Regulating housing quality: evidence from France*

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Abstract

I provide quasi-experimental evidence that housing quality regulations can raise costs and reduce quantities, but also foster endogenous market segmentation. Since 1977, French law imposes minimum standards on new home construction, only above a size threshold. Using exhaustive data on building permits, I evidence that the cost of new construction jumps at the discontinuity. In turn, quality standards distort the distribution of quantity choices: the size of new homes bunches below the time-varying regulatory notch. Nonetheless, a substantial number of households are either unaffected, or comply with the policy by distorting quality decisions, in line with the predictions of a structurally estimated model with two-dimensional preferences for quality and quantity. Homeowner demographics, dwelling features, and spatial location decisions are all discontinuous at the threshold, implying that size-dependent regulations induce heterogeneous households to sort across fragmented sub-markets.

JEL codes: R52, R21, R38.

Keywords: housing demand, bunching, building codes, quality standards.

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1 Introduction

Households in advanced economies dedicate a steadily rising share of their budget to housing. This "affordability crisis" has led to calls for relaxing regulations perceived as hindrances to new development. However, ensuring that new dwellings, while abundant, remain of high enough caliber, requires walking a fine line between loosening *quantity* restrictions and maintaining *quality* standards. Demonstrating this tension, when releasing his Housing Supply Action Plan in 2022, President Joe Biden stated: "*the best thing we can do to ease the burden of housing costs is to boost the supply of* quality *housing*".[1] Similarly, in the UK, the Prime Minister's Long-Term Plan for Housing committed to "*transformational plans to supply* beautiful, safe, decent *homes in places with high-growth potential*".[2]

Academic research (Hsieh and Moretti, 2019; Glaeser and Gyourko, 2018) and policy analyses (Yglesias, 2012; Dougherty, 2020) often focus on zoning regulations restricting the *quantity* of new housing construction. By contrast, regulations regarding housing *quality*, and the trade-offs they face when households respond at both the intensive and extensive margins, have mostly been ignored. This blind spot owes to the fact that quantifying the relevance of such rules is complex. Terms like "neighbourhood character", "quality standards" or "aesthetic mandates" abound in building codes, but often do not have a measurable counterpart to credibly estimate the sensitivity of demand or costs to quality constraints.

In this paper, I take advantage of sharp *quantitative* variation in *quality* regulations, to estimate their effect on housing production costs, the demand for living space, the spatial sorting of heterogeneous households, and welfare. In France, since 1977, filers of permits for single-family homes are required to hire a licensed architect to prepare and certify the plans to erect or modify any dwelling. The stated aim of the rule is to ensure that only aesthetically pleasing, durable, and safe new housing is built. Individual households, however, can be exempted from the constraint, whenever the floor area of their new homes – or the post-improvement size, for extensions – does not exceed a specific "Architect Requirement Threshold" (*ART*). This quasi-experiment exposes construction projects varying only

[1] White House briefing (President Biden Announces New Actions to Ease the Burden of Housing Costs), May 2022, emphasis added.

[2] UK government news briefing, Long-term plan for housing, July 2023, emphasis added.

slightly in size to distinct quality regulations, creating incentives to bunch the physical size of units below the *ART*. I leverage this discontinuous variation to shed light on the consequences of quality regulation for costs, consumption, and spatial sorting by household type. I show that, beyond local distortions, size-dependent regulations act as a focal point and lead to a full segmentation of sub-markets by quality level, when agents have heterogeneous tastes for both quantity and quality.

I start by developing a framework extending the bunching approach when customers have two-dimensional preferences for quantity and quality. Because some households value architect services, the requirement to use them above a certain size is not a pure tax notch (Kleven and Waseem, 2013), and could affect both quality and quantity decisions. First, picking a home size just below the threshold allows consumers with the lowest tastes for quality to circumvent architect fees, at the cost of deviating from their preferred quantity. Second, households far above the threshold may over-consume quality to comply with the regulation, rather than suffer large quantity distortions. In addition, the two-dimensional approach rationalizes the presence of households immediately above the notch by strong enough tastes for quality, rather than commonly used "adjustment frictions" (Kleven, 2016). Leveraging exhaustive administrative data covering private construction projects in France from 1973 to 2019, I then exploit the implementation and subsequent reforms of the *ART* to test key predictions of the model and evidence four main reduced-form results.

First, the realized average cost of construction jumps upwards at the size threshold. Regression discontinuity estimates, while not entirely interpreted as causal in the presence of sorting, imply that housing costs for structures are on average 8 to 10 percentage points higher for houses with a size slightly above the architect requirement trigger, relative to those just below. This implies that the minimum quality standard is binding for at least some households, since complying with the architect mandate raises construction costs for consumers. This jump in *average* price per square meter creates a large implied marginal cost premium associated with exceeding the size threshold. Land costs – but not lot sizes – are also discontinuously higher above the threshold, due to spatial sorting by quality choice.

Second, there is stark bunching in the distribution of dwelling sizes immediately below

the regulatory threshold. An excess mass of houses with a size just below the *ART* only appears after the implementation of the threshold at 250 square meters in 1977, and especially following its tightening to 170 square meters in 1979. This rules out explanations based on time-invariant salient round numbers or technological constraints in construction. The missing mass above the threshold grows over time, suggesting a gradual unraveling of the large homes market segment. Households also quickly respond to variation in rules: when a change in the square footage measurement in May 2012 reduced the effective stringency of the mandate, bunching declined in magnitude. Conversely, after the *ART* was lowered to 150 square meters in March 2017, bunching quickly moved strictly below the new exemption level, with its absolute magnitude rising substantially. The evolution of the *ART* over time allows me to estimate the counter-factual distribution either with a non-parametric fit from "placebo" years. Using this difference-in-bunching approach, I find an economically substantial bunching mass of about eight times the counter-factual density immediately above the *ART*, a conclusion robust to the use of alternative estimation strategies, including traditional polynomial estimates of the counter-factual density. While bunching is considerable, the large marginal cost increase implies reasonable reduced-form elasticities.

Third, I use the richness of my data to examine the mechanisms underlying the response to the quality regulation. Households respond both at the extensive and intensive margins. An increased stringency of the threshold is associated with an overall decrease in construction, and in architect business activity. Extension projects for existing houses, which face complex interlocked regulatory notches, are commonly downsized to prevent triggering the requirement, or to entirely avoid filing for a building license. They are frequently not undertaken altogether for units with an initial floor area close to the limit. The considerable fraction of households locating immediately above the *ART* implies that some "always-takers" value architect services at or above cost, thus remaining unaffected by the rule. I estimate however that only a small share of "complier" households further above the threshold abide by the regulation by distorting their quality choice rather than quantity.

Fourth, household characteristics, dwelling features, and spatial location decisions all jump discontinuously around the threshold. Younger agents, and those in lower income occupations, are more likely to bunch below the threshold, a fact I attribute to their higher marginal utility of income and lower value of time, relative to the perceived benefit of em-

ploying architect services. Homes that bunch below the *ART* also locate in municipalities with more construction overall, and a higher share of bunchers among neighbors, suggesting the presence of production complementarities and a stronger local willingness to accommodate standardized projects. On the other hand, consistent with the model's predictions, "always-takers" houses remaining just above the size threshold – thereby revealing a high valuation for architect services – face more idiosyncratic complexity, are less likely to be part of homogeneous joint development projects, take longer to finalize, and are more often used as second homes by long-distance owners. They also locate in more expensive municipalities with better amenities, higher average incomes, and more inequality.

Finally, I structurally estimate the model to match the distribution of quality and quantity choices in the data. I evidence a substantial welfare loss for households with counter-factual choices immediately above the threshold, and a significant aggregate decrease in the consumption of living space owing to the regulation. Overall, the architect requirement leads to a misallocation of housing consumption across families and locations; to a potentially regressive transfer of rents away from less sophisticated households, and towards higher-income professionals; and to a broad-based segmentation of housing markets by quality, without immediate evidence of substantial positive external effects.

Contribution to the literature This paper relates to two distinct strands of research. First, it adds to a growing body of work on the consequences of housing regulation — reviewed in depth by Gyourko and Molloy (2015). Rules like minimum lot sizes or maximum floor-area ratios constrain the provision of housing. Their varying stringency over time and across places is widely thought to affect how easily new construction responds to increasing demand (Ihlanfeldt, 2007; Glaeser and Gyourko, 2018).

Credible causal evidence on their impact, however, has been surprisingly hard to obtain. First, data on regulation stringency are scarce and rarely harmonized. A few exceptions include local regulatory information in England (Hilber and Vermeulen, 2016), and across US metros (Gyourko, Hartley, and Krimmel, 2021). Second, building rules are not randomly assigned. They are the byproduct of local or national political economy processes, which coincide over time and across locations with determinants of housing demand and sup-

ply, blurring the estimation of their causal impact (Davidoff et al., 2016). My paper makes progress on this identification issue, by exploiting a sharp dwelling-level discontinuity in regulations between houses that are comparable, but for the fact that their square footage places them on either side of a legal threshold.[3] This allows me to provide, to the best of my knowledge, the first direct evidence on the *intensive margin* response to regulation, for homeowners who build new houses, and to document the spatial sorting consequences of housing quality requirements.

On the other hand, this paper is connected to a broader research agenda exploring the welfare consequences of size-dependent regulations. Distortions implied by size-contingent rules exist in the labor (Gourio and Roys, 2014; Garicano, Lelarge, and Van Reenen, 2016), product (Bachas, Jaef, and Jensen, 2019), and input markets (Chen et al., 2021). Two studies – on the conforming loan limit by DeFusco and Paciorek (2017), and on the mortgage interest tax deduction by Hanson (2020) – adopt a bunching approach to quantify borrower choices driven by discontinuous variation in interest rates in the US mortgage market. While my design also relies on bunching, I study the effect of regulations on the physical size of new units, rather than the amount of borrowing. Unique data on housing permits directly demonstrate a real quantity response for housing space, and allow me to explore the underlying mechanisms of sorting. Methodologically, my model with two dimensions of preferences (one continuous and one discrete) speaks to recent advances in the bunching literature (e.g. Cox, Liu, and Morrison (2021)). Using changes in the level of the notch to identify "bunchers", "always-takers", and "compliers" with the regulation relates to the welfare effects of changing notches for transfer programs (Bergstrom, Dodds, and Rios, 2022). A recent strand of literature adapts bunching designs to study size-dependent, or "attribute-based", regulations, for energy efficiency (Ito and Sallee, 2018), government procurement (Carril, 2019), or financial disclosure (Ewens, Xiao, and Xu, 2021). I provide novel evidence that such discontinuous size-dependent rules can foster a complete segmentation of the market, and the threshold acts as a focal point that divides sub-markets by quality level.

[3]Recent quasi-experimental work on the response to built-area-ratios or minimum lot sizes in the US (Brueckner and Singh, 2020; Song, 2021), Brazil (Anagol, Ferreira, and Rexer, 2021) and China (Tan, Wang, and Zhang, 2020), relies on spatial discontinuities at the boundary between jurisdictions. The size-based quality regulation I study operates across units along the intensive margin choice of housing quantity.

2 Institutional background and data

2.1 Institutional setup

The architect requirement threshold In France, building licenses (henceforth, BL) for new residential or commercial construction are granted by a town's urban planning office. The construction of new units, as well as the extension of existing ones, must comply with a wide array of constraints, including a maximum square footage built per acre of land, minimum parking requirements, or energy efficiency mandates.

Among the most salient regulations is a 1977 law[4] requiring households filing for a building license to resort to the services of a government-certified architect[5] for the construction or modification of any building. The official motive for the architect mandate was to ensure minimal quality standards in the housing stock and maintain "neighbourhood character".

Individuals however are not mandated to use an architect for a unit with a square footage below $\bar{h}$, the architect requirement threshold (*ART*). The justification for "attribute basing"[6] – i.e. only applying the architect mandate if dwelling size falls above a discrete threshold – could be twofold: efficiency, or equity. On the one hand, under a universal architect mandate, compliance costs may be high for small houses: a desire to minimize these costs could provide a rationale for the size-based exemption. Alternatively, households building smaller houses may have lower incomes, and the exemption could then be motivated by distributional motives.

The exemption level $\bar{h}$ was first set at 250 square meters (c. 2,700 square feet) in January 1977. Starting October 15$^{\text{th}}$, 1979, it was reduced to 170 square meters (c. 1,850 square feet), a threshold that remained in force until March 1, 2017. The square footage definition used for the *ART* changed several times since 1977. From January 2007 to March 2012, the relevant area was labelled the *SHON*, an acronym standing for *Surface Hors Oeuvre Nette*, or "Net Area of Outside Structure". It included the floor area of all covered and enclosed spaces,

[4] Article 3 of the January 3$^{\text{rd}}$, 1977 law n. 77-2 on Architecture.

[5] Architects in France receive a degree from certified schools and universities, allowing them to use the title of "Government-recognized degree-holding Architect" (*Architecte DPLG*) until 2007. Since 2007, they must be affiliated with the Order of Architects, a government-sanctioned professional guild.

[6] Ito and Sallee (2018) define "an attribute-based regulation" as one that "aims to change one characteristic or behavior [...] (the "targeted characteristic"), but [...] takes some other characteristic or behavior (the "secondary attribute") into consideration when determining compliance".

starting from outside external walls, with only the exceptions of indoor parking spaces, and top floors with a ceiling lower than 1.8 meter (5 feet and 11 inches). The *SHON* allows for a 5 percent flat deduction to the square footage thus calculated. The post-2007 period thus constitutes the core sample for my analysis of bunching below the ART.

The 2012 change in square footage definition In 2012, as part of its climate strategy, France implemented new regulations in the residential construction sector, a leading consumer of energy. To encourage better housing insulation, the government adjusted the computation of square footage used in all urban planning regulations. The "floor area", or *Surface de Plancher* (henceforth, *SDP*), replaced the *SHON* after March 1, 2012. The *SDP* computed floor area starting from the *inside* of external walls, unlike the *SHON*, which started from the *outside* of the structure. The objective was to stop penalizing building materials with better insulation properties: houses using thicker walls to lower energy consumption and emissions would no longer need to reduce *indoor* space to meet planning requirements. Appendix figure A.1 compares the two measures: due to the exclusion of external walls, the *SDP* was generally c. 10 percent smaller than the *SHON*, and an *SDP* of 170 sq.m. corresponded to a *SHON* of c. 185 to 190 sq.m. The switch to the *SDP* loosened the architect mandate,[7] by raising the effective quantity of indoor livable space below which an architect was not required.

The 2017 change in the level of the *ART* In 2017, the level of the threshold was lowered to 150 square meters of *SDP*. The stated objective was to roughly match the pre-2012 stringency, since an *SDP* of 150 square meters corresponded on average to a *SHON* of 165 to 170 square meters – depending on the shape of the dwelling and thickness of the walls. The dual test was eliminated: only the *SDP* would count towards the exemption level. The 2017 change fostered incentives to distort housing consumption at previously unaffected levels of *SDP*, relative to the situation prevailing since the 2012 reform. I exploit the 2017 adjustment in a difference-in-bunching empirical strategy to assess both the intensive and extensive margin responses to quality regulations.

[7] An additional "dual test" was introduced to take into account the overall footprint of a construction. Appendix A provides additional institutional details on the March 2012 reform and the various adjustments to the computation made from March to May 2012. It also evidences the re-timing of projects prior to March 2012 to front-run additional environmental regulations, unrelated to the architect mandate.

The special case of additions If the size-dependent rule only applied to initial constructions, a simple avoidance strategy to reach a preferred size would involve gradual additions to a project initially below the *ART*. To circumvent project-splitting incentives, additions are also subject to the architect mandate. If the owner of a house of *existing* size h^E expands it by h^N and files a building license, they must use an architect if the completed size is above the *ART*: $h^N + h^E \geq \bar{h}$. This creates incentives to downsize additions, so that the *completed* unit remains strictly below the *ART*, by choosing h^N immediately below $\bar{h} - h^E$.

However, there is no need to file a building license – and thus no architect requirement – when the size h^N of the addition itself is below a "BL threshold", h_{BL}.[8] Before 2012, the BL threshold h_{BL} was 20 sq.m everywhere. It was raised to $h_{BL} = 40$ in urban areas after January 2012, while remaining at 20 in rural areas. This creates incentives to bunch the size of an extension project, h^N, strictly below $\bar{h}$ (20 or 40).[9] Appendix figure C.2 describes the complex interaction of incentives to bunch at either the *ART* or the *BL* threshold, depending on the existing size of the unit and the desired size of the addition. At all existing sizes h^E, there is a strong rationale to build extensions smaller than h_{BL}, in order not to file for a BL altogether. For small enough additions ($h^N < h_{BL}$), there are no incentives to bunch the completed size ($h^C = h^E + h^N$) below $\bar{h}$, and the project requires neither a building license nor an architect. I examine discontinuities in these incentives when assessing the effect of quality regulations on incentives to expand the existing housing stock.

2.2 Data

To evaluate the impact of the regulation on costs, consumption, and segmentation, I use the *Sit@del2* database, an administrative, restricted-access repository containing detailed information on the universe of housing permits requested in France from 1973 to 2022. The data are collected by the French Housing Authority and include details about the exact date, location, and characteristics of units built, for each approved and rejected construction project

[8] The architect mandate can only apply to projects for which a *building license* (BL) is required, and only construction projects with a square footage larger than h_{BL} square meters must obtain a BL. Construction projects below 5 square meters require no formal registration. Construction projects larger than 5 square meters, but below h_{BL}, are allowed to use a tacit approval expedited processing method, the *Declaration prealable* or "Pre-registered Statement" (PS), instead of a BL.

[9] In the $20 \leq h^N < 40$ interval, an architect was still mandatory in urban areas, if (i) the initial square footage h^E was less than the *ART* h^* and (ii) the addition would push the complete footage $h^E + h^N$ above h^*.

in the country. I restrict the sample to single-family residential units. On average, over the 2010-2019 decade, the *Sit@del2* database counts around 130,000 authorized new housing units every year, and 165,000 approved extension projects for existing dwellings units.[10]

I focus on the 2007-2011 period to analyse the 170 square meters of *SHON* threshold; on the 2013-2016 period for the post-2012 computation (*SDP*) 170 square meters threshold; and on the 2018-2022 period for the consequences of the reduction of the *ART* to 150 square meters of *SDP* in 2017. In robustness checks, I also exploit 1973 to 1985 data to study the implementation of the threshold at 250 square meters in 1977 and its modification to 170 in 1979.

