-0.083
		(0.049)	(0.038)	(0.046)	(0.057)
N		50,207	35,317	39,813	32,058
$\mathbb{E}(y)$		$1,076	$1,026	$1,007	$892
$\mathbb{E}(\theta^{HD})$		0.0994	0.0447	0.1112	0.0847
$\mathbb{E}(\theta^{GD})$		0.4033	0.4014	0.5227	0.4836
Single-Family (owner cost of housing)					
θ^{HD}	-0.498	-0.104	-0.104	-0.099	-0.031
	(0.248)	(0.091)	(0.060)	(0.057)	(0.086)
θ^{GD}	0.144	-0.164	-0.213	-0.060	-0.201
	(0.100)	(0.038)	(0.048)	(0.043)	(0.062)
N		604,110	188,389	77,731	86,844
$\mathbb{E}(y)$		$2,133	$1,713	$1,455	$1,434
$\mathbb{E}(\theta^{HD})$		0.0287	0.0257	0.0805	0.0548
$\mathbb{E}(\theta^{GD})$		0.1416	0.2393	0.4046	0.3466

Note: This table illustrates the coefficient on share of high density (4 or more 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 2. Top panel presents results where the dependent variable is log monthly rents and the bottom panel show results where the dependent variable is log monthly owner cost of housing.

cisely estimated. As the previous figures suggested, we find sizable negative impacts of increased gentle density on owner costs of housing at boundaries where DUPAC regulations change alone or in combination with allowing multi-family housing. For an increase in the share of gentle density of 1 percentage point there is a 0.16 percentage point fall in home prices at boundaries where only dwelling units per acre change and a 0.21 percentage point fall in home prices at boundaries where dwelling units change together with allowing multi-family homes. We find no effects at boundaries where DUPAC and height change together. Somewhat counter intuitively, the effect sizes are larger for gentle density than for high density, implying that home owners dislike 2-3 unit homes in their immediate vicinity more than 4+ unit homes. Looking at the sample averages for different types of density we see that this might be a bit misleading. The fraction of high-density buildings is extremely low, between 2.5 and 8%, therefore we attribute the larger and more precise effects for gentle density to the fact that single-family homes almost never lie directly next to high-density properties and if so, then there are also 2-3 unit buildings nearby. This can also be seen in Figure B.2.

Combined, the effect zoning regulations have on both supply, prices, and willingness-to-pay for density highlight possible avenues for reforms that increase supply, lower prices, but may avoid some of the pitfalls to new construction that come in the form of neighborhood opposition. For example, relaxing DUPAC alone or in combination with allowing multi-family or relaxing height all increase supply. In addition, only relaxing DUPAC or in combination with relaxing height also lowers housing costs. In general, homeowners do not like living near higher density, therefore part of the effect of zoning regulations on prices is an indirect effect capturing this dislike.

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 are in line with sorting of households that dislike density into suburban areas and households that have less of a distaste into urban centers. In the next section, we further investigate the importance of spatial heterogeneity.

6. Local Town Governance and Land Regulations

The zoning laws and their stringency are set at municipalities (town) level by local governments. In addition to making zoning laws, they also review new housing projects, especially those that have aspects that are not permitted by-right under local zoning code. There are four forms of local governance in Massachusetts: Mayoral system (40.87% of our sample of properties), Council 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 towns and the first two being typically adopted by cities. Each of these local governance structures have different types of approval and voting processes. In OTM, especially common among smaller towns, any local voter is allowed to attend and vote in zoning matters, while in RTM voters select representatives to attend town meetings.

Einstein et al. (2019) use meeting minutes from local government meetings in Greater Boston Area and find that individuals who are older, male, longtime residents, voters in local elections, and homeowners are significantly more likely to participate in housing and development policy meetings and oppose new housing construction. However they do not study how different forms of local governance are more amenable to public participation, and in turn, oppose newer housing. Recently, Hankinson and Magazinnik (2020) and Mast (2020) have found that switching from an open structure to a more representative town governance structure reduces overall supply of housing, especially the supply of multi-family housing. The intuition for this result is that in an open structure more powerful constituencies along the lines of Einstein et al. (2019) are able to push through new housing that is concentrated in already dense areas that tend to be less powerful. By increasing representation, these communities are able to 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 governance structure of the town. The magnitudes of these results should not be interpreted as causal to the town governance structure. However, we do learn about heterogeneity in supply and price effects by different forms of governance. We omit the Council system due to its low sample size.