The *Sit@del2* database provides information on the timing and processing of construction projects, as well as some additional details on the exact geo-location of the projects, which allows me to match each project to ZIP code-level demographics from a variety of sources, including Census, Treasury, and transactions (*DV3F*) data. However, a key limitation in the data is the absence of pricing information or detailed household demographics. I therefore complement the data with project level micro-data from two annual surveys. First, I use the EPTB survey[11], which is exhaustive since 2010, and includes information on the decomposition between land and structure prices for all new single-family unit building projects, in order to assess the extent of the cost jump associated with building units with a size above the architect requirement threshold. Second, I use the PRLN survey,[12] in which a random sample of individual building licenses drawn from the *Sit@del2* database are surveyed every year to obtain more detailed information on the duration and nature of construction projects they correspond to, as well as additional household demographics.

[10] Other building licenses in the sample correspond to small modifications of the exterior aspect of houses, or to commercial, industrial, or agricultural building projects. Only individuals who build a home for their own dwelling purposes or destined to be leased can be exempt from the architect mandate below the ART. Corporations and other juridical persons are required to use the services of an architect for the construction or modification of any building, independently of its square footage. Agricultural constructions benefit from a higher threshold, and both are excluded from the main analysis sample.

[11] *Enquete sur le Prix des Terrains a Batir* or Survey on the Price of Buildable Land.

[12] *Enquete sur le Prix de Revient des Logements Neufs* or Survey on the Cost of Newly Built Dwellings. In particular, this survey is used to build nationwide indices of construction costs for rent controls.

3 Conceptual framework and research design

3.1 A model of the housing quality-quantity trade-off

I develop a pared-down model of housing consumption involving a continuous *quantity* decision (how much livable space to purchase), and a discrete *quality* choice (whether or not to use an architect), under potential regulatory frictions. I test its qualitative implications for dwelling sizes and household sorting in section 4, before structurally estimating a parameterized version to analyse welfare and counter-factual rule changes in section 5.

Behavior under laissez-faire An agent consumes a quantity h of housing, at user cost p_H, and a composite basket of other goods c (the numeraire). They also make a binary quality choice: using the services of an architect ($A = 1$) or not ($A = 0$), at the cost of a fixed fee F.[13] If they do, they receive an idiosyncratic taste shock corresponding to their own valuation of architect-built units. Households have income y, and maximize utility (parameterized by a vector of tastes for quantity and quality Θ):

$$max_{h \in \mathbb{R}, A \in \{0,1\}} u(c, h, A, \Theta) \text{ subject to } c + p_H \times h + F \times A \leq y \tag{1}$$

Under laissez-faire – denoted with superscript x^L – each household computes optimal quantity choices conditional on architect use, then compares the indirect utility when using an architect $v^{L,1}(y, p_H, F)$ to their maximized utility at optimal choices without one $v^{L,0}(y, p_H)$:

$$A^L = \text{argmax}_A \left[v^{L,A=0}(y, p_H), v^{L,A=1}(y, p_H, F) \right]$$

$$h^L = A^L \times \text{argmax}_h u(c, h, 1, \Theta) + (1 - A^L) \times \text{argmax}_h u(c, h, 0, \Theta)$$

Given un-distorted choices $\left(h^L, A^L\right)$, the distribution of tastes Θ gives rise to a (counter-factual) density of *quantity* choices summing vertically the marginal densities for architect

[13] This premium is modelled as a fixed additional fee, leading to an increase in average costs starting from the first euro of housing consumption, to relate closely to the empirical findings of my study.

users and non-users, as in the left panel of figure C.1:

$$g^L(h) = g^{L,0}(h) + g^{L,1}(h)$$

Household choice with quality regulation I then introduce a rule (with choices indicated by superscript x^R) requiring households consuming more than $\bar{h}$ to use an architect. The new – constrained – household problem is (1), subject to an attribute-based quality standard:

$$A \geq \mathbb{1}[h > \bar{h}] \tag{2}$$

The table below summarizes the incentives faced by households of various types, given their counterfactual choices. Households with a high taste for quality ("always-takers") use an architect ($A^L = A^R = 1$) even absent the regulatory constraint (2), and are thus left unaffected by the regulation, whether or not they consume more than $\bar{h}$. Without the constraint, "never-takers" households consume a quantity of housing strictly below the threshold ($h^{L,0} < \bar{h}$) and do not resort to an architect ($A^L = 0$). Thus their choices are also undistorted: the previous decision remains *a fortiori* optimal under the regulation ($h^{R,0} < \bar{h}$ and $A^R = 0$).

		Quality choice absent regulation	
		Architect	No architect
Quantity choice absent regulation	Above $\bar{h}$	*No effect* (always-takers)	*Distort quantity* (bunchers) / *Distort quality* (compliers)
	Below $\bar{h}$	*No effect* (always-takers)	*No effect* (never-takers)

Summary of incentives relative to counter-factual choices absent regulation

The only group directly affected[14] are households with counter-factual choices $A^L = 0, h^{L,0} > \bar{h}$ in the upper-right quadrant of table **??**. When re-optimizing subject to 2, agents with a sufficiently high valuation for quality ("compliers" with $\Theta \in C$) consume an interior

[14] I abstract from any potential general equilibrium effects – such as regulation-induced variation in the cost of architect services – on groups not directly affected by the requirement.

amount $h^I \geq \bar{h}$ above the threshold but now use the services of an architect $A^R = 1 \neq A^L$, distorting *quality*. Alternatively, affected agents with a lower valuation of quality ("bunchers" with $\Theta \in B$) distort housing *quantity* by bunching consumption immediately below the regulatory notch ($h^R = \bar{h}$), to remain exempt from the mandate $A^R = 0 = A^L$ while remaining as close as possible to their preferred quantity.

The *actual* density of housing *quantity* choices with the regulation, $g^R(h)$, is then:

$$g^R(h) = g^{R,0}(h) + g^{R,1}(h)$$

In the absence of extensive margin responses (households exiting the market for new homes), choices strictly below the notch ($h < \bar{h}$) are undistorted and equal to the counter-factual distribution, both with and without an architect:

$$g^{R,0}(h) = g^{L,0}(h), g^{R,1}(h) = g^{L,1}(h) \text{ for } h < \bar{h}$$

At the notch ($h = \bar{h}$), the density of architect users equals the counter-factual density of users:

$$g^{R,1}(\bar{h}) = g^{L,1}(\bar{h})$$

On the other hand, at $\bar{h}$, the density of non-users is equal to the sum of counter-factual non-users $g^{L,0}(\bar{h})$, and the number of bunchers (with parameter vector Θ in B):

$$g^{R,0}(\bar{h}) = g^{L,0}(\bar{h}) + \int_{\Theta \in B} \int_{\bar{h}}^{+\infty} g_{\Theta}^{L,0}(h) dh d\Theta$$

Above the notch ($h > \bar{h}$), the density of non-architect users is $g^{R,0}(h) = 0$ by construction. The density of users now also potentially includes compliers who did not bunch:

$$g^R(h) = g^{R,1}(h) = g^{L,1}(h) + \int_{\Theta \in C} g_{\Theta}^{L,0}(h) d\Theta \geq g^{L,1}(h) \text{ for } h > \bar{h}$$

Appendix figure C.1 graphically describes the laissez-faire and actual distributions of dwelling sizes. The average price of housing services increases discontinuously at the notch: while all households above the threshold pay unit price $p_h + \frac{F}{h}$, the average price immediately below

the notch is $\lim_{h \to \bar{h}^-} p_h(h) = \frac{(p_h + \frac{F}{\bar{h}}) \times g^{L,1}(\bar{h}) + p_h \times (g^{L,0}(\bar{h}) + B)}{g^R(\bar{h})}$ where B is the bunching mass.

3.2 Bunching estimation

This framework suggests that, under an attribute-based regulation, the behavior of the overall density around the notch can be used to reveal both the reaction of *bunchers* (at the quantity threshold), and of non-bunchers, who are either undistorted *always-takers*, or who distort their quality decision to *comply* with the rule. Intuitively, the density at the threshold (relative to the counter-factual) measures the number of bunchers; the behavior of the density immediately above the threshold helps estimate the number of always-takers; and the density further to the right of the notch is informative about compliers.

To estimate the size of these responses at the regulatory notch, I compare the counts of new homes with a square footage of h square meters, $N(h)$, to an estimate of the counterfactual distribution $\hat{N}(h)$ that would be realized in the absence of discontinuities in the budget set. I use two different estimates of this counter-factual distribution.

Polynomial approach The first standard methodology relies on a polynomial approximation of the density outside the manipulation range (Chetty et al., 2011). I restrict the data to all new housing projects with a square footage above 40 square meters, and below 400 square meters, from 2013 to 2016.[15] I regress counts of projects in each 1 square meter bin of *SDP* on a K-order polynomial of the floor area, and fit the observed distribution, excluding the manipulation range (corresponding to units with a square footage between h_L and h_U), and including an indicator for bunching at round and salient numbers in the (potentially

[15] This corresponds to close to 500,000 distinct approved housing projects. The time frame restriction ensures a consistent computation of the square footage – the *SDP* – was used throughout. The exclusion of projects below 40 square meters selects homes with a building license throughout the 2013-2016 period, since new units with a floor area below 40 square meters were not required to file for a BL in urban areas. Due to rounding in the underlying data collection process, the area of a project is available at 1 square meter bin frequency.

empty) set S_t outside the manipulation range[16]:

$$N(h) = \sum_{k=0}^{k=K} \beta_k h^k + \sum_{i=h_l}^{h_u} \delta_i \mathbb{1}(h = i) + \theta_t \mathbb{I}\{\frac{h}{t} \in \mathbf{N}\} + \epsilon_h \tag{3}$$

The predicted distribution from the polynomial regression, excluding the contribution of dummies for the bins in the manipulation range, provides a hypothetical counterfactual $\hat{N}^{\text{Poly}}(h) = \sum_{k=0}^{K} \hat{\beta}_k h^k + \theta_t \mathbb{I}\{\frac{h}{t} \in \mathbf{N}\}$. Bunching is then defined as the excess mass below the regulatory notch

$$B(\bar{h}) = \sum_{i=h_L}^{\bar{h}} N(h) - \hat{N}^{\text{Poly}}(h)$$

As is customary in the bunching literature, and given the graphical starkness of bunching, I obtain h_L by visual inspection as the first point where the slope of the density switches from negative to positive under the notch, and the upper bound of the bunching interval h_U is defined to minimize the difference between the resulting missing mass of units above the notch and the bunching mass below it. Standard errors are obtained using the bootstrap procedure described in Chetty et al. (2011).

Difference-in-bunching approach In the second approach, I rely on reforms of the notch over time. I study bunching at 150 sq.m, after the 2017 reform lowered the threshold. When the regulation was located at the higher 170 sq.m ART, the mass at 150 sq.m was undistorted (and composed of a mix of always-takers and never-takers). The smoothness of quantity choices around the 150 notch in "placebo" years evidences the distortion in housing consumption, and enables the construction of a counterfactual distribution, $\hat{N}^{\text{Placebo}}(h)$. Specifically, in order to measure bunching in the post-2017 reform period at the 150 sq.m of *SDP* mark, I use the 2013-2016 distribution around 150 square meters as a counterfactual. To allow for time trends in overall new construction, I re-scale the counter-factual counts so that the total number of units below 140 square meters is similar in the pre- and post-reform periods. Formally, I rescale counter-factual relative frequencies from 2013-2016 to match the

[16]The set of round and/or salient numbers $S_t = \frac{h}{t} \in \mathbf{N}$ is empty in the baseline empirical application, and includes multiples of 10 square meters in robustness checks. I selected the degree of the polynomial to be 9 to optimize the Akaike Information Criterion, and vary the polynomial order and upper bound h_U in robustness exercises.

2018-2019 total counts:

$$\hat{N}^{\text{Placebo}}(h) = \frac{N^{\text{Pre}}(h)}{\sum_{h' \leq 140} N^{\text{Pre}}(h')} \times \sum_{h' \leq 140} N^{\text{Post}}(h') \tag{4}$$

and estimate bunching $B(\bar{h}) = \sum_{i=h_L}^{\bar{h}} N^{\text{Post}}(h) - \hat{N}^{\text{Placebo}}(h)$ as the excess mass of units immediately below 150 in 2018-2019, relative to the predicted counts of units in this region obtained from the 2013-2016 relative frequencies.

I use estimates of the bunching mass $B(\bar{h})$ obtained with either the cross-section (equation 3) or placebo notch approach (equation 4). Then, under the standard assumption that the distribution $g^{0,N}(h)$ of counter-factual choices for non-architect using households would be smooth around the threshold absent the policy, bunching immediately below the notch provides evidence of responsiveness to the regulation, and allows me to quantify the magnitude of the marginal response. In particular, I can estimate the point in the counter-factual distribution of choices where the average marginal buncher comes from, based on the extent of bunching at $\bar{h}$:

$$B(\bar{h}) = \int_{\Theta \in B} \int_{\bar{h}}^{\bar{h}+\Delta h(\Theta)} g_{\theta}^{L,0}(h) dh d\Theta \simeq \int_{\Theta} \Delta h(\Theta) d\Theta g^{L,0}(\bar{h}) \tag{5}$$

where the approximation assumes the conditional density is constant in the interval immediately above the notch.[17] The estimate of $B(\bar{h})$ is computed from the difference between the counter-factual and actual counts of homes strictly below the notch. The remaining difficulty lies in quantifying $g^{L,0}(\bar{h})$ at the notch, since the only estimated object is the aggregate density $g^{0}(\bar{h}) = g^{L,1}(\bar{h}) + g^{L,0}(\bar{h})$. Similar to the "bunching hole" approach of Kleven and Waseem (2013), this requires "grossing up" the estimate of the marginal buncher, Δh, by $\frac{1}{1-a(\bar{h})}$ where $a(\bar{h}) = \frac{g^{L,1}(\bar{h})}{g^{L,1}(\bar{h})+g^{L,0}(\bar{h})}$ is the fraction of "always-takers" households with a high enough taste for quality to use an architect at $\bar{h}$ even absent the regulation (estimated as the fraction of the counter-factual density locating immediately above the notch).

[17] This assumption is relaxed in the empirical application, where I use the downwards-sloping estimated counter-factual distribution above the notch to infer Δh from the observed amount of bunching.

Additions to existing houses I also examine the behavioral response of owners of single-family units who expand existing homes.[18] As explained in section 2.1, they can pick an extension of size h^N so that total size $h^E + h^N$ is strictly below $\bar{h}$; or an extension smaller than h_{BL}, the threshold below which no BL is required. First, I quantify strategies designed to reduce the total area of the unit below $\bar{h}$. I compute the footage of the completed project as the sum of the area of the existing unit, plus any additions, minus any demolitions. Similar to equation 3 for new homes, I examine bunching at the regulatory threshold by regressing the number of extensions with a post-extension area of h, $E(h)$, on a K-order polynomial in h, as well as dummies for counts in the manipulation range from h_L to h_U:

$$E(h) = \sum_{k=0}^{k=K} \beta_k^E h^k + \sum_{i=h_L}^{h_U} \delta_i \mathbb{1}(h = i) + \theta_t \mathbb{I}\{\frac{h}{t} \in \mathbf{N}\epsilon_h \tag{6}$$

As before, the predicted distribution from the polynomial regression (including the contribution of an indicator for bunching at round, salient numbers) constitutes the hypothetical counterfactual $\hat{E}^{\text{Poly}}(h) = \sum_{k=0}^{K} \hat{\beta}_k^E h^k + \theta_t \mathbb{I}\{\frac{h}{t} \in \mathbf{N}$. Bunching then corresponds to the excess mass of extensions below the notch:

$$B^E(\bar{h}) = \sum_{i=h_l}^{\bar{h}} E(h) - \hat{E}^{\text{Poly}}(h)$$

Second, I use a regression discontinuity approach to demonstrate that owners choose to build extensions below the BL threshold, h_{BL}, as an alternative strategy to avoid being subject to the architect requirement. While bunching below the BL threshold might be justified in its own right to reduce hassle costs, incentives to do so change discontinuously due to the ART whenever the existing size of the unit is located between $\bar{h} - h_{BL}$ and $\bar{h}$. Therefore, I estimate $r_{h_{BL}}(h^E) = \frac{f_{h_{BL}}(h^E)}{f_{h_{BL}+1}(h^E)}$, the fraction of extensions with a size immediately below h_{BL} relative to extensions with an area of $h_{BL} + 1$, along the distribution of initial sizes h^E.

[18] Additions only start to be reported exhaustively and consistently in the data after 2008, so I focus on the 2009-2019 time period. The data from 2009 to 2019 contain slightly less than 1.3 million approved extension projects of existing homes with exhaustive data on the square footage of the completed unit and the extension.

4 Reduced-form empirical results

4.1 Cost effects of quality regulations

The first stage of the analysis demonstrates that the construction cost of new units jumps exactly at the architect requirement threshold. Unlike the case of a notched tax, such a cost jump is not a mechanically guaranteed result (since households always have the option to use an architect for any size). Its presence implies the regulation binds for at least some households at the threshold.

Using data on the subset of new home building permits that were part of the EPTB survey to obtain detailed information on project costs, I offer direct evidence that homes with a square footage immediately above the threshold indeed present discontinuously higher construction costs than those immediately below. Figure 1, panel (a), displays the average structure price in each bin of 1 square meter of *SHON*, with a linear fit on both sides of the threshold, for the 2012-2016 period, when the ART was located at 170 square meters of square footage. Panel (b) plots the discontinuity of structure prices at the new ART of 150 square meters for the post-2018 period. In both cases, while costs increase linearly with size on both sides of the policy notch, a visible jump in raw prices occurs exactly at the currently prevailing *ART*, consistent with the regulation raising costs for homes subject to the mandate. Appendix figure C.3 shows that houses on the right-hand side of the threshold appear to cost about 9 log points more than those on the left-hand side of the threshold, a discontinuity representing about 10% of the baseline cost, or 125 EUR out of an average cost per square meter of 1250 EUR on the left-hand side of the threshold. The discontinuous increase in overall construction costs implies high marginal costs for additional space immediately in excess of the threshold: as per the framework of section 3, the regulation can be formalized as a notch. A "flat fee" interpretation is also consistent with the fact that average construction costs per square meter are flat on the left-hand side of the threshold, but exhibit a declining pattern with size on the right-hand side, especially under the 170 sq.m. threshold.

On the right-hand side of the *ART*, an upwards jump is also visible for the cost of land. Appendix figure C.4 documents that the cost of land is about 15 to 20% higher for houses built with a square footage above the threshold (both in the 2012-2016 period above 170 square

meters of *SDP*, and in the post-2018 period above 150), an increase of about 20 EUR/square meter of land over the baseline cost of 120 EUR. Houses on the right-hand side of the threshold also display significantly more dispersion in land costs per square meter. If the cost of the regulation for larger homes was partly capitalized in the price of land, we would expect a *drop* in land prices at the threshold. In contrast, the visible increase suggests that the regulation is likely to not only lead to higher construction costs (as reflected in the cost of structures) as a result of architect fees, but also to a spatial segmentation of the housing market by quality level, across locations with varying underlying land prices, a fact explored further in subsection 4.5.

Finally, additional non-monetary hassle costs can also discourage households from choosing a higher quality level. In particular, I compute the delay between the date of approval of the building license, and the actual starting date of construction works, when available. I show that construction starts systematically longer after the initial approval date for projects that are required to resort to the services of an architect - i.e. those above the *ART*. Appendix figure C.5 documents (for both the 2013-2016 and the post-2018 periods) that delays are systematically longer on the right-hand side of the threshold, consistent with the possible explanation that the mandate to resort to an architect also entails additional non-monetary compliance costs for households. Regression discontinuity estimates, while not directly interpretable as causally linked to the quality choice in the presence of sorting, help quantify this difference: I find an average delay of 22 days (std. err: 6.21) relative to the baseline on the right-hand side of the threshold.

4.2 Bunching response to quality regulation

Having documented a discontinuous jump in costs associated with locating above the *ART*, I then show that the binding *quality* regulation entails substantial *quantity* distortions for the size of newly built units. In particular, I evidence that households respond to higher costs by adjusting the square footage of both new units and additions below the *ART*, in order to circumvent the architect mandate, leading to economically meaningful reductions in the real quantity of livable space they consume.

Descriptive evidence Figure 2 provides separate measures of bunching for selected years in the main analysis sample.[19] The year-by-year panel of histograms demonstrates that the distribution of home sizes was smooth in 1976 immediately before the implementation of the architect mandate. Bunching started to appear at the 250 square meters mark after the regulatory notch was first implemented, in 1977 (the first full year of bunching at 250 square meters occurs for building licenses requests filed in 1978). The excess mass and bunching behavior moves to the 170 square meters level immediately after the notch was lowered in October 1979 (the first full year of bunching at 170 square meters is 1980).

Bunching displays a peculiar pattern over time: while the excess bunching mass remains at a similar magnitude between 1980 and 2000 (with a peak around 1.25% of all units), the missing mass immediately above the threshold increases substantially over the period. Immediately above the notch, the share of homes drop from about 0.5% in 1980 to less than 0.25% in 2000. This suggests a potential long-term unraveling of the market for larger homes subjected to the mandate as of right. A possible explanation relies on the presence of dynamic selection and learning by producers: as the most price-elastic households gradually exit the market for architect services by bunching below the threshold, the remaining households above the notch are known to be less elastic and architects offer higher-markup services, further enhancing incentives to sort below the threshold. Such a dynamic process, reminiscent of Atal et al. (2022), leads to a gradually increasing missing mass above the threshold.

Appendix figure C.6 compares the distribution of the floor area of new constructions built by corporations and other juridical persons over the period 2013-2016, to the distribution for natural persons. As mentioned in section 2, the exemption from the architect mandate below the *ART* only applies to natural persons, not to corporations or other juridical persons. The "juridical persons" distribution (a substantially smaller total number of new constructions) does not exhibit any evidence of bunching in relative frequencies at the $\bar{h}$ threshold, confirming the hypothesis that the excess mass visible among units built by natural persons is indeed driven by the exemption, rather than by alternative institutional constraints, round numbers, salience of the 170 square meters level, or other technological reasons.

[19] The corresponding square footage is expressed in units of the measure applicable at the time; therefore, it corresponds, for example, to the *SHON* from 2007 to March 2012, and to the *SDP* after March 2012.

Polynomial approach I next implement the polynomial approach to estimating the counter-factual distribution described by equation 3. Figure **??** displays counts of homes in bins of 1 square meter in 2013-2016, as well as a polynomial fit of order 9 shown to fit the distribution of housing consumption fairly closely across non-manipulation region choices.[20] The visual depiction of the distribution evidences two main results. First, it exhibits a clearly visible and substantial spike in the immediate lower vicinity of the threshold (among projects with a size from 166 to 169 square meters). Most of the bunching response is concentrated in the 168 and 169 square meters bins. Second, there is a sharp drop or "missing mass" immediately above the threshold, relative to the smoothed polynomial estimate of the counter-factual distribution plotted on the same figure, with convergence between the two series reaching up to 200 square meters.

The bunching mass of about 12,000 units (over four years) hovers around 10% of the counter-factual density at the threshold. As shown in table 1, the exact quantification of bunching is sensitive to the use of alternative polynomial approximations of the counter-factual density. The estimated bunching mass represents from 5 to 13 percent of the counter-factual density (depending on the order of the polynomial and upper limit of the excluded range), motivating a more stable estimation strategy based on the difference in bunching in years with varying levels of the notch.

Placebo notch approach after 2017 As an alternative estimation strategy, I exploit variations in the level of the threshold over time to provide an estimate of the marginal bunching response that is non-parametric and therefore more robust to mis-specification of polynomial fits for the counter-factual density. In particular, I exploit the "placebo notch" approach described in section 3. Appendix figure C.8 plots raw counts of units by size to demonstrate how bunching immediately moved towards the 150 square meters new regulatory notch after March 2017. Bunching at the 170 square meters mark, which was prevalent in 2013-2016, entirely disappears after the change in the level of the threshold. Once again, a stark and

[20] The presence of bunching is also visible in alternative years and sub-samples, when a different definition of the square footage was in force. As an example, pooling together all c. 760,000 building licenses for new housing units approved from 2007 to 2011, appendix figure C.7 displays similar results for a polynomial fit during the 2007-2011 period, under the alternative *SHON* definition of the square footage. The 168 and 169 square meters bins together include around 27,000 new units throughout the period, or more than thirteen times the proportion in the two bins immediately above the notch (at 171 and 172 sq.m).

concentrated excess mass of housing projects is visible in the bins immediately below the new *ART*, and a substantial missing mass appears immediately above the new discontinuity.

As formalized by equation 4, I rescale the 2013-2016 choices of *SDP* to construct a fit of the counter-factual distribution of housing choices that matches the total counts of units in the post-reform time period. Because housing consumption choices were undistorted around the post-reform 150 sq.m. ART in the 2013-2016 period, pre-reform re-scaled counts provide a relevant counterfactual to compute the excess mass immediately below 150 sq.m. of *SDP*. Figure 4 graphically describes the empirical implementation of this alternative identification strategy.[21] Way below the bunching region, over the (likely) undistorted 40 to 130 square meters of *SDP* range, the placebo distribution based on re-scaled 2013-2016 counts matches almost exactly the actual distribution of housing consumption choices in 2018-2019. Excess bunching is very sharp below the post-reform new *ART* at 150 sq.m., and corresponds to more than 10.000 units (over two years) in the two bins immediately below the notch, or close to eight times the counter-factual density to the left of the threshold ($\hat{b} = 7.67$, $s.e. = 0.14$). Reassuringly, the placebo notch approach to estimating the excess bunching mass in the 2018-2019 distribution provides quantitatively similar results to adopting the polynomial fit approach in the post-2017 reform around the new ART of 150 square meters.

Always-takers and compliers The placebo notch approach described in figure 4, exploiting the switch from an *ART* of 170 to 150, allows for two additional considerations. First, a substantial number of households locate immediately above the *new* notch of 150 (about 0.5% of all new construction locates in bins $h = 150$ and $h = 151$). Since a very small reduction in housing consumption would allow these households to avoid spending a discrete amount on architect fees if they wanted to, we can assume these households are "always-takers" who strictly prefer using an architect even absent the regulation ($A^L = 1 = A^R$). Such

[21] This alternative identification method has the added benefit, relative to the polynomial approach of the previous subsection, that bunching at round or salient numbers is mechanically accounted for, if it is stable over time in relative frequencies. The missing mass above the regulatory threshold, however, cannot directly be estimated using this method, since the placebo distribution around 170 square meters is affected by the pre-reform notch at the former *ART*.

always-takers correspond to about $\hat{a} = 40\%$ of the estimated counter-factual density at $\bar{h}$.[22] Second, the behavior of the density at the *old* notch of 170 can be exploited to estimate compliance with the regulation. In the pre-reform 2013-2016 period, households locating immediately above 170 are defined as "always-takers", for the same reason as above. By revealed preference, these households strictly prefer using an architect, since they could avoid doing so at the cost of only a tiny deviation in their quantity choice. In the 2018-2019 period, however, the density at 170 is composed of two types: always-takers, but also "compliers" who distort quality choices ($A^R = 1 \neq A^L = 0$) rather than bunch at 150. Using the counter-factual distribution at the old notch as a measure of the always-takers share, I compute compliers as the remainder of the actual density. Locally, I estimate the share of compliers at bin $h = 171$ (20 square meters away from the new threshold) to be about 30% of the actual mass of households, suggesting substantial distorsions of the *quality* decision far above the threshold.

4.3 Mechanisms underlying the response

I now provide additional evidence on the dynamics of the bunching response to the two regulatory reforms described in section 2: the introduction of the *SDP* computation (replacing the *SHON*) in 2012, and the lowering of the *ART* to 150 sq.m. of *SDP* in 2017.

Household information: the 2012 change in computation I examine the implications of the change in the computation of the threshold that occurred after May 2012, and was in force until March 2017. While the nominal *level* of the *ART* stayed constant at 170 square meters, starting from the inside of external walls meant its effective stringency was reduced by the less inclusive *definition* of the square footage. Appendix figure C.10 documents bunching at the 170 square meters regulatory threshold during this interim period (2013-2016), relative to the distribution in the 2007-2011 period under the earlier computation. Since square footage is reported in square meters of *SDP* during 2013-2016 (but in units of *SHON* before 2012), the overall distribution is shifted to the left relative to the pre-2012 period, as the *SDP* of a given house is likely to be about 10 percent lower than its *SHON*. More importantly,

[22] Due to round number bunching, the estimate of $\hat{a}$ is higher when using 150 as the "immediate" post-notch bin ($\hat{a} = 0.63$, $s.e. = 0.02$) than when using 151 ($\hat{a} = 0.33$, $s.e. = 0.02$). 40% is an average share over the three bins above the notch.

while bunching remains substantial and significant immediately below the exemption level, its quantitative magnitude falls substantially relative to the earlier period. This reduction in bunching is consistent with the regulatory notch hitting the distribution of preferred livable space choices at a "higher" effective level (since 170 square meters of *SDP* corresponds to roughly 185 to 190 square meters of *SHON*), where the density of consumption choices absent any regulation would be smaller. It also shows that households rapidly understand and react to technical changes not only in the level of the threshold, but in the computation of the measurement used in the regulation.

Dynamics in response to the 2017 reform Next, I turn to the dynamics of livable space consumption after the March 2017 reform adjusted the *ART* downwards substantially, from 170 to 150. I use a difference-in-differences strategy, taking advantage of the fact that I can use as a control group the set of houses with a square footage strictly above (but not far from) 170 square meters, which are unaffected by the change in the level of the *ART*, as they were subject to the architect mandate both before, and after the reform. In practice, I use as a control group the set of houses in the $[171-180]$ sq.m. range of square footage. I plot in appendix figure C.11 the relative trends in construction of new units for various size categories. The figure shows that the *ART* reform leads to substantial real effects in the housing market, and a drastic decline in livable space built, as bunching moves towards the lower exemption level. In particular, the number of units built in the $(151,170)$ range (formerly subject to bunching, but now falling under the purview of the architect mandate) falls dramatically, by around 50 percent, while the number of units in the new bunching range $(140-150)$ increases substantially by around ten percent, both relative to the control group. While the *relative* magnitude of the decrease for former bunchers $(151,170)$ is larger than the relative increase for new bunchers $(140-150)$, the absolute *number* of new units (seen in panel (b) of figure C.11) affected in both categories is comparable, at around 500 per month in each subgroup. This suggests a limited magnitude of extensive margin responses of newly built construction to the change in the level of the *ART* after March 2017. Overall, about 6000 homes per year move from the 150-170 range to the 140-150 range, leading to substantial deadweight losses, and a reduction of livable space consumption of around ten percent for close to two percent of all new homes in each year. By allowing for a

granular assessment of the evolution of trends in subgroups of the $(151 - 170)$ region, the difference-in-differences strategy also allows for a decomposition of the "new" bunching response at 150 square meters by the sub-region of livable space consumption that they would have consumed under the previous level of the notch, as detailed in appendix figure C.13. This methodology demonstrates that about half the new bunching response comes from "counter-factual bunchers" at the 170 threshold, while the other half comes from "counter-factual non-bunchers" in the new missing mass region (151-164).

4.4 Quality regulation and the expansion of existing housing

A common concern in the presence of non-linear incentives, such as size-dependent regulations, is the potential for "splitting", i.e. the arbitrage opportunity stemming from transforming a project above the threshold into several sub-projects that all fall below the level at which the non-linear price or regulation applies. If all bunching were due to project splitting, its real consequences for housing consumption would be limited, and its consequences should mostly be interpreted as a form of regulatory avoidance transferring revenue away from licensed architects. Such project-splitting incentives have been mentioned as a concern for the interpretation of bunching results in the case of contract-splitting under non-linear procurement regulatory guidelines Carril (2019), or firm-splitting for the case of value-added tax notches in Liu et al. (2019).

Because housing construction is a lumpy process, and because the rules that govern expansions of existing housing in France (described in section 2.1) are precisely designed to limit the potential for project-splitting, this phenomenon is less likely to be a concern in my setting. On the other hand, the choice of additions to the existing housing stock is also likely distorted by the presence of the architect mandate.

4.4.1 Bunching of completed unit size below the *ART*

While new constructions represent between 110 000 and 160 000 building licenses every year in the pre-2012 sample, expansions of existing units are more numerous, at c. 165 000 building permits per year on average (not counting the simplified procedure of "preliminary statements"). As detailed in section 2, these projects are also affected by the *ART*, since any

addition that is subject to a building license and pushes the completed floor area of the construction beyond h^* triggers the mandatory use of the services of an architect. In Figure C.12, I plot the total (post-addition) square footage of completed units that underwent a modification project from 2009 to 2011, among houses with an initial *SHON* (h^E) of more than 20 square meters and less than 170 square meters.

The figure provides striking evidence of two facts. First, there is a substantial amount of bunching at amounts of new construction such that the *total* square footage ($h^E + h^N$) of the unit, lies strictly below the 170 square meters level that triggers the architect mandate. While for new constructions, a single and salient threshold may serve as a focal point for the size of new units, in the case of additions, the threshold is "unit-specific": each household must compute the optimal maximum size of the addition $\hat{h^N}(h^E) = h^* - h^E$ in order to remain below the threshold. Second, there is clear evidence of a large missing mass of completed sizes to the right of the threshold. This suggests that for extensions of existing dwellings, extensive margin responses may be substantial, with a large proportion of additions not taking place altogether, because they would bring the total square footage of the unit above the exemption level. In robustness checks, using the same approach for the post-2017 period, extensions of existing constructions also display significant excess mass at square footages limiting the overall floor area of the unit exactly below the threshold of 150 square meters in 2018 and 2019, as shown in appendix figure C.14.

4.4.2 Bunching of extensions below the BL requirement

When they decide to extend an existing building with an initial area lower than the threshold, homeowners can avoid the architect requirement in another ways. They can can build the extension itself under the minimum size above which a building license (BL) is required (since in the absence of a BL, the architect requirement threshold is moot). Figure 5 provides evidence of this alternative avoidance strategy. In particular, it documents substantial bunching in the size of extensions below the 20 square meters *BL* threshold prior to 2011, and the gradual appearance of a bunching mass at the newly introduced *BL* threshold in urban areas at 40 square meters after 2013. The size of extensions themselves is therefore reduced at the level below which a building license is not necessary.

Many other rationales could exist for households to avoid filing for a building license and file a simplified "Preliminary Statement" instead. However, bunching at the *BL* threshold specifically to be exempt from the architect requirement is irrelevant for units with an initial size h^E in the $[\bar{h} - h_{BL}, \bar{h}]$ interval. Households understand and act in response to the complex interlocked incentives of the *BL* and *architect requirement* thresholds. Indeed, figure 6 demonstrates that the excess mass of additions at the new *BL* threshold of 40 square meters for extension sizes h^N only appears for units with an initial size h^E below 130 (i.e. 170 minus 40) square meters. This implies that bunching of addition sizes at the 40 square meters *BL* threshold is partly driven specifically by the desire to avoid the architect mandate, rather than other hassle costs associated with filing for a building license.

4.5 Quality regulations and market segmentation

In this section, I document that housing quality regulations have effects beyond the distortion in housing quantity consumption documented above. Specifically, they have the unintended consequence of segregating household types across sub-markets of housing consumption. In particular, instead of encouraging the production of high-quality units for all, the architect mandate effectively concentrates the quantity adjustment among the least well-off homeowners. Effectively, quality regulations act as a tool to foster spatial sorting, and reinforce local housing segregation.

4.5.1 Sorting of households across the threshold

I first provide evidence that households sort across the architect requirement threshold alongside characteristics that correlate with their taste for quality, and therefore with their propensity to favor a quantity distortion over the cost of complying with the prescribed level of quality.

In particular, households on both sides of the threshold differ substantially by age and income levels. Households who bunch below the threshold tend to be younger, and are more likely to belong to lower socioeconomic status occupations, as shown in figures 7 and 8. Households who bunch below the threshold are also more likely to benefit from government-sponsored and means-tested zero-interest loans (appendix figure C.15), and

more likely to be individuals building by themselves rather than resorting to contractors or other external suppliers (appendix figure C.16). All of these indicate a higher marginal utility of income relative to the valuation of architect services. Conversely, "always-takers" households who comply by the regulation by remaining on the immediate right-hand side of the threshold are more likely to live in a different province than the location in which the housing construction project is occurring, suggesting that they may face larger supervision and monitoring costs, which may in turn partly explain their willingness to use the services of an architect (figure 9). Even conditional on living in the same province, the households filing for building licenses for homes below the threshold are less likely to be living in a different postcode than the municipality where the unit is to be built.

Houses immediately below the threshold, which are more likely to correspond to strategic "bunchers", are characterized by distinct characteristics from their counterparts above the threshold. As shown in appendix figure C.17, they are much more likely to be used as primary homes, rather than second homes, by their owners. They also more likely to include additional elements, such as garden sheds or garages, that may correspond to ways for their owners to circumvent the strict measurement of square footage.

Projects that remain above the threshold and comply with the regulation reveal their relatively higher valuation of architect services. As documented earlier, I find that houses above the threshold take longer to start construction after receiving an authorization, consistent with the quality constraints delaying the start of a project, but (for the subsample where data on completion date are available) do not take longer to complete overall. They are also likely to be more complex or idiosyncratic construction projects, notably by being more likely to involve the demolition of existing elements (appendix figure C.18). On the other hand, average lot area evolves continuously around the threshold (appendix figure C.19).[23]

[23] Appendix figure C.20 documents bunching in the distribution of the ratio of square footage to lot area, suggesting that built-area ratios regulations may also bind in a substantial number of cases. However, there is no differential likelihood of bunching at any of the common built-area ratio thresholds (0.2, 0.25, 0.4, 0.5) on both sides of the *ART*.