Table 6 shows results for boundaries at which dwelling units per acre change alone or in combination with allowing multi-family housing. We focus on these regulations as they are most represented across all types of towns and governance structures. The top panel shows the effects on the supply of gentle and high density buildings relative to single-family homes. For towns with open town meetings or a mayoral structure, we find positive effects of dwelling units per acre on a building being a two-to-three unit home or a four-or-more unit home. We also find that allowing multi-family homes in combination with relaxing DUPAC regulations increases the supply of both gentle and high density. We find much smaller and more imprecise effects for towns with representative town governance. This is in line with the literature, finding that it is harder to build multi-unit housing in places with a more representative town structure that allows less powerful communities to have more of a say.

The bottom panel shows the effects on prices. Supply effects dominate at boundaries where only density regulations change in towns with open town meetings or a mayoral structure which also saw the highest increases in supply. Similarly for the combination of allowing multi-family and relaxing dwelling units per acre, effects are less pronounced in towns with representative town meetings (though still negative) and are negative in places governed by mayors or open town meetings for low levels of allowed density. For high levels of allowed density, the demand effects dominate, in accordance with desirable town centers. Preferences for density of all types are negative throughout, particularly so for single-family home prices, reinforcing our previous findings that home owners dislike density. The effect sizes are larger for cities with mayors and representative town governance than for towns with an open town meeting. This could be due to the fact in towns governed by open town meetings only projects get approved that are more tolerable to the local population and therefore less disliked.

We conclude that town governance structure is strongly related to the impacts of land use regulation. These effects go above and beyond capturing differences between the central business district and different types of suburbs as governance structures vary within towns in the central business district of the Greater Boston Area as well as on

Table 6: Town Governance Table

		OTM		RTM		Mayor	
(a) Supply		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)
	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)
MF X DU	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)
(b) Log Prices		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	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)
	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)
	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)

Note: This table presents the results from an OLS regression of Equation 1 separately for different forms of government, namely towns with open town meetings (OTM), representative town meetings (RTM), or a mayoral system (Mayor). The dependent variable is an indicator for different types of buildings in the top panel and the log of either annual owner cost of housing (SF) or annual rent (MF). We control for boundary fixed effects and year fixed effects (only in price regressions). Standard errors are clustered at the boundary level. 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 outskirts. Understanding these effects has important policy implications because relaxing regulations will have different effects when channeled through different forms of town governance.

7. Inclusionary Zoning and Land Regulations

Table 7: Land Regulation and Inclusionary Zoning (Chapter 40B)

	MF	H	DU	MF X H	MF X DU	H X DU	MF X H X DU	N
All	-0.335	0.004	0.000	0.080	0.008	-0.001	-0.002	6,468
	(0.158)	(0.004)	(0.000)	(0.036)	(0.004)	(0.000)	(0.001)	
MF	-0.823	0.018	0.002	0.208	0.019	-0.001	-0.004	3,794
	(0.168)	(0.009)	(0.001)	(0.043)	(0.005)	(0.000)	(0.001)	

Note: This table presents the results from an OLS regression of Equation 1. The dependent variable is an indicator whether a given property was built using Massachusetts' Chapter 40B zoning policy to override local zoning rules. We control for boundary fixed effects. Standard errors are clustered at the boundary level. We only look at boundaries where all regulations change at the same time – we did not find conclusive effects of the Chapter 40B policy at other boundaries. "All" indicates any building built using Chapter 40B's comprehensive permitting procedure while "MF" indicates only 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.

Relaxing zoning regulations is just one tool available for policymakers who are seeking to expand the supply of housing. Other laws, programs, and local initiatives exist with the same goal. One example of these is Massachusetts' Comprehensive Permit Act, often referred to as Chapter 40B. Chapter 40B is meant to incentivize local communities to build affordable housing by giving developers a pathway for project approval that does not solely rely on local zoning board decisions. In Massachusetts municipalities where less than 10 percent of their housing stock is affordable for households making 80 percent of area median income or less, Chapter 40B allows developers of housing to bypass local zoning regulations (like multi-family, height, or DUPAC restrictions) by applying for a comprehensive permit through a state zoning board. This comp-permit process allows certain local zoning regulations (for instance height restrictions) to be relaxed for the specific project even though they remain enforced locally. At its core, the Chapter 40B law 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. The law also incentivizes communities below the 10 percent threshold to increase affordable housing in order to reach it. Municipalities are allowed to count toward their affordable housing stock units developed through local initiatives and programs outside of the zoning pathway of Chapter 40B. Together this housing stock is tracked in a municipality's Subsidized Housing Inventory (SHI).