4.5.2 Spatial sorting by quality

Finally, I document that housing units built immediately below the *ART* in order to avoid meeting the minimum quality standards involved with a larger size locate in towns and neighborhoods that differ substantially from those in which units above the threshold are situated. I merge all individual housing permits for the post-2017 period (when the threshold's value is constant at 150 square meters) to cross-sectional 2017 Census and Treasury data on the characteristics of French municipalities.[24] I then compare the characteristics of the municipalities in which units immediately around the threshold are located.
First, bunchers are more likely to be located in municipalities with higher housing construction overall (figure 11), and a larger share of bunchers among *other* housing projects (figure 10). The higher level of overall housing construction is indicative of a difference in the aggregate behavior of housing supply in the towns where strategic bunchers live. It potentially suggests the presence of complementarities in housing production between homes located exactly at the size threshold, and of spatial sorting depending on the leniency of local planning authorities in allowing for standardized, "below-threshold" housing construction.

Second, towns in which the bunchers are more likely to be located (those immediately below the 150 square meters threshold) exhibit a substantially higher share of household incomes deriving from a variety of public transfers (including unemployment insurance and means-tested benefits), as seen in appendix figure C.21. The pattern of benefit receipt likelihood, which shows a spike specifically among towns in which units at the 149 sq.m. are located, tends to suggests that bunching households, who are by construction overrepresented in these bins of square footage, are substantially poorer than the rest of the population. These discontinuities in municipality characteristics are observed both for a 170 square meters *ART*, and after the *ART* moves below 150 square meters, suggesting that they are not driven by the relative availability, for example, of land suitable for different construction sizes in different types of towns, but rather by the effective spatial housing segregation

[24]There are about 36,000 municipalities in France, with an average population of around 1,800. 97% of them have fewer than 10,000 inhabitants, making them somewhat comparable in size to US Census tracts. The municipality level income data are called *Filosofi* files, and the municipality-level rent data are from the *Observatoire des loyers*.

introduced by the quality regulation itself.

Importantly, towns corresponding to homes on the right-hand side of the threshold are characterized by higher rents and housing prices (figure 12). They also exhibit higher inequality (third to first quartile ratio and Gini coefficient), and higher incomes at the median and third quartiles of the income distribution (see appendix figure C.22), but not at the bottom quartile. Towns in which the higher quality units locate also generally exhibit substantially higher population and population density. The pattern of the relationship between twon average rents and incomes and home sizes is flat on each side of the threshold. This suggests that rather than being driven merely by the resorting of some bunching households from the right to the left side of the *ART*, which would lead to a "dip" exactly at the threshold, the regulation acts as a focal point. This salient watershed delineates two sub-segments of the new home market: a higher-quality, "large homes" segment above the *ART*, and a lower-quality, "small homes" one below.

5 Structural estimation

I parameterize the the vector of tastes Θ in the model detailed in section 2 to structurally estimate the distribution of tastes for, respectively, the quantity of housing services, and the quality added by architects. This allows me to recover an underlying structure of preferences such that optimal choices closely match the cross-sectional frequency of housing choices observed in the $ART = 170$ period (2013-2016), to evaluate the welfare cost of the regulation, and to run counter-factual experiments in the model.

Parametric assumptions In the structural estimation, I assume utility is quasi-linear in the outside good and iso-elastic in housing quantity:

$$u(c,h,A) = c + (\theta^{\eta} + (1-t)\alpha^{\eta}A)\frac{h^{1-\eta}}{1-\eta} + t\alpha A \tag{7}$$

The distribution of θ governs tastes for housing quantity; the distribution of α reflects the perceived quality added from using architect services; and t determines whether preferences for quality have a "fixed" or "variable" nature – i.e. to what extent the valuation of architect-

built housing scales with the quantity of housing consumed.

For each α, the marginal buncher (with choices $\bar{h} + \Delta h(\alpha)$, $A^0(\alpha) = 0$ absent the regulation) is indifferent between bunching at $\bar{h}$, or using an architect at interior choice $h_I \geq \bar{h}$. Agents with lower α – who value architect services less – are the most willing to bunch, so that the location of the marginal buncher, $\bar{h} + \Delta h(\alpha)$, is decreasing in α: the lower α, the "further" from the notch there exist households willing to distort quantity rather than comply with the quality requirement.[25]

I assume that quantity preferences are drawn from a log-normal distribution $F_\theta = \mathcal{N}(\mu_\theta, \sigma_\theta)$. The parameter governing the share of households choosing to use an architect α is drawn from a Frechet distribution with shape and location (s_α, l_α). I also allow for "bunching noise" (which matches the shape of the bunching mass to be diffuse to the left of the notch in the data, rather than located exactly at the notch) to come from an exponential distribution with mean λ.

Estimation via method of simulated moments Parameters of the model are estimated using the simulated method of moments to closely approximate the observed distribution of housing choices made by individual households in the data. The main objective is to select a set of parameters Θ governing the distributions of θ and α to generate simulation-based moments that closely align with K key moments from the data, corresponding to frequencies of housing choices for K bins of one square meter in the cross-section for the period 2013-2016 in the range [60,450]. Since the parametric distributions will give rise to smooth choices in the simulated moments, I follow Carril (2019) in first smoothing the distribution of housing choices in the data using an 8-order polynomial on both sides of the threshold, excluding the bunching range [167,169] (see appendix B). The model then selects parameters to fit the smoothed distribution in the data. These smoothed moments are the *target moments*, denoted by m_d. Corresponding *model moments* $m_s(\Theta)$ are created by simulating $N \times s$ observations with the model parameterized by Θ. The estimated parameters are chosen to minimize a

[25] Assuming $\alpha \geq 0$ (meaning the valuation of architect services cannot be negative), the regulation for the "last" marginal buncher with $\alpha = 0$ is akin to a pure "tax notch" of size F. For a constant (inverse) elasticity η, this household's preferred quantity choice is located the furthest away from the notch in the counter-factual distribution, and could be estimated according to the "convergence point" method of Kleven and Waseem (2013).

standard distance metric:

$$\widehat{\Theta} = \underset{\Theta}{\operatorname{argmin}}(m_d - m_s(\Theta))' W_N (m_d - m_s(\Theta)) \tag{8}$$

where W_N is a $N \times N$ weighting matrix, which is the identity matrix modified linearly to give more weight to bins close to the threshold. Following "Provider Incentives and Healthcare Costs: Evidence From Long-Term Care Hospitals" and Carril, 2019, I increase the weights of bins closer to the policy threshold. Specifically, I subtract a constant amount of 1/J for each moment away from the threshold.

Identification Although all parameters are jointly estimated, certain data moments help identify specific parameters. The mean μ_θ and variance σ^2_θ are determined by the overall position and shape of the distribution of optimal housing space. Both moments below and above the policy threshold pin down the overall shape and location of the distribution.
The moment at the policy threshold, as well as moments just above the policy threshold identify the (inverse) elasticity of bunching η, and the shape s_α and location l_α of α. In addition, the moments just below the policy threshold identify the magnitude of the mean bunching noise λ.
The cost per unit housing space p_H is normalized to 1. In addition, I calibrate F so that the change in average cost between the policy threshold and the bin right after is around 9%. Incomes are calibrated so that households spend 30% of their income on housing costs on average.

Results and counter-factuals Table (2) summarizes the estimated parameters, depending on the calibration of t, which varies the "fixed" or "variable" nature of preferences for quality depending on the optimal choice of quantity. Appendix figure C.23 displays the fit of the model for various choices of t, showing that the model does a good job at replicating both the overall shape of the distribution of preferred housing quantity choices, and the large bunching mass immediately below the threshold during the $ART = 170$ period. Importantly, as shown in figure C.24, the model can also be informative about unobservable outcomes, such as the average cost of construction or the share of households using architects (both in

the equilibrium with regulation and in the counter-factual without it). Overall, the model implies that the regulation substantially distorts quantity and quality choices, and that the welfare loss from distortions is concentrated among "compliers" who distort quality choices. Intuitively, compliers are "infra-marginal" and unwilling to distort consumption, but must suffer the cost of paying for an architect despite their intermediate or low valuation of their services.

Finally, the model also allows me to compute various counter-factuals. I show that the model performs well in replicating untargeted moments, and in particular in quantitatively matching the consequences of tightening the *ART* to 150 after 2017 (see figure 13). As shown in the figure, only a relatively low value of t (suggesting preferences for quality heavily correlated with preferences for quantity) is able to replicate not only the movement in the bunching mass from the old to the new threshold, but also the quantitatively large share of "switchers" who would buncher under the 170 threshold but comply with the regulation under the new, lower threshold of 150. Intuitively, when preferences for quality are variable in nature, households further away from the new threshold are more likely to have sufficiently high tastes for quality that they prefer complying with the regulation by using the services of an architect, rather than distorting quantity.

6 Discussion and conclusion

I estimate the sensitivity of housing demand to its user cost, exploiting a notched regulation for the provision of new buildings in France. France requires any new home with a floor area exceeding a certain level (170 square meters until 2012, or c. 1830 square feet) to use the services of a government-licensed architect in order to obtain a building permit. This peculiar setting allows me to make progress on a key question, heretofore hindered by the absence of data and causal identification: how do quality regulations imposing burdens on new housing development affect the cost of new housing, the quantity consumed, its characteristics, and its spatial allocation?

A simple conceptual framework shows that whether and how much households reduce consumption to circumvent the "notched" increase in regulatory stringency can be used to re-

veal the cost of regulation. Empirically, static and dynamic bunching methods demonstrate that the rule indeed distorts the intensive margin of dwelling size, as well as the decision to expand existing constructions or undertake new projects. Regression discontinuity estimates allow me to quantify the additional charge associated with regulatory compliance, and to evidence patterns of consumer sorting along the quality-quantity trade-off. These regularities suggest that a discrete threshold for regulatory enforcement acts as a salient watershed, segmenting sub-markets across space and quality ladder.

In essence, the regulation intends to improve the aesthetic quality of new single-family homes beyond what the *laisser-faire* equilibrium would yield. It treats housing quality as an external amenity value, that households would under-consume in the absence of the regulation. Forcing all construction to be of high-quality, in the absence of a compliance trading system, could potentially generate inefficiently heterogeneous compliance costs: some households with adjustment costs (i.e. cost net of private benefit) above the unique Pigouvian tax-equivalent of the constraint will have to pay a cost in excess of the social value of their compliance. If such compliance costs are indeed systematically higher for small-scale constructions (for example because of fixed costs of compliance), or if the externality is size-dependent, making the architect mandate only applicable to large-scale houses might be more efficient than applying it to everyone.

In practice, however, I find that the attribute-based regulation leads to increased monetary and non-monetary costs above the threshold, but also to a sharp segregation of housing markets as households sort based on their relative taste for quality. Lower-income, lower socio-economic status households are forced to under-consume more standardized housing by bunching below the threshold, with the share of adjustment operating through quantities being substantially larger than the quality compliance effect of the regulation. Regulating housing quality thus leads to substantial *quantity* distortions for newly built units, and, given the durable nature of housing structures, temporary changes in regulatory norms have long-lasting effects on housing consumption, spatial sorting, and inequality.

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Main tables

Polynomial	Upper threshold of manipulation range h_U			
	180	185	190	195
B_b				
7	7,410.3	7,192.3	7,201.8	7,360.4
	(185.9)	(188.2)	(189.5)	(190.14)
8	12,023.6	12,020.7	12,189.0	12,409.4
	(189.19)	(192.75)	(194.75)	(195.74)
9	11,693.6	11,546.7	11,551.9	11,593.2
	(187.31)	(190.23)	(191.49)	(191.61)
10	12,958.1	12,924.7	13,065.0	13,225.9
	(186.93)	(191.27)	(194.11)	(195.1)
$\widehat{b}_1$				
7	5.07	4.82	4.83	5.02
	(0.15)	(0.15)	(0.15)	(0.16)
8	13.67	13.66	14.40	15.53
	(0.39)	(0.42)	(0.47)	(0.55)
9	11.61	11.18	11.19	11.32
	(0.28)	(0.28)	(0.29)	(0.3)
10	15.84	15.68	16.39	17.33
	(0.43)	(0.46)	(0.53)	(0.6)

Table 1: **Estimated bunching mass, polynomial fit, 2013-2016**

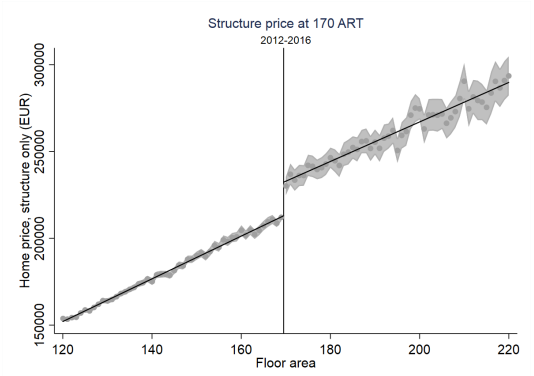
Note: The statistics in the table are estimated using a flexible polynomial as the counterfactual distribution. The polynomial used is estimated according to equation 3, varying the order K of the polynomial and $h_U = \{180, 185, 190, 195\}$. The actual distribution of housing space between 2013-2016 is capped at 41 and 400. As outlined in equation 3, the estimated bunching mass is the difference between the counterfactual and actual distributions for the range of housing space between $h_L = 160$ sq.m. and $\bar{h}$ sq.m, inclusive. Standard errors are computed via bootstrap with B=100.

Parameter	Estimate (s.e.)					
F= 19.094	t=0.90	t=0.75	t=0.5	t=0.25	t=0.10	t=0.0
Elasticity (η)	0.209	0.336	0.428	0.530	0.587	0.625
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
Location housing quantity preference distr. θ (μ_θ)	100.818	102.277	102.909	102.947	103.491	103.505
	(0.096)	(0.094)	(0.087)	(0.087)	(0.088)	(0.085)
Scale housing quantity preference distr. θ (σ_θ)	23.907	25.014	25.855	26.566	27.395	27.636
	(0.077)	(0.079)	(0.068)	(0.066)	(0.064)	(0.066)
Shape housing quality preference distr. α (ξ_α)	0.957	1.540	3.199	4.882	6.866	8.086
	(0.010)	(0.018)	(0.046)	(0.083)	(0.158)	(0.201)
Location housing quality preference distr. α (ζ_α)	5.423	1.331	0.060	0.000	0.000	0.000
	(0.059)	(0.027)	(0.004)	(0.000)	(0.000)	(0.000)
Mean bunching noise λ	1.333	1.389	1.332	1.114	1.109	1.100
	(0.039)	(0.041)	(0.038)	(0.037)	(0.035)	(0.032)
SSE ($\times 10^5$)	3.0	3.18	3.35	3.74	3.97	4.11
Δ Avg. Construction Cost	8.90%	9.03%	8.99%	9.10%	9.21%	9.41%

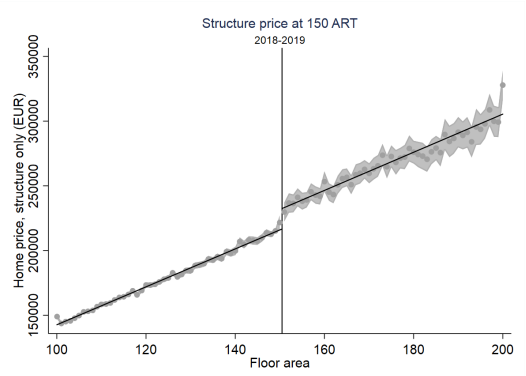
Table 2: **Estimated structural parameters via SMM**

Note: This table summarizes estimated parameters of the model discussed in the previous section when F is calibrated. I simulate 30,000 households in a distribution and take the average of the simulated moments across 20 distributions. These sets of estimates minimize distances between simulated moments and data moments. The weighting matrix used puts more weight on bins near the policy threshold. Standard errors are in parentheses, computed using the asymptotic variance-covariance matrix. When $F = 19.094$, the change in average construction cost approximates 9%.

Main figures

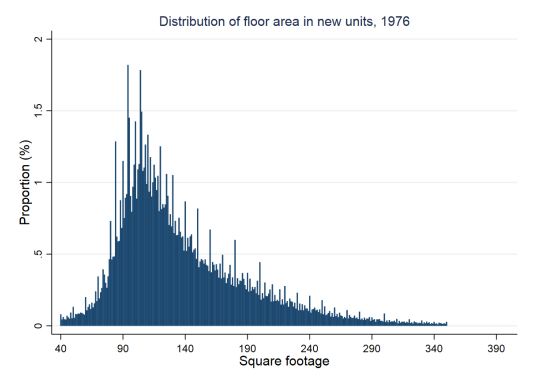


(a) 2012-2016, 170 sq.m. ART

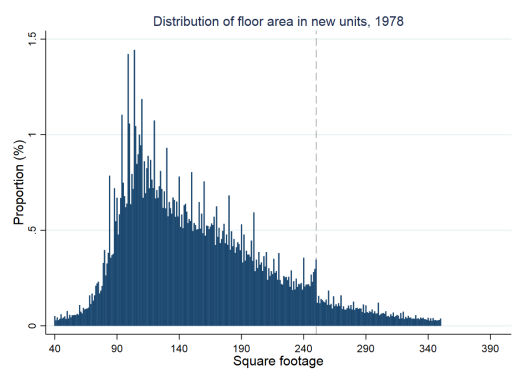


(b) Post-2018, 150 sq.m. ART

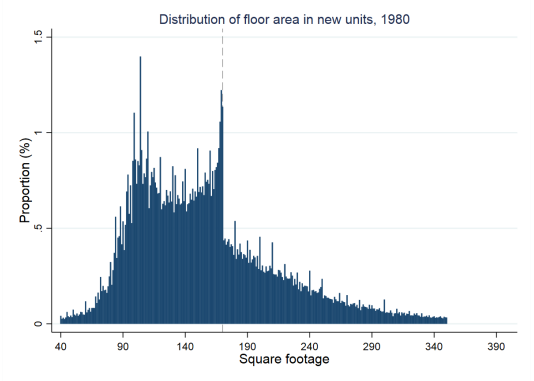
Figure 1: **Construction cost for new units** The figure plots a binned scatter plot of the construction cost (only including structure price) of new units against their square footage (*SDP*) for new units with approved building licenses in the EPTB data. Panel (a) plots the discontinuity at the 170 square meters mark in the 2012-2016 data, while panel (b) plots the discontinuity at 150 square meters after 2018. The raw data are only adjusted for year fixed effects to account for nationwide inflation in construction costs across years.