To examine how Chapter 40B effects the housing affordability this report uses data on the location of properties in the SHI. This included both multi-family and single-family properties that used the comprehensive permit process to obtain approval, and those that did not but were still counted toward a municipalities affordable housing stock. Table 4 displays the effect zoning regulation changes have on the supply of Chapter 40B properties. Chapter 40B properties are broken out by all properties counted toward a municipalities SHI, those that were built using the comp-permit process, and only multi-family comprehensive permit properties.

Ideally, Chapter 40B, and in particular comprehensive permit properties, should be a substitute for relaxing land-use regulations, meaning they would more likely be found in more restrictive zoning areas. An example of this can be seen in Table 4. When multi-family construction is allowed, the supply of comp-permit Chapter 40B buildings decreases by 0.3 percentage points. Thus, in cases where multi-family construction is not allowed, the effect would be a .3 percentage point increase, and so in the places where only this regulation is changing Chapter 40B acts to incentivize the construction of affordable housing. However, this substitution effect appears to only apply to single-family comprehensive Chapter 40B housing. When only multi-family comprehensive Chapter 40B properties are included, the likelihood a property is found in an area where multi-family is allowed increases (increased supply by 249 percentage points). 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 this case and in most cases Chapter 40B has acted as a compliment to relaxing zoning regulations.

When multi-family housing is allowed and height and DUPAC restrictions are lower, the supply of comprehensive Chapter 40B buildings increases by 9-10 percentage points. In particular, the supply of affordable multi-family buildings increases by 2.1 to 22.9 percentage points. 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 Figure 3.

Given the estimates from Table 4, the total probability for a comprehensive permit 40B building to be built is 19.7 percentage points. This 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 percent affordability threshold. Given this probability, to increase the current comprehensive-permit 40B building stock by 50 percent there would need to be an estimated 1477 building applications made, or 5 times more the number of properties that would ultimately be built. Since it is unlikely that developers bring forward such a large number of applications, for policies like Chapter 40B to make a significant dent in affordability, the approval probability would need to increase significantly (at least 3 times), even in the areas where the land-use regulations are low and building multi-family housing is relatively easy.

8. Conclusion

This paper highlights which regulations might provide the most fruitful means of increasing the supply of multifamily housing and reducing house prices and rents, and it examines how effective Chapter 40B can be in increase the supply of affordable units. Housing has become increasingly unaffordable in Greater Boston. From 2010 to 2018, the house price index in the area increased 49 percent, and median rents increased 17.4 percent. The supply of new housing has not kept up with the increasing population. Today, vacant space in Greater Boston is scarce. Only 1.9 percent of all lots are undeveloped.

We find that relaxing dwelling units per acre density (DUPAC) restrictions alone and in combination with relaxing maximum-height restrictions and allowing multi-family homes are the most effective ways of increasing supply and reducing multifamily rents and single-family home prices. The impact on prices from relaxed regulations comes from two sources: directly from a change in regulation, which changes the types of housing built in an area, and indirectly through changes in neighborhood density. Based on our estimates, only DUPAC restrictions will result in a modest increase in the number of new units and a modest reduction in rents and house prices. This is especially true in less dense suburban communities, where most DUPAC boundaries are located and where demand for housing is less intense so any increase in housing supply would have a greater impact on prices. However, as our estimates suggest, single-family homeowners dislike higher density near DUPAC boundaries, so this fall in rents and house prices would occur alongside a measurable dislike for the changing density of the neighborhood.

Changing just multifamily zoning would neither increase the supply of rental properties nor lower the cost of renting in the area. Allowing greater density would do both. Thus, mirroring the recent reforms to multifamily zoning that have been enacted in other U.S. metro areas may not be the best course of action in Greater Boston. Instead focus should be placed on reforms that allow denser housing to be built in general. Results studying the heterogeneity effects across towns with different types of local governance structure indicate that it is important 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.

Finally, there is the question of the role that state policies play in promoting affordable housing. Zoning reform itself is a local process, but the state's Chapter 40B law does function as a form of regional zoning policy, holding municipalities to a minimum level of housing affordability within their borders. 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 larger share would need to be approved. However, Chapter 40B buildings also face significant local opposition.

In addition to efficiency arguments for why policymakers in Greater Boston should consider various ways to increase the housing supply and reduce housing costs, there is also an equity argument. The current equilibrium hurts first-time home buyers, who tend to be younger, and renters of multi-unit housing, who tend to be people of color and low- or middle-income earners, while benefiting older and wealthier homeowners. Thus, lowering housing costs could help first-time home-buyers and lower-income renters, but it would be at the expense of—and therefore likely generate substantial political opposition from—current homeowners.

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A. Additional Tables and Figures

Table A1: Exogeneity 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	0.017		0.116		0.006		0.041	
	(0.094)		(0.033)		(0.049)		(0.017)	
Height (H)				0.011				0.012
				(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	29,569	17,855	17,015	1,374	19,094	10,434	8,540
$\mathbb{E}(y)$	0.374	0.296	0.294	0.235	0.323	0.367	0.206	0.383

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. 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

Table A2: Supply 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	0.419		0.045		0.032		0.003	
	(0.074)		(0.021)		(0.0171)		(0.009)	
Height (H)				-0.010				-0.006
				(0.010)				(0.006)
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				0.000				0.000
				(0.000)				(0.000)
N	5,839	92,226	35,294	13,058	5,009	87,697	30,129	9,878
$\mathbb{E}(y)$	0.456	0.397	0.371	0.507	0.397	0.499	0.269	0.520

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. 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.

Table A3: Price Not 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		-0.025		-0.046		-0.135	
		(0.035)		(0.022)		(0.019)	
Height (H)			0.002				0.002
			(0.010)				(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
			(0.001)				(0.000)
N	175,228	125,448	137,262	49,875	772,426	305,184	129,792
$\mathbb{E}(y)$	$1,076	$1,026	$1,007	$1,821	$2,133	$1,713	$1,455
R^2	0.626	0.633	0.631	0.696	0.732	0.768	0.870

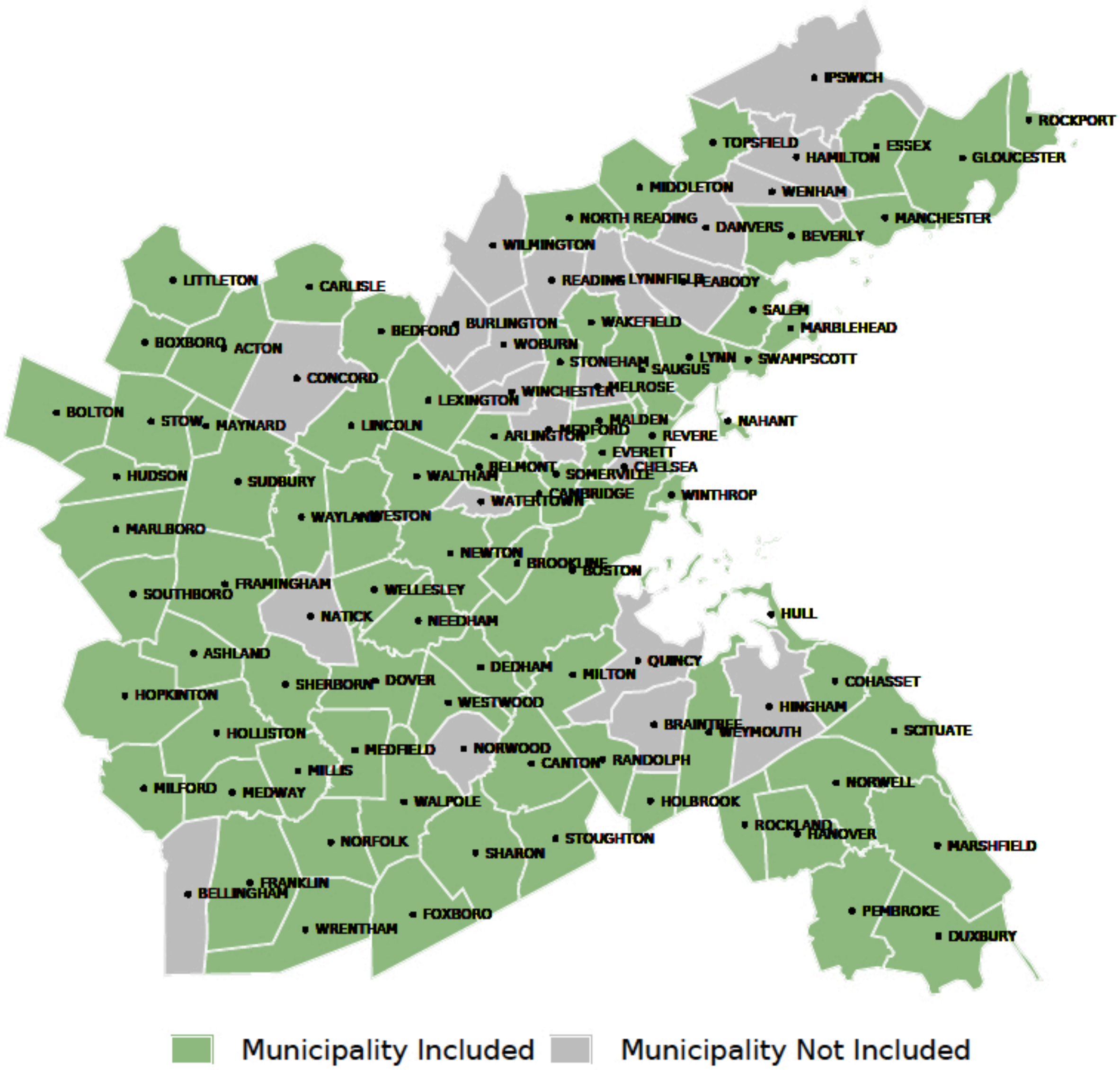
Note: This table presents the results from an OLS regression of Equation 1 where the dependent variable is either log of annual owner cost of housing or annual rent. Controls are boundary fixed effects and year fixed effects. Standard errors are clustered at the boundary level. Only MF are boundaries 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.