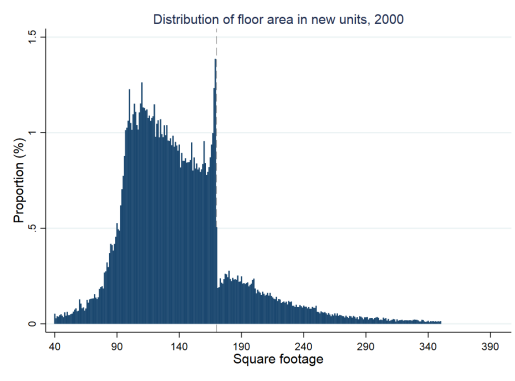
(a) 1976, no ART



(b) 1978, 250 sq.m. ART



(c) 1980, 170 sq.m. ART



(d) 2000, 170 sq.m. ART

Figure 2: **Distribution of new unit size, selected years** The figure plots the distribution of square footage (*SHON*) for new units for selected years. In particular, panel (a) plots the distribution in 1976, before the implementation of the architect mandate. Panel (b) plots the distribution in 1978, the first full year of implementation of an ART at 250 square meters. Panel (c) plots the distribution in 1980, the first full year after the lowering of the threshold to 170 square meters. Panel (d) plots the distribution in 2000, showing the relative stability of bunching over a twenty year periods but also the substantially larger missing mass above the threshold.

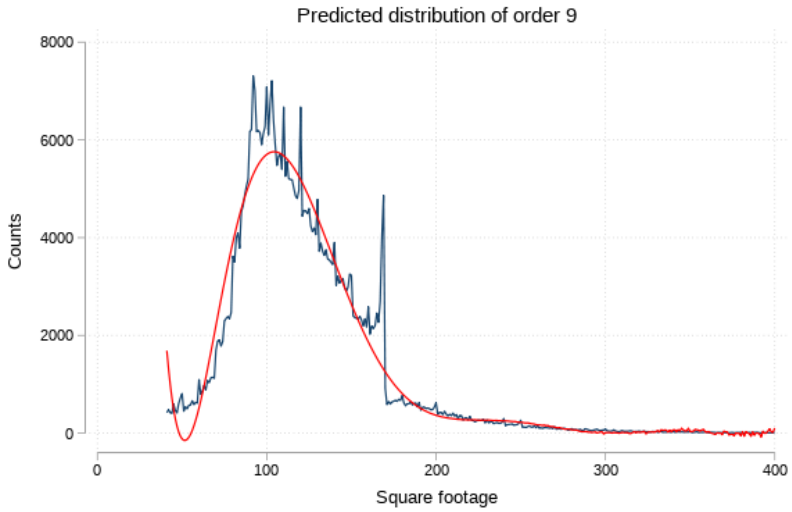


Figure 3: **Distribution of new unit size, 2013-2016, polynomial fit (baseline)** The figure plots the distribution of the square footage (*SDP*) of new units with approved building licenses from 2013 to 2016 in the Sit@del data. The blue line is the underlying distribution of housing space between 2013-2016, capped at 41 and 400. The red line is a 9th-order polynomial fit, derived according to equation 3.

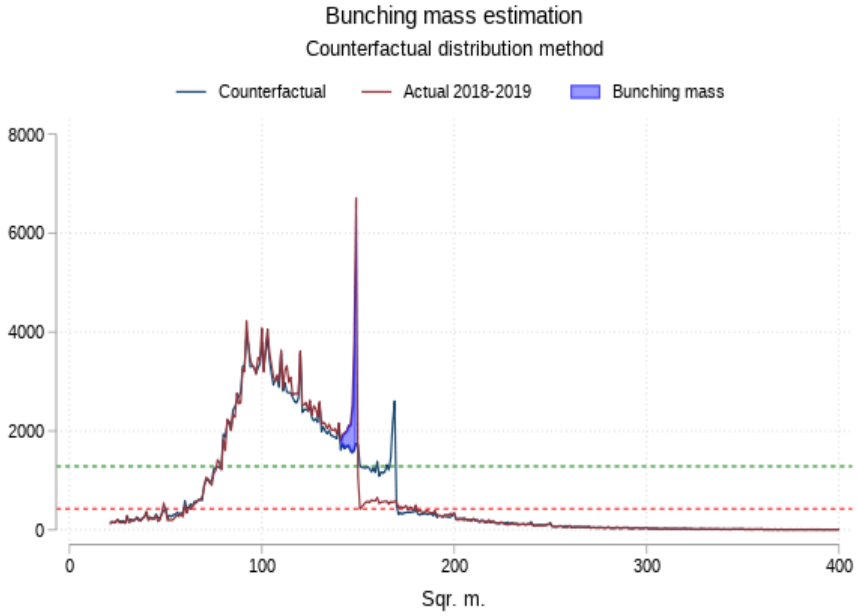


Figure 4: **Distribution of the size of newly built units, placebo notch approach** The figure plots the distribution of the square footage (*SDP*) of new units with approved building licenses from 2018 to 2019 in the Sit@del data. The ART was lowered to 150 square meters in 2017. The counterfactual distribution is the 2013-2016 distribution of new housing space constructed rescaled using the total count across all values of housing space in the post-2017 distributions, as described in section 3. The estimated bunching mass $B_b = N(h) - \widehat{N}(h)^{Ctf}$ is illustrated by the blue area. The red dashed line is the actual level of the density immediately above the new notch, corresponding to an estimate of the number of "always-takers" at 150, and the green dashed line is the counter-factual level.

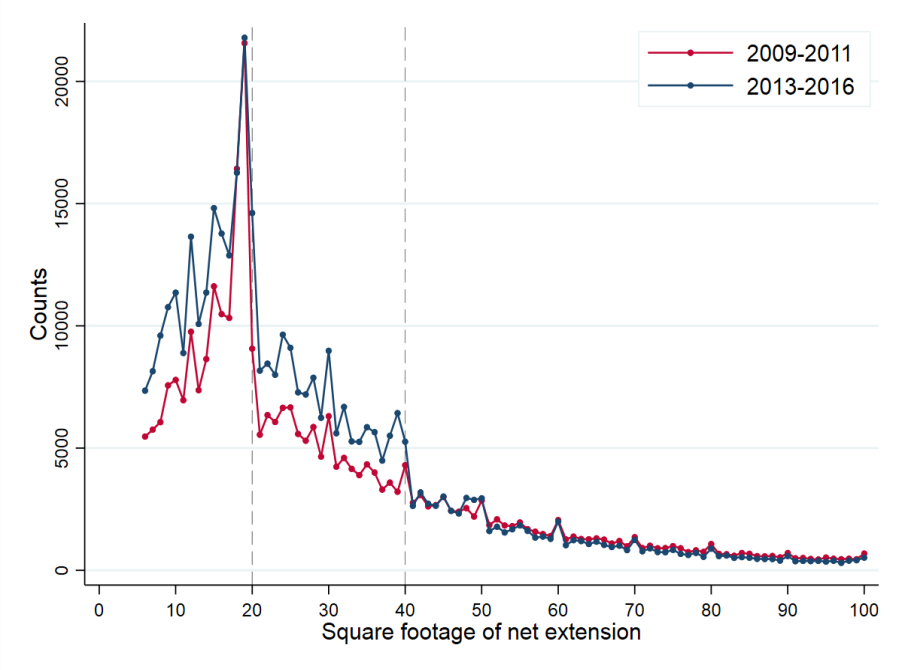


Figure 5: **Distribution of extension sizes: bunching at the building license thresholds** The figure plots the distribution of the square footage of extensions with approved building licenses from 2009 to 2011 (red line), and from 2013 to 2016 (blue line) in the Sit@del data. The sharp bunching at 20 square meters (and smaller bunching at 40 square meters after 2012) indicates the willingness of owners to avoid filing for a building license (BL), since only a preliminary statement (PS) is required for extensions below $\bar{h} = 20$ square meters (40 in urban areas after 2012). Filing a BL instead of a PS constitutes an alternative avoidance mechanism to avoid meeting the architect requirement conditions if the completed size of the unit exceeds the ART h^*.

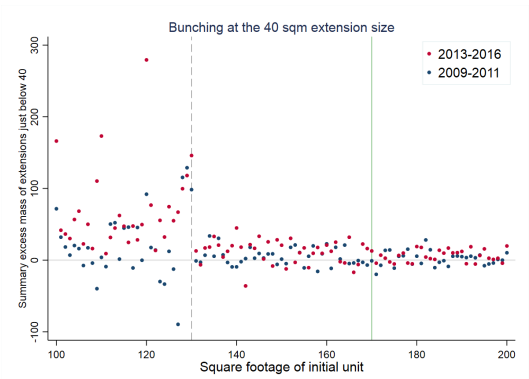
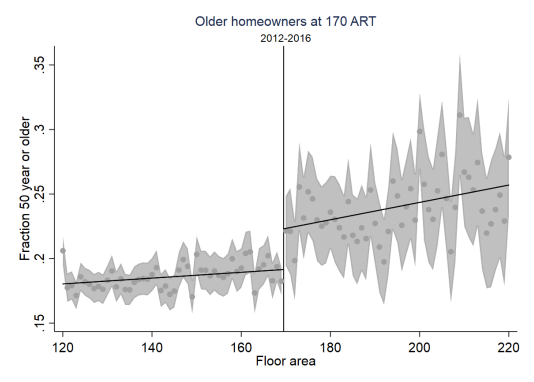
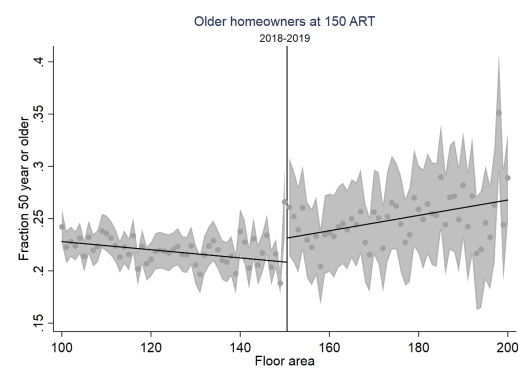


Figure 6: **Summary excess mass at 40 square meters** The figure plots the summary excess mass of additions at exactly 40 square meters in the Sit@del data, before and after the introduction of the new 40 square meters BL threshold in urban areas.

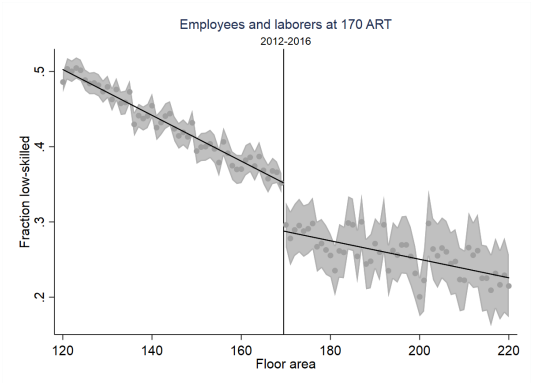


(a) 2012-2016, 170 sq.m. ART

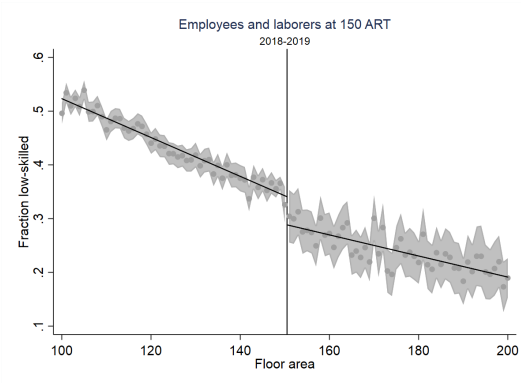


(b) Post-2018, 150 sq.m. ART

Figure 7: **Share of older households** The figure plots the share of households with a head of household aged 50 or more against the square footage of new units, before and after the threshold was lowered to 150 square meters, in the EPTB data.



(a) 2012-2016, 170 sq.m. ART



(b) Post-2018, 150 sq.m. ART

Figure 8: **Share of low-skill households** The figure plots the share of lower-skill socio-economic status (employees and blue-collar workers) households against the square footage of new units, before and after the threshold was lowered to 150 square meters, in the EPTB data.

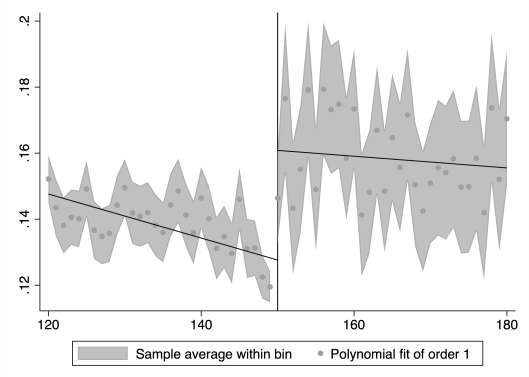


Figure 9: **Out-of-town households** The figure plots the share of filers who live in a different French province (*departement*), for each bin of square footage of new units, after the threshold was lowered to 150 square meters, in the EPTB data.

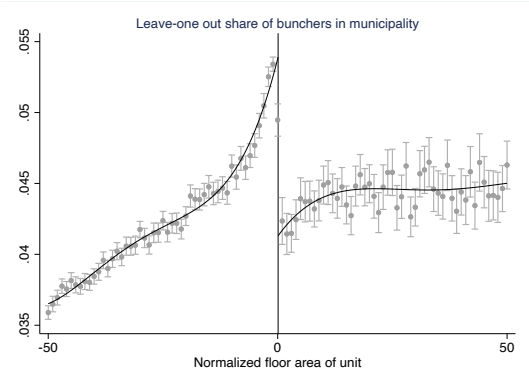


Figure 10: **Share of bunchers in municipality** The figure plots the share of *other* projects in the municipality with a size immediately below the threshold (excluding the project itself), for each bin of square footage of new units, pooling all post-2013 data in the Sitadel data and normalizing the threshold to zero.

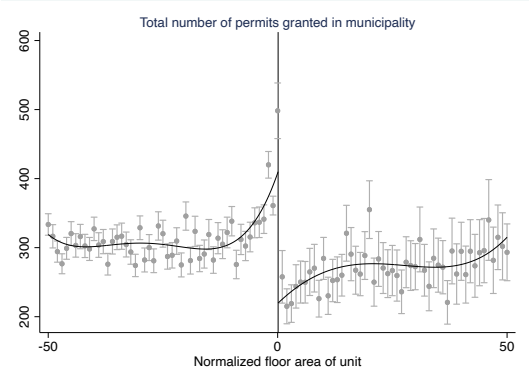


Figure 11: **Total construction in municipality** The figure plots the total number of projects in the municipality (excluding the project itself), for each bin of square footage of new units, pooling all post-2013 data in the Sitadel data and normalizing the threshold to zero.

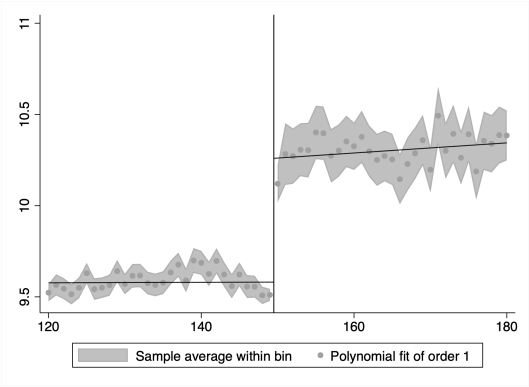
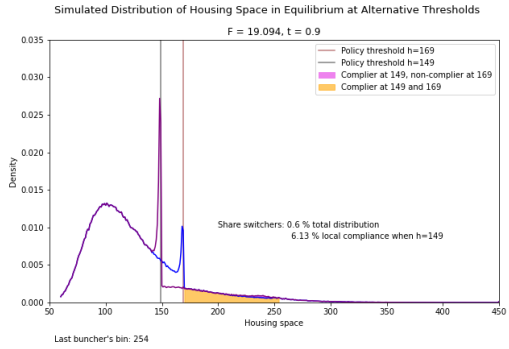
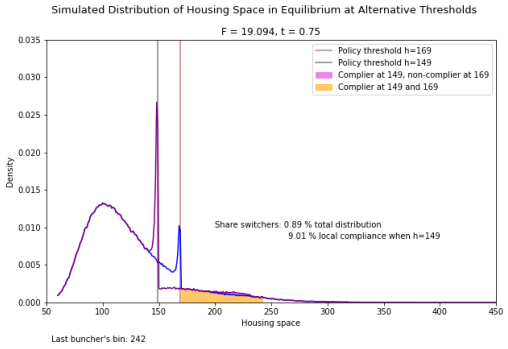


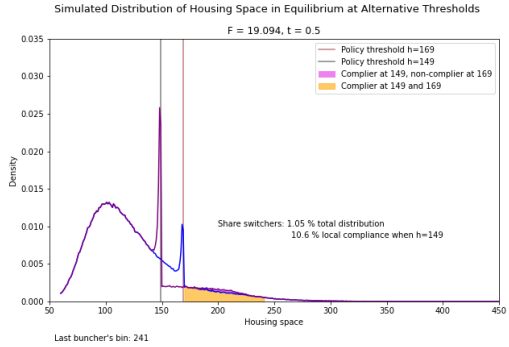
Figure 12: **Town average rents** The figure plots the average rents per square meters in the towns for each bin of square footage of new units, after the threshold was lowered to 150 square meters, in the Sitadel and *Observatoire des loyers* data.