Table A4: 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		-0.029		-0.022		-0.092	
		(0.027)		(0.017)		(0.014)	
Height (H)			0.003				0.001
			(0.009)				(0.006)
DUPAC (DU)	-0.001	-0.003	-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)				(0.001)
N	172,422	124,440	135,421	49,723	769,845	304,643	129,562
$\mathbb{E}(y)$	$1,076	$1,026	$1,007	$1,821	$2,133	$1,713	$1,455
R^2	0.659	0.691	0.714	0.783	0.807	0.825	0.893

Note: This table presents the results from an OLS regression of Equation 1 where the dependent variable is either log of annual owner cost of housing or annual rent. 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.

Figure A.1: Our Sample: Towns Included in Analysis



Municipalities were 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.

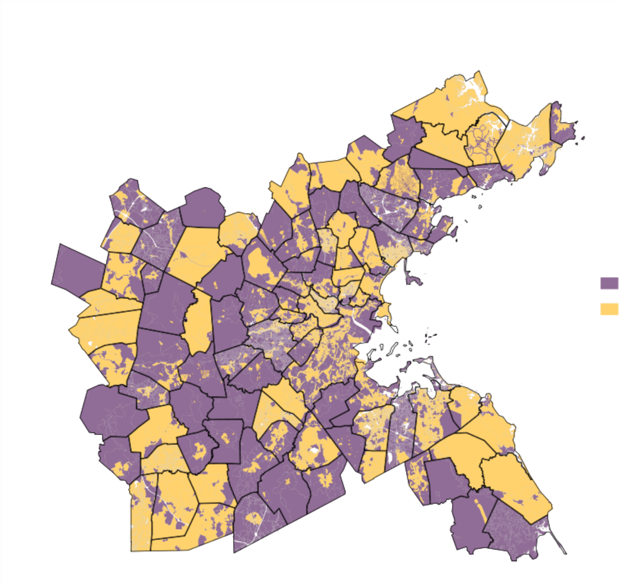


Figure A.2: Multi-Family

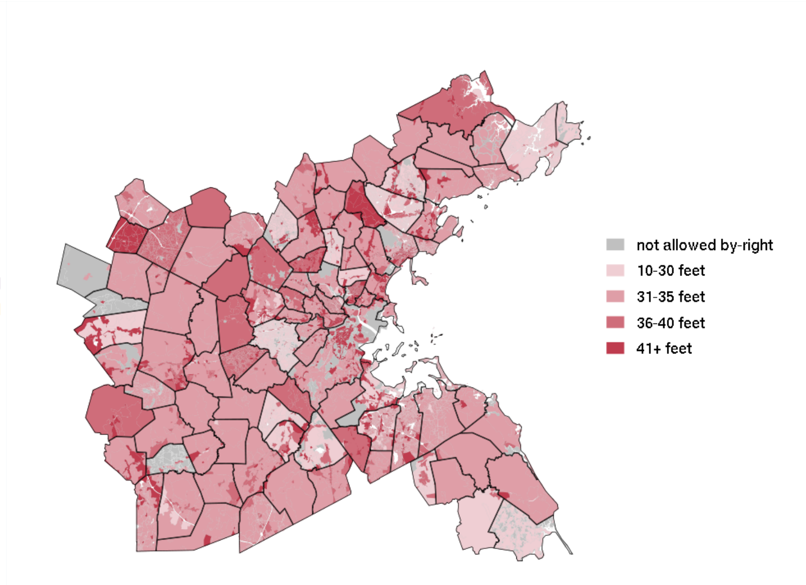


Figure A.3: Maximum Height

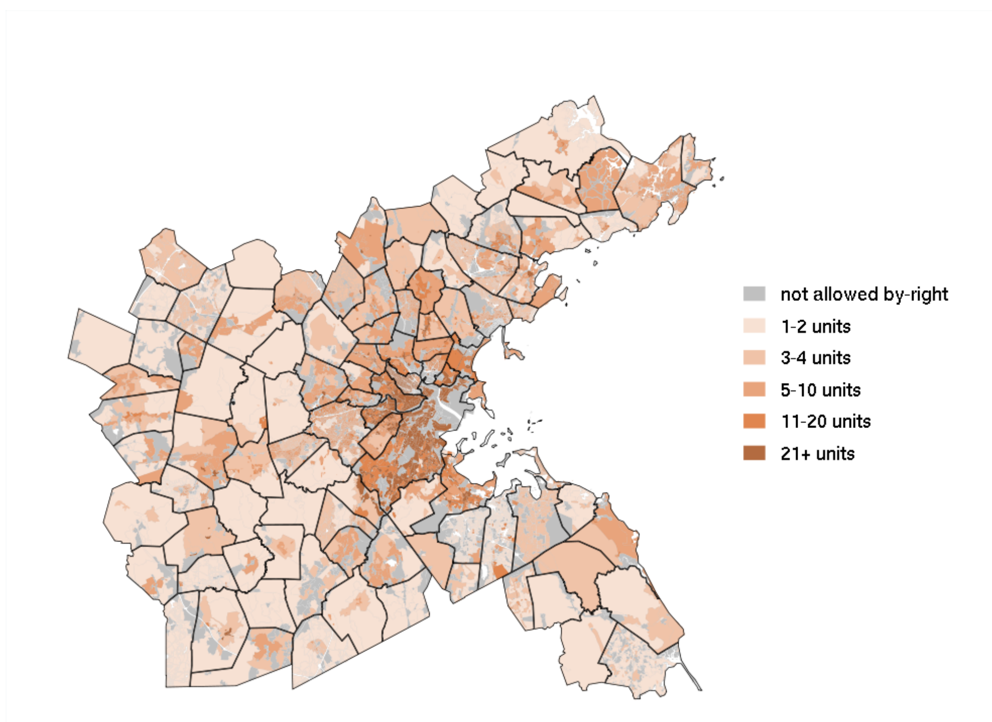
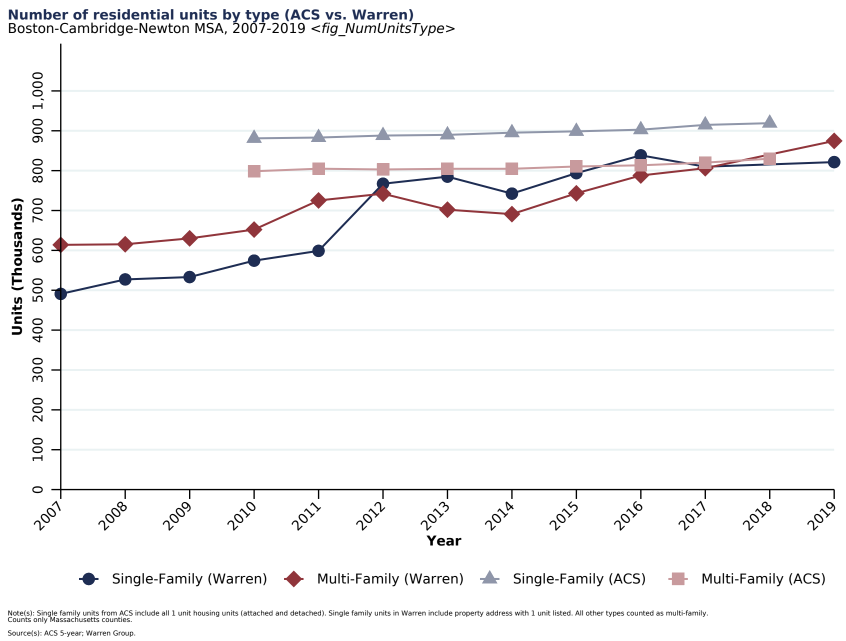