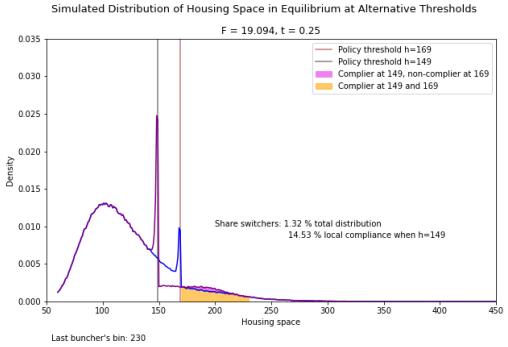
(a) t=0.90



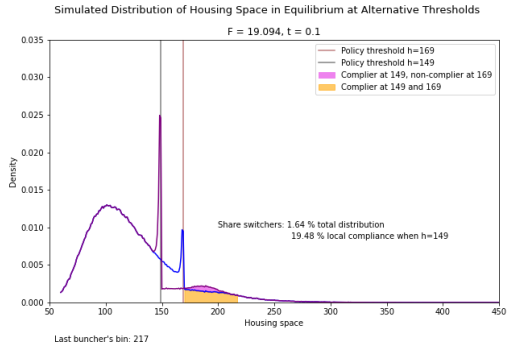
(b) t=0.75



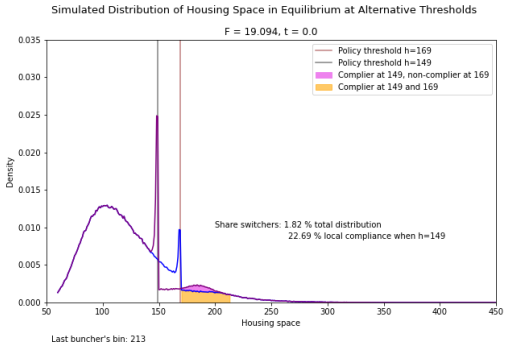
(c) t=0.50



(d) t=0.25



(e) t=0.10



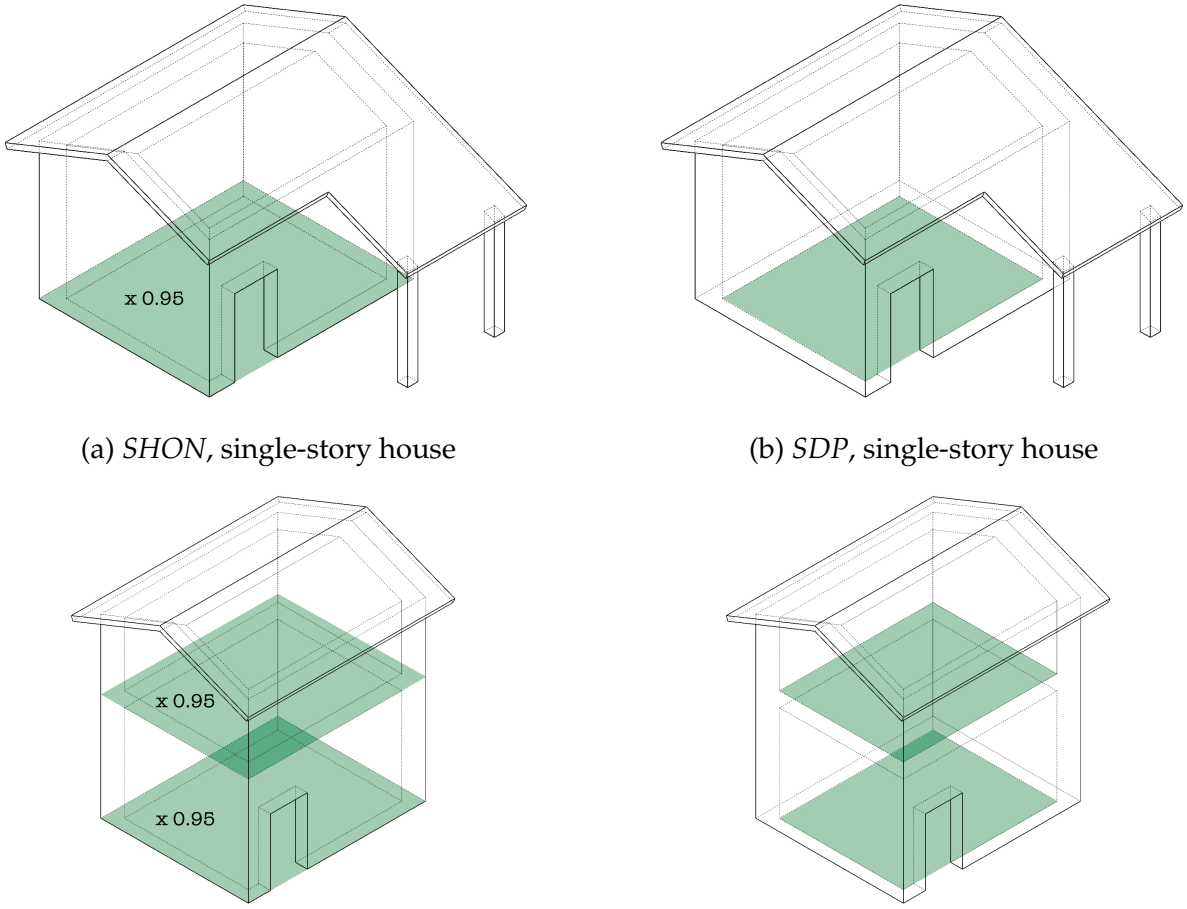
(f) t=0.0

Figure 13: **Model simulation of tightening the *ART*** This figure plots the simulated distributions (colored lines) around the policy thresholds ($\bar{h} = 169$) and ($\tilde{h} = 149$) using structural parameters estimated via the method of simulated moments. The set of estimated parameters used is $\widehat{\Theta}$ where $F = 19.094$. I simulate 30,000 households in a distribution and take the average of the simulated moments across 20 distributions. The weighting matrix used gives more weight to housing space bins near the policy threshold.

Appendices

A Institutional background: addendum

The March 2012 reform led to the replacement of the *SHON* (computed from the outside of external walls) by the *SDP*, computed from the inside of external walls. This led to a decrease of 5 to 12 percent of the measured square footage for the same new construction, and therefore implied that the architect mandate effectively applied to only a more limited part of the home size distribution upper tail. In the simplest case of a square home, with external walls of thickness ε and an *SDP* of side L, the *SDP* would be: $SDP = L^2$ while the corresponding *SHON* would be: $SHON = 0.95 \times (L + 2\varepsilon)^2$. Thus the *SDP* was smaller than the *SHON* as long as: $0.05L^2 < 3.8(\varepsilon^2 + L\varepsilon)$. Since on average, walls in homes built after 2012 had a thickness ε of 0.45 meter (c. 18 inches), the *SDP* would be from 5 to 12 percent lower than the *SHON* for standard floor areas, in the 100 to 300 square meters interval. It could be substantially lower, up to 20 percent less, for a more elongated or less compact construction.



(a) *SHON*, single-story house

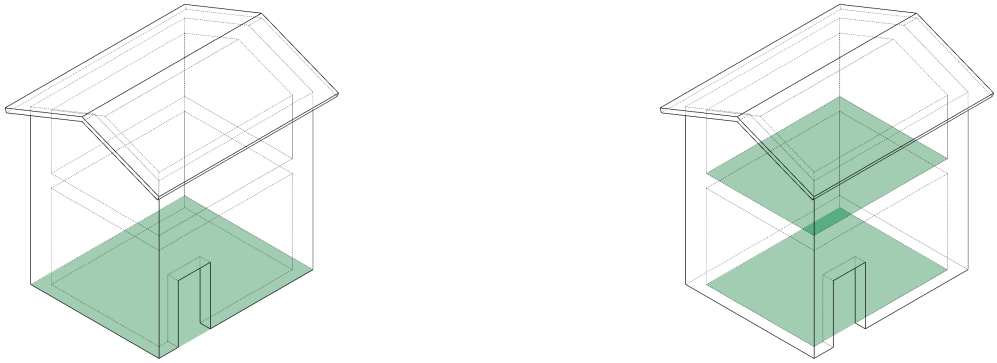
(b) *SDP*, single-story house

(c) *SHON*, multi-story house

(d) *SDP*, multi-story house

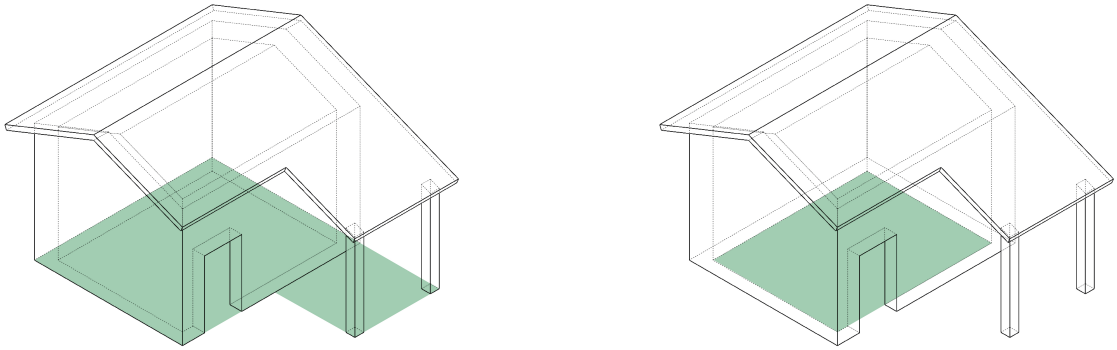
Figure A.1: **Comparison of the *SHON* and *SDP*** The figure compares the pre-2012 definition of square footage (*SHON*) used in the computation of the architect requirement threshold to the post-March 2012 definition (*SDP*). Panels (a) and (b) compare the two computations for a single-story home, while panels (c) and (d) compares the computations for a multi-story unit. The *SHON* (panels (a) and (c)) includes a five percent flat deduction, but the non-inclusion of external walls in the *SDP* (panels (b) and (d)) makes the latter smaller for a given amount of livable space, especially in less compact or more elongated constructions. The *SDP* also excludes areas beneath indoor stairs. Sources: French Housing Ministry documentation.

To compensate for the change and preserve the role of architects, the March 2012 reform initially added a dual test for the ART computation. It defined an additional measure, the *emprise au sol* (henceforth, *EAS*) or "footprint" of a construction, which corresponded to the ground-level vertical projection of the structure. The *EAS* started from the *outside* of external walls, did not allow for a flat deduction, and included the projection of terraces, porch roofs, and indoor parking spaces, none of which were part of the computation of the *SHON* or the *SDP*. An architect was required for units in which *either* the *EAS* or the *SDP* exceeded the 170 sq.m. threshold.



(a) *EAS*, multi-story house (b) *SDP*, multi-story house

Figure A.2: **Comparison of the *EAS* and *SDP* for a multi-story house** The figure compares the March 2012 definition of square footage (*SDP*) to the March 2012 definition of footprint (*EAS*) used in the dual architect requirement threshold test. Panel (a) plots the *EAS* of a multi-story home, while panel (b) shows the *SDP* of the same unit. The *SDP* was generally larger than the *EAS* for multi-story homes, since the same amount of livable space deployed over several floors took up a smaller amount of land footprint. Sources: French Housing Ministry documentation.



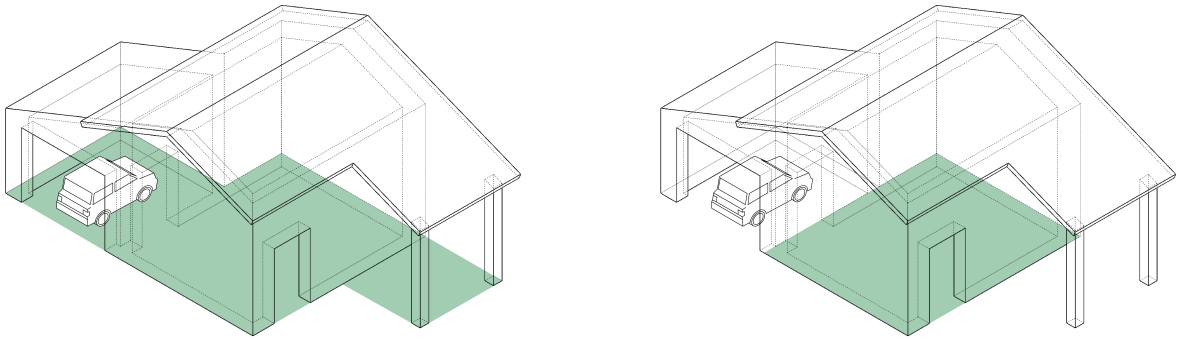
(a) *EAS*, single-story house (b) *SDP*, single-story house

Figure A.3: **Comparison of the *EAS* and *SDP* for a single-story house** The figure compares the March 2012 definition of square footage (*SDP*) to the March 2012 definition of footprint (*EAS*) used in the dual architect requirement threshold test. Panel (a) plots the *EAS* of a single-story home, while panel (b) shows the *SDP* of the same unit. The *EAS* was generally larger than the *SDP* for single-story homes, due to its inclusion of the vertical projection of garages, balconies, awnings, and external walls, all excluded from the *SDP* computation. Sources: French Housing Ministry documentation.

Figure A.2 shows that for a multi-story unit, the *EAS* was much smaller than the *SDP*, and therefore was not a binding constraint. However, for single-story units with awnings or garages (see figure A.3), the *EAS* was higher than both the *SDP* and the pre-2012 *SHON*. For these units, the dual test actually lowered the *de facto* amount of livable space below the exemption. It quickly became apparent that many single-story homes with a *SHON* below 170 square meters now fell under the architect mandate's purview, due to the *EAS*

condition.

In May 2012, the law was rectified again. In the dual test, the *EAS* was replaced by the so-called *EAS-CSDP*[26]. The *EAS-CSDP* included only the "footprint" of the elements of a structure with a "floor area" (*SDP*), therefore excluding balconies or garages (see figure A.4). After the May 2012 modification, the reform had thus substituted a dual test ($EAS\text{-}CSDP < 170$ and $SDP < 170$) to the previous single-measure test ($SHON < 170$). Relative to the pre-2012 situation, the reform had effectively raised the ART by 10 to 12 percent for multi-story units, but lowered it for single-story units by c. 5 percent.[27]



(a) *EAS*, single-story house (b) *EAS-CSDP*, single-story house

Figure A.4: **Comparison of the *EAS* and the *EAS-CSDP* after the May 2012 rectification** The figure compares the March 2012 definition of footprint (*EAS*) to the May 2012 reformed definition of floor-area generative footprint (*EAS-CSDP*) used in the architect requirement threshold test. Panel (a) plots the *EAS* of a home, while panel (b) shows the *EAS-CSDP* of the same unit. The *EAS-CSDP* was generally smaller than the *EAS* since it no longer included the vertical projection of garages, balconies, and awnings. This had the implication of generally making the *EAS-CSDP* smaller than the *SDP*. It was therefore no longer relevant for the dual test in multi-story units, but still relevant and slightly larger than the pre-March 2012 *SHON* for single-story units. Sources: French Housing Ministry documentation.

B Smoothing of Housing Space Frequency Moments

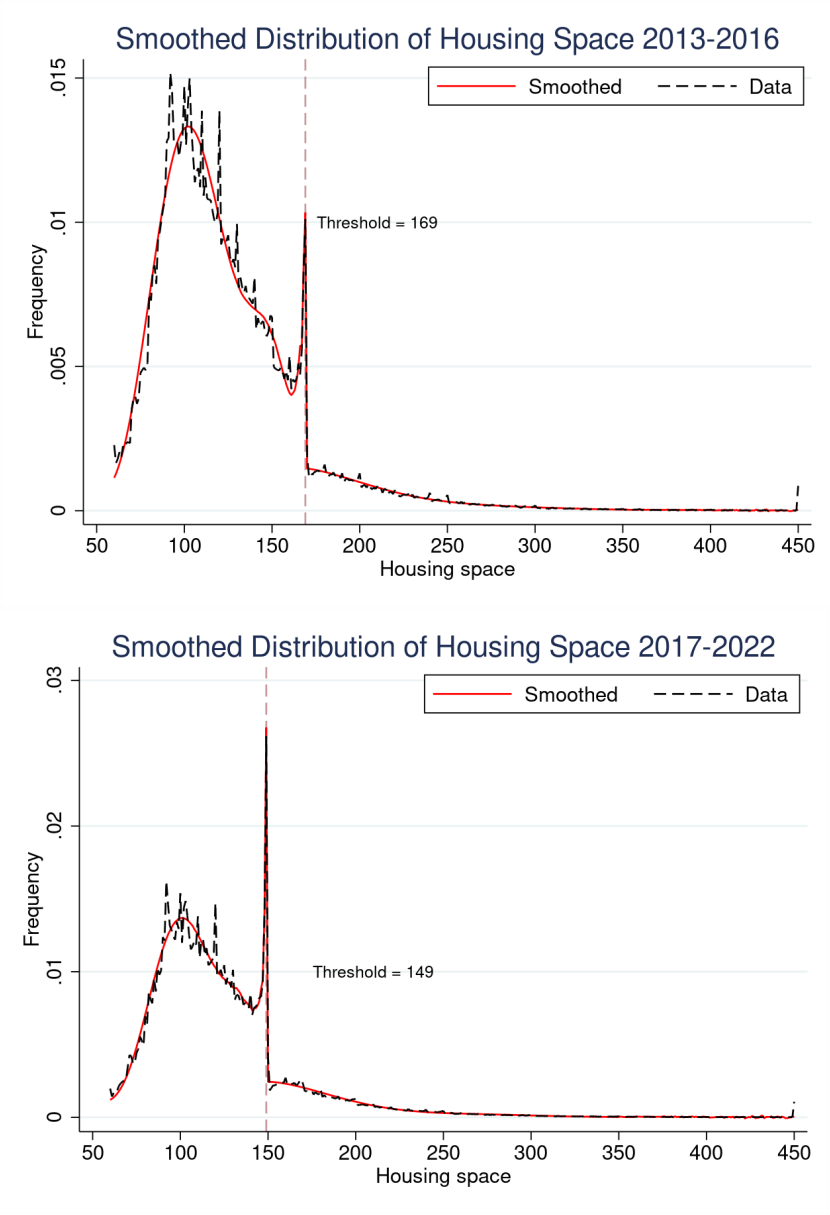
Following Carril, 2019, I smooth out spikes at round numbers in the real data, which our simulated distribution of housing space would not otherwise be able to match. In addition, since our objective is to model the bunching behavior around the policy threshold, it is reasonable to focus on matching the data moments around the notch. The housing space

[26]The acronym stands for *emprise au sol constitutive de surface de plancher* or "*SDP*-generative footprint".

[27]Since $SDP > EAS - CSDP$ in multi-story homes, the binding constraint for these was $SDP < 170$, and generally *SDP* was 10 to 12 percent below the *SHON*. On the other hand, since $SDP < EAS - CSDP$ in single-story homes, the binding constraint among these units was $EAS - CSDP < 170$, and *EAS-CSDP* was five percent higher than the *SHON* in the absence of the flat deduction.

distribution will be smooth at all moments except at the policy threshold.