Figure A.4: Dwelling Units per Acre

Multifamily allowed includes areas where multifamily construction is allowed generally or with special-permit. Maximum height and DUPAC indicate the maximum building height and density allowed in an area.

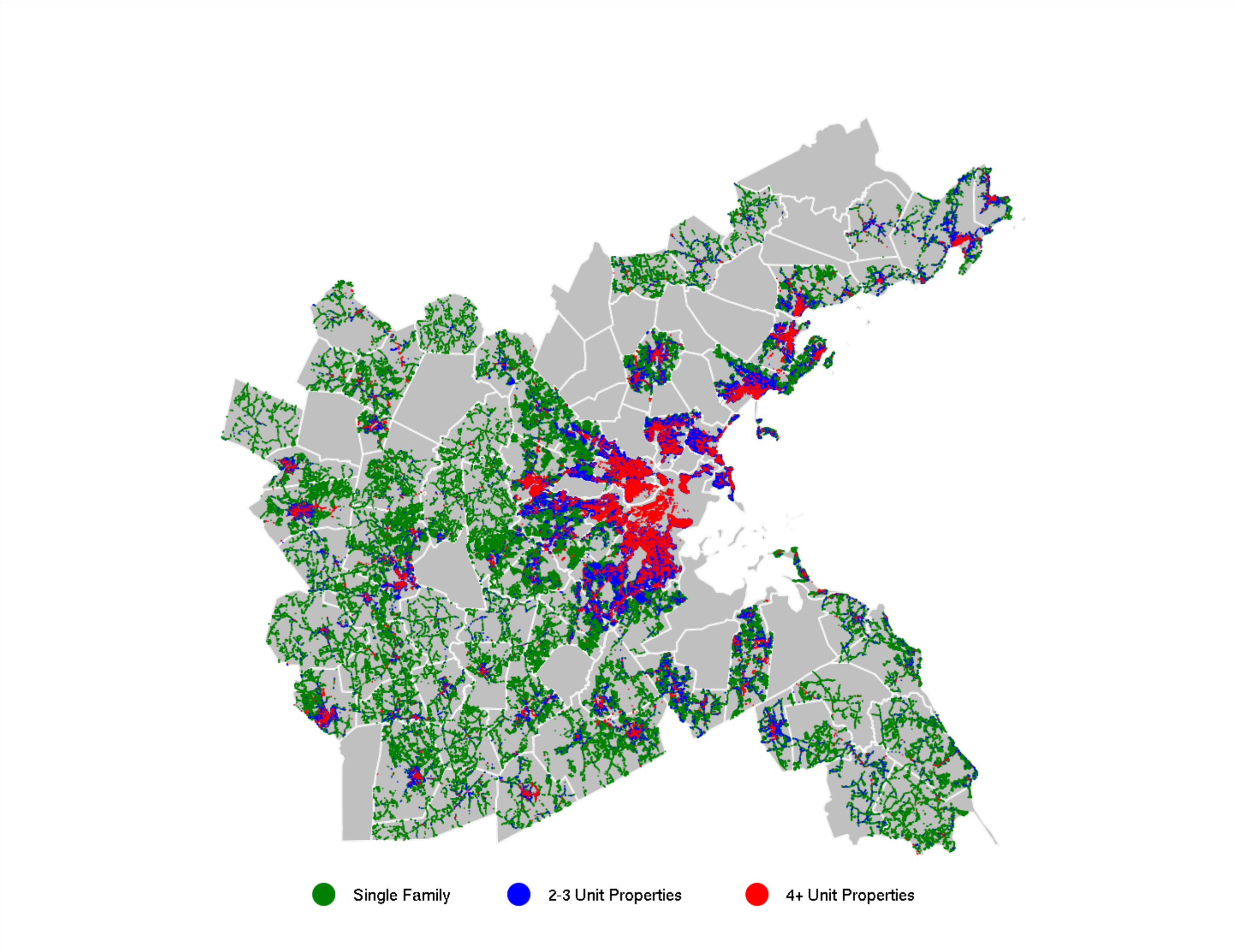
B. Data Appendix

Figure B.1: Total Units by Housing Type: Warren Group and ACS



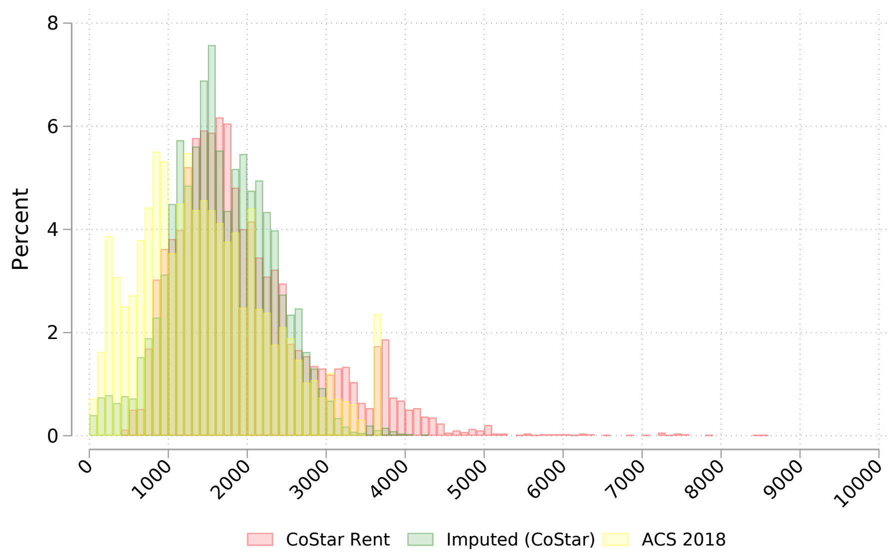
Single family units from ACS include all 1 unit housing units (attached and detached). Single family units in Warren include property addresses with 1 unit listed. All other types counted as multi-family. Counts only Massachusetts counties.