Figure B.1: Smoothed data moments



I smooth out the housing space distribution by estimating two regressions, one above and one below the notch. Let n_b be the number of houses in bin $b \in 60,450$ and T be a vector of numbers which are multiples of 10. The regressions to be estimated take the form

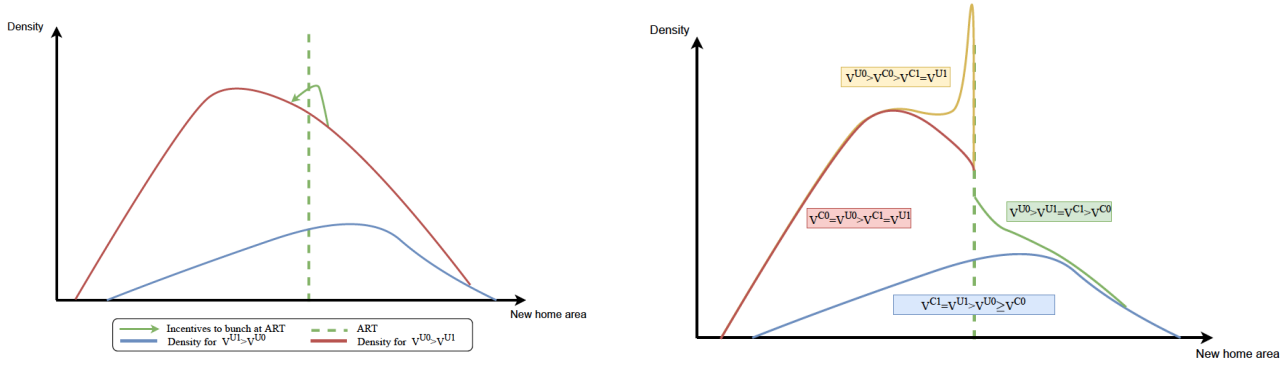
$$n_b = \sum_{p=1}^{P=10} \beta_p b^p + \sum_{t \in T} \zeta_t \mathbb{I}\{\frac{b}{t} \in \mathbf{N}\} + \sum_{k=0}^{2} \gamma_k \{b = \bar{h} - k \ + \varepsilon_b \tag{9}$$

where the first summation is a P-order polynomial and the second is a vector of dummies for multiples of 5, so $t = 5$. We select $P = 10$ since this polynomial matches actual moments well, especially around the notch. As in Carril, 2019, I take the prediction from these the two regressions, leaving out the contribution from the dummies for multiples of 5. The smoothed distributions above and below the policy threshold are then adjusted by a fixed factor so that the number of observations in the smoothed distributions match that of the actual data. Specifically,

$$\hat{n_b}^{smoothed} = \begin{cases} \hat{n_b}^{pred} \frac{\sum_{b=60}^{168} n_b}{\sum_{b=60}^{168} \hat{n_b}^{pred}} & \text{if b} \in 60, ..., 169 \\ \hat{n_b}^{pred} \frac{\sum_{b=170}^{450} n_b}{\sum_{b=70}^{450} \hat{n_b}^{pred}} & \text{if b} \in 170, ..., 450 \end{cases} \tag{10}$$

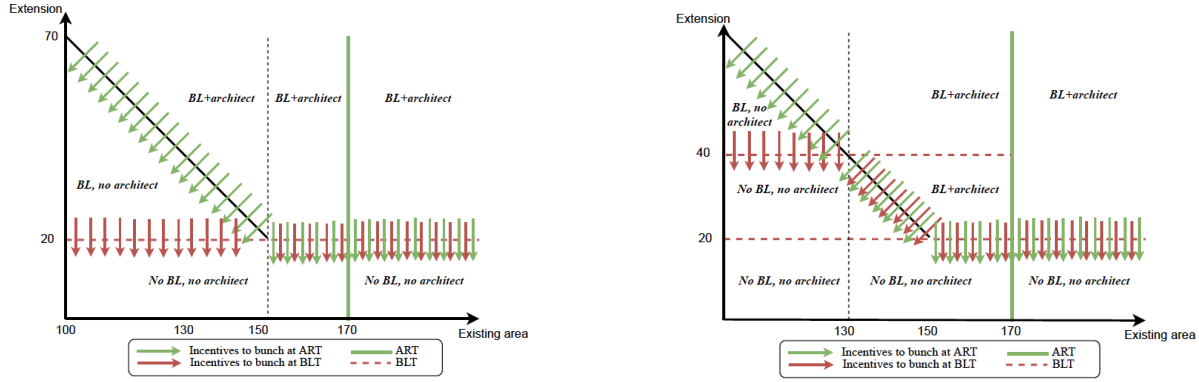
where $\hat{n_b}^{pred}$ represents the predicted frequency counts. We obtain the set of simulated moments by normalizing this smoothed distribution. Figure B.1 below plots the actual data moments and the smoothed data moments.

C Additional figures



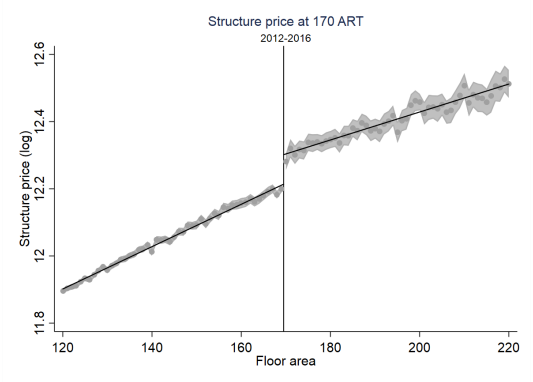
(a) Counter-factual case (b) With the attribute-based regulation

Figure C.1: **Stylized description of the quantity-quality trade-off model outcomes** The figure describes graphically the constrained choices (denoted by C) and incentives to bunch at the *ART* for both types of households (architect users, denoted by 1, and non-users, denoted by 0), depending on whether their unconstrained choices, denoted by U, would involve the use of an architect or not, as described in section 3.

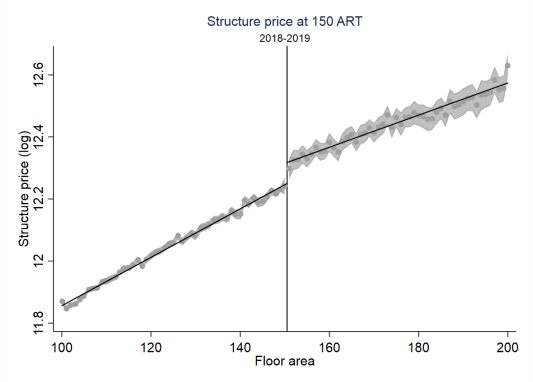


(a) Non-urban areas (b) Urban areas

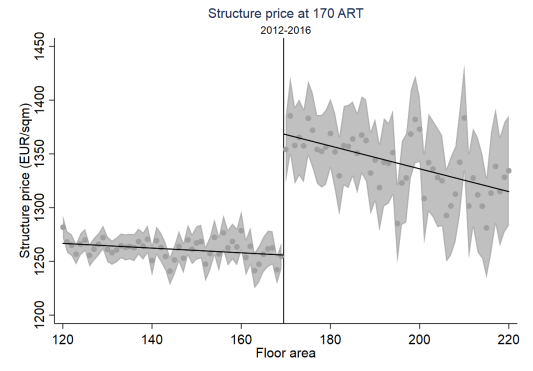
Figure C.2: **Incentives for additions to existing units, 2012-2017** The figure describes graphically the incentives to bunch the size of the addition to an existing home either at the *building license* threshold $\bar{h}$, or at exactly the difference between the *ART* h^* and the existing size h^E, as described in section 2, for homes of various sizes. Panel (a) presents the case of non-urban areas, where the building license threshold is 20 square meters, while panel (b) presents the case of urban areas (after 2012), where the BL threshold is 40 square meters, except for extensions that would drive the completed size $h^E + h^N$ above the *ART*.



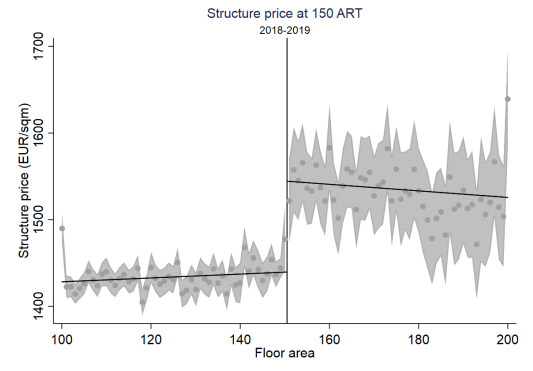
(a) 2012-2016, 170 sq.m. ART



(b) Post-2018, 150 sq.m. ART

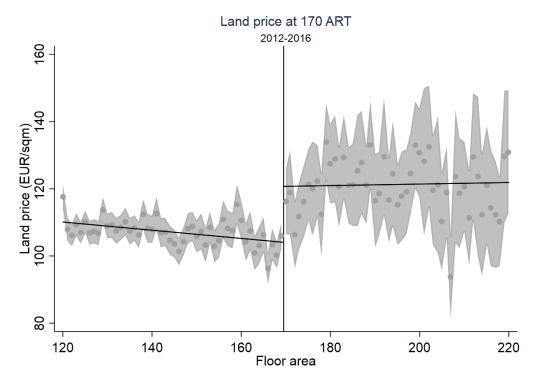


(c) 2012-2016, 170 sq.m. ART

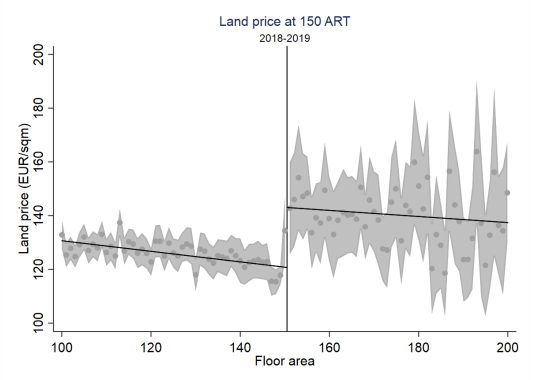


(d) Post-2018, 150 sq.m. ART

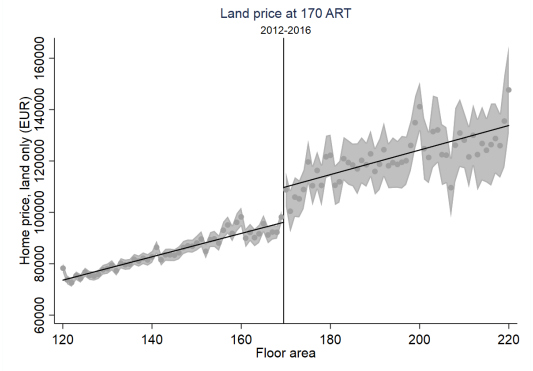
Figure C.3: **Construction cost for new units** The figure plots a binned scatter plot of the construction cost (only including structure price) of new units against their square footage (*SDP*) for new units with approved building licenses in the EPTB data. Panel (a) plots the discontinuity in log points at the 170 square meters mark in the 2012-2016 data, while panel (b) plots the discontinuity at 150 square meters after 2018. Panels (c) and (d) plot the discontinuity in EUR/sq.m. of *SDP* around the same thresholds for the same periods.



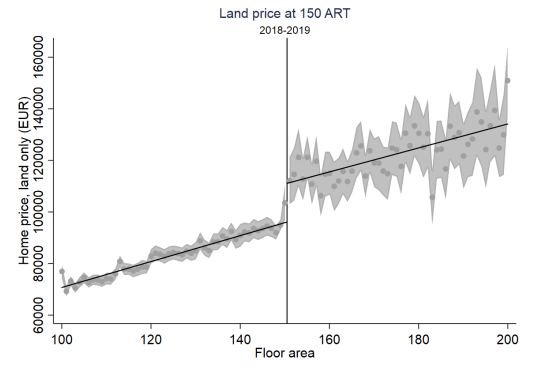
(a) 2012-2016, 170 sq.m. ART



(b) Post-2018, 150 sq.m. ART

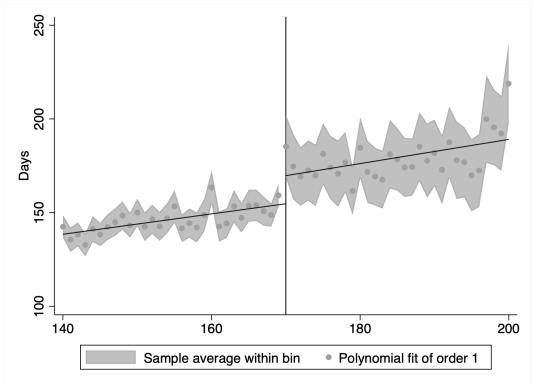


(c) 2012-2016, 170 sq.m. ART

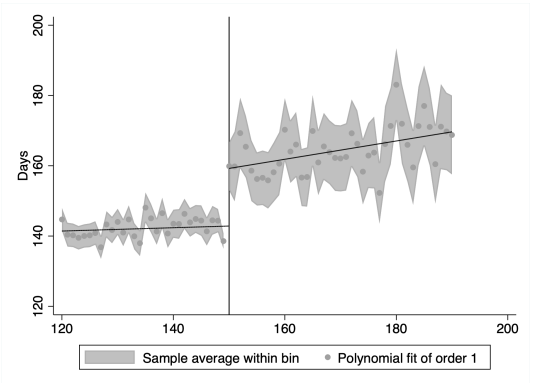


(d) Post-2018, 150 sq.m. ART

Figure C.4: **Land prices for new units** The figure plots a binned scatter plot of the cost of land for new units against the square footage of the structure (*SDP*) for new units with approved building licenses in the EPTB data. Panel (a) plots the discontinuity in EUR/sq.m. of land at the 170 square meters (of structure) mark in the 2012-2016 data, while panel (b) plots the discontinuity at 150 square meters after 2018. Panels (c) and (d) plot the discontinuity in overall land costs around the same thresholds for the same periods.

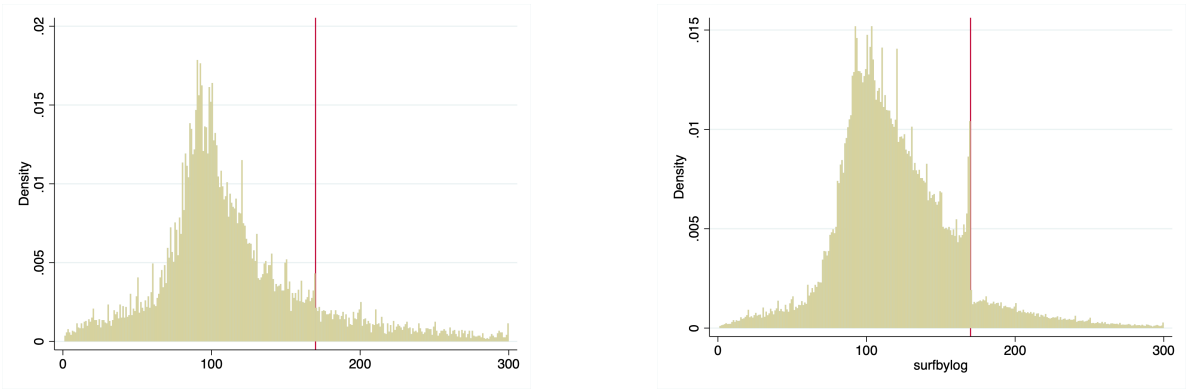


(a) 2012-2016, 170 sq.m. ART



(b) Post-2018, 150 sq.m. ART

Figure C.5: **Construction delays for new units** The figure plots a binned scatter plot of the construction delay (computed as the difference between the initial approval date of the building license and the stated start of construction works) of new units against their square footage (*SDP*) for new units with approved building licenses in the Sitadel data. Panel (a) plots the discontinuity in days at the 170 square meters mark in the 2012-2016 data, while panel (b) plots the discontinuity at 150 square meters after 2018.



(a) Juridical persons (b) Natural persons

Figure C.6: **Distribution of the size of newly built units, 2013-2016** The figure plots the distribution of the square footage (*SHON*) of new units built, respectively, by juridical persons (for whom no exemption exists) in panel (a), and by natural persons (for whom the ART applies) in panel (b), for approved building licenses from 2007 to 2011 in the Sit@del data. The histogram corresponds to the counts of units in each square meter bin.

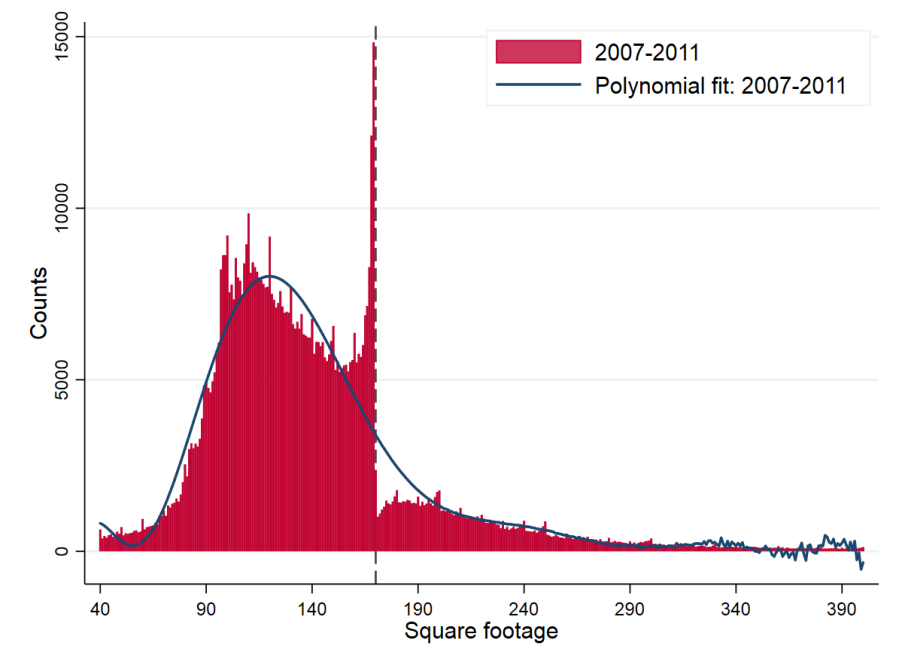


Figure C.7: **Distribution of the size of newly built units, 2007-2011** The figure plots the distribution of the square footage (*SHON*) of new units with approved building licenses from 2007 to 2011 in the Sit@del data. The histogram corresponds to the counts of units in each square meter bin, while the solid line plots a polynomial fit of order 10 excluding the manipulation range, according to the methodology defined in section 3.