Figure B.2: Housing types over space

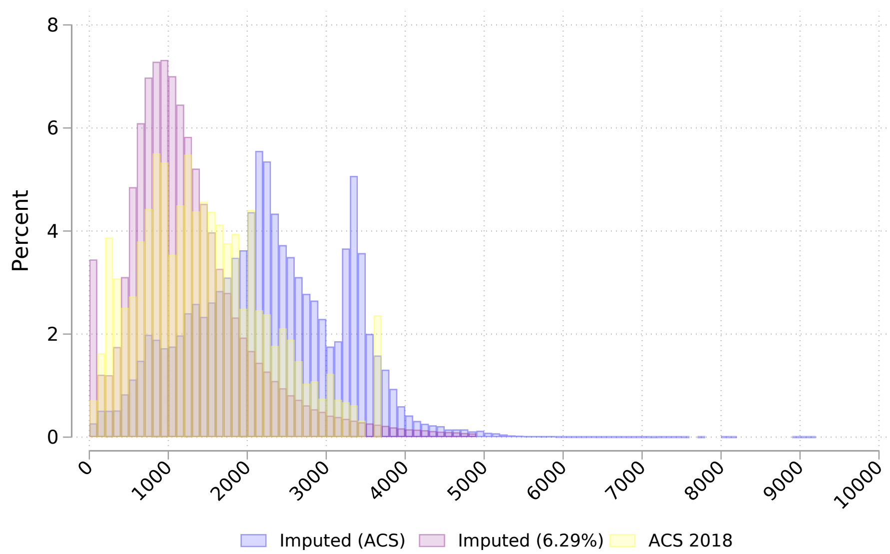


Single-family properties are those classified as single-family on their 2018 tax assessment record. Two-to-three and four plus unit properties are those classified as such on their tax assessment record, or mixed use or other residential properties with two-to-three or four or more units.

Figure B.3: Rent Imputation



(a) CoStar Imputation



(b) BLS and ACS Imputation

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