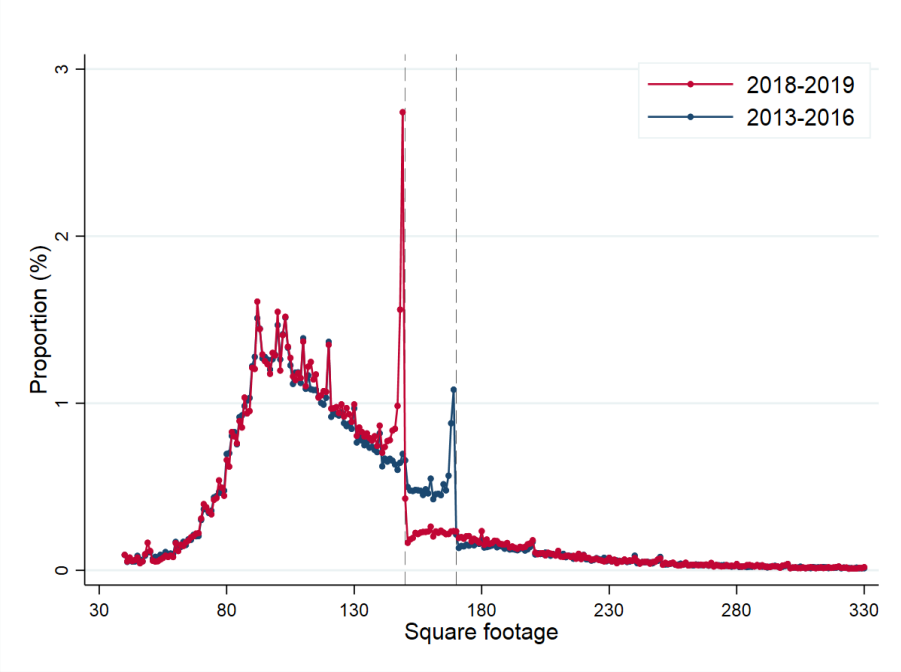


Figure C.8: **Distribution of the size of newly built units, 2017 reform** The figure plots the distribution of the square footage (*SDP*) of new units with approved building licenses from 2018 to 2019 (red line), and from 2013 to 2016 (blue line) in the Sit@del data. The ART was lowered to 150 square meters in 2017, down from its earlier value of 170 square meters, as described in 2.1.

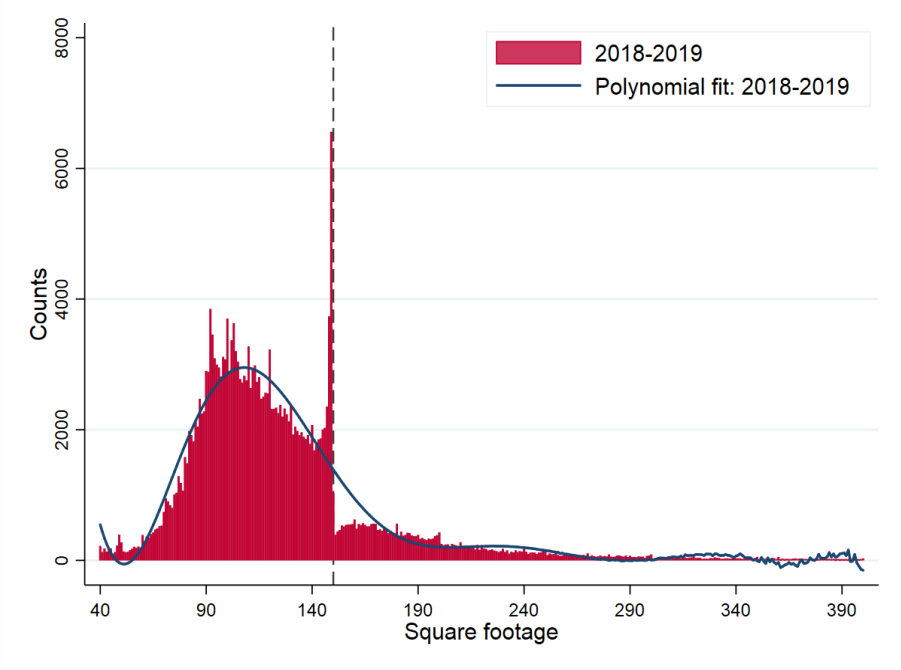


Figure C.9: **Distribution of the size of newly built units, after the 2017 reform** The figure plots the distribution of the square footage (*SDP*) of new units with approved building licenses from 2018 to 2019 in the Sit@del data. The histogram corresponds to the counts of units in each square meter bin, while the solid line plots a polynomial fit of order 10 excluding the manipulation range, according to the methodology defined in section 3.

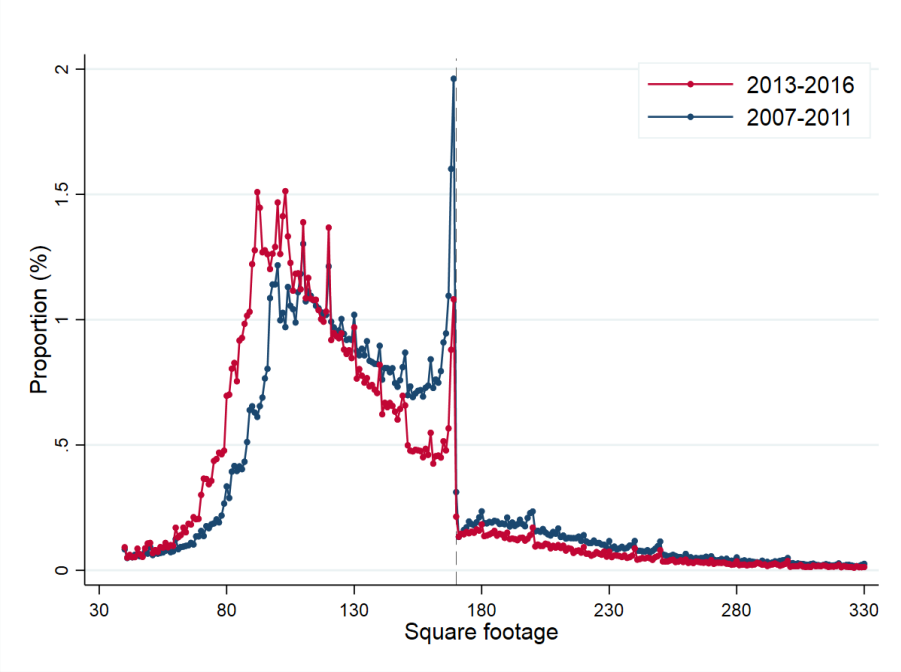
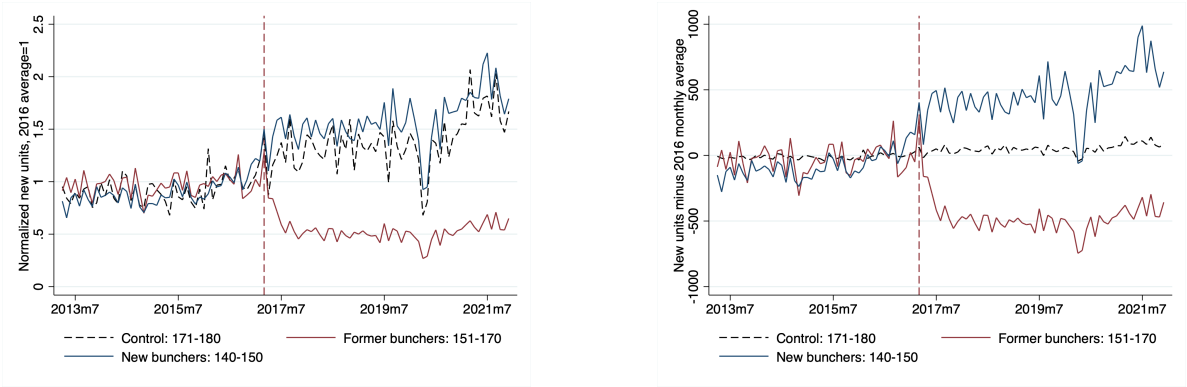


Figure C.10: **Impact of the 2012 change in definition on the size distribution for new units** The figure plots the distribution of the square footage (*SHON*) of new units with approved building licenses from 2007 to 2011 (blue line), and the floor area (*SDP*) of new units built from 2013 to 2016 (red line) in the Sit@del data. The change in computation from the *SHON* to the *SDP*, as described in 2.1, shifted the distribution of unit sizes leftwards, and made the 170 square meters ART less likely to bind when expressed in terms of *SDP* than in terms of *SHON*.



(a) Relative changes

(b) Absolute changes

Figure C.11: **Impact of the 2017 reform on the size distribution for new units** The figure plots the impact of the 2017 lowering of the *ART* from 170 square meters to 150 square meters for the relative (in panel (a)) and absolute (panel (b)) number of new units built in three size categories: former bunchers (150-170), new bunchers (140-150), and control (171-180), in the Sit@del data.

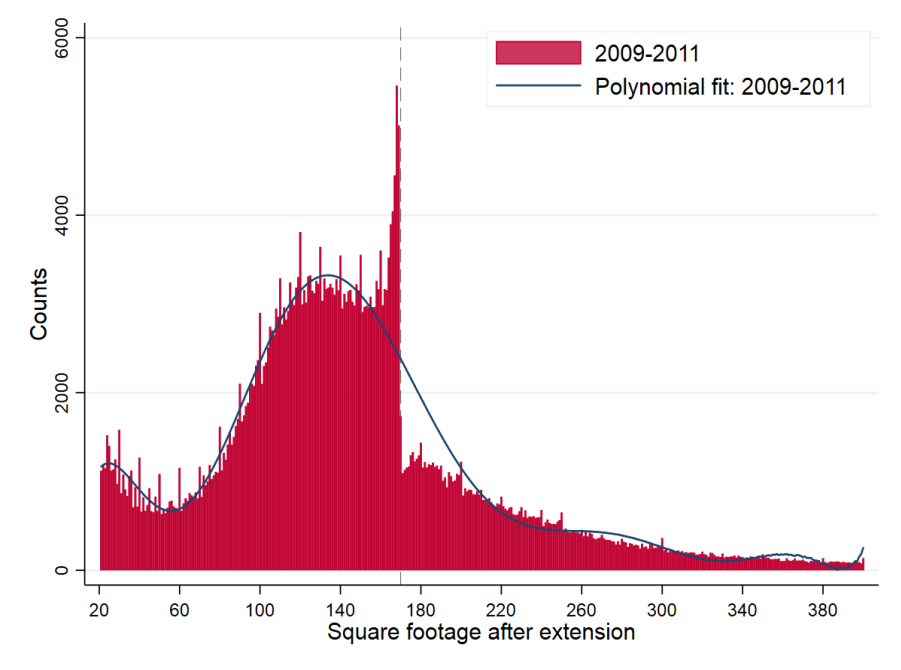


Figure C.12: **Distribution of the size of completed units for extensions, 2009-2011** The figure plots the distribution of the square footage (*SHON*) of completed units after extension projects, from 2009 to 2011 in the Sit@del data. The histogram corresponds to the counts of units for which the size of the completed, post-extension dwelling falls in each square meter bin in the 2009-2011 period, while the solid line plots a polynomial fit of order 10 excluding the manipulation range, according to the methodology defined in section 3.

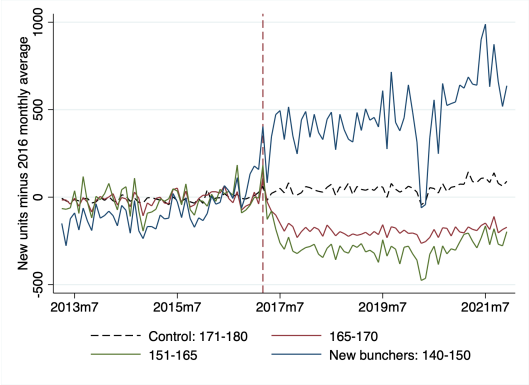


Figure C.13: **Impact of the 2017 reform on the size distribution for new units** The figure plots the impact of the 2017 lowering of the *ART* from 170 square meters to 150 square meters for the absolute number of new units built in four size categories: former likely non-bunchers in new bunching region (150-164), former likely bunchers (165-170), new bunchers (140-150), and control (171-180), in the Sit@del data.

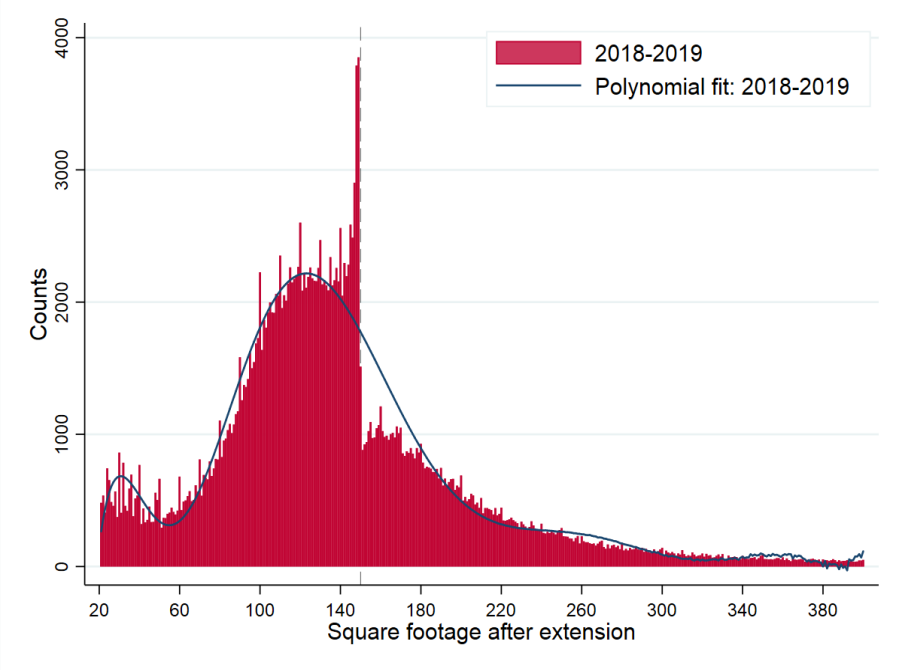


Figure C.14: **Distribution of the size of completed units for extensions, 2018-2019** The figure plots the distribution of the square footage (*SDP*) of completed units after extension projects, from 2018 to 2019 in the Sit@del data. The histogram corresponds to the counts of units for which the size of the completed, post-extension dwelling falls in each square meter bin in the 2018-2019 period, while the solid line plots a polynomial fit of order 10 excluding the manipulation range, according to the methodology defined in section 3.

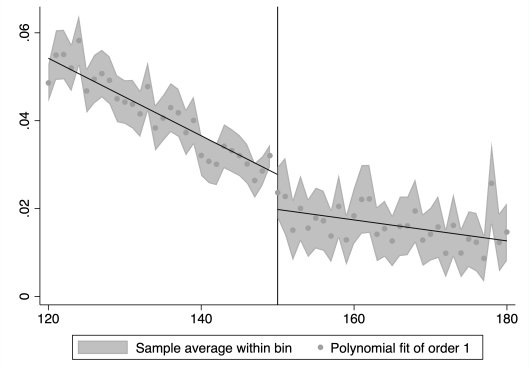
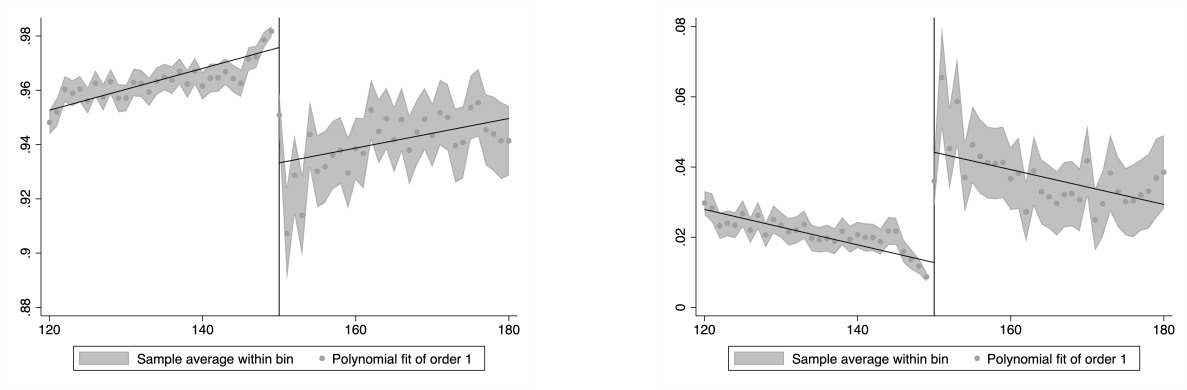


Figure C.15: **Share with means-tested zero-interest loans** The figure plots the share of households who received a means-tested zero interest loan for their construction project, for each bin of square footage of new units, after the threshold was lowered to 150 square meters, in the Sitadel data.



(a) Filer is an individual

(b) Filer is a developer

Figure C.16: **Household characteristics around the threshold, post-2018** The figure plots the share of households who file by themselves (left panel) and the share resorting to a developer, for each bin of square footage of new units, after the threshold was lowered to 150 square meters, in the Sitadel data.

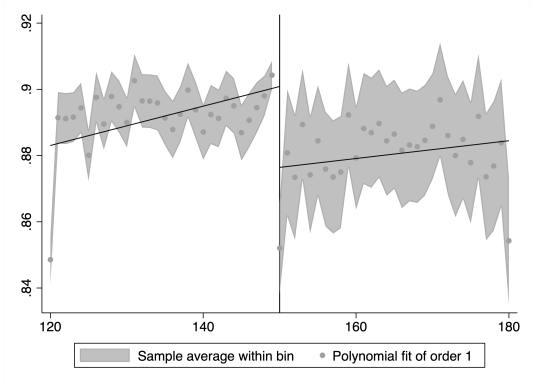


Figure C.17: **Primary home designation** The figure plots the share of units designed to be used as the household's primary home, for each bin of square footage of new units, after the threshold was lowered to 150 square meters, in the EPTB data.

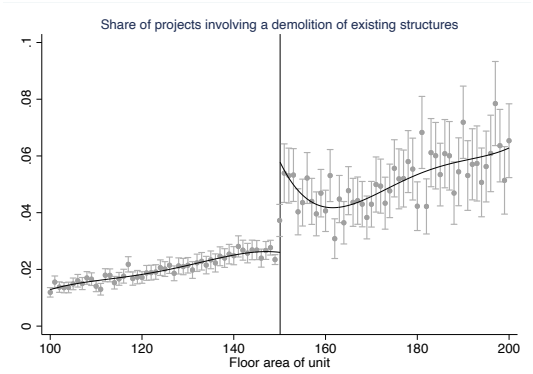


Figure C.18: **Share of projects involving a demolition** The figure plots the share of construction projects involving a demolition of existing structures, for each bin of square footage of new units, after the threshold was lowered to 150 square meters, in the Sitadel data.

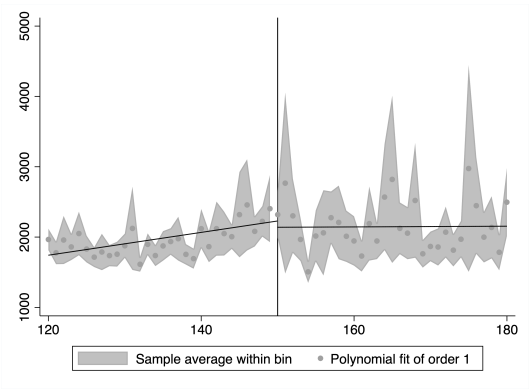


Figure C.19: **Average lot area** The figure plots the average land area of construction projects, for each bin of square footage of new units, after the threshold was lowered to 150 square meters, in the Sitadel data.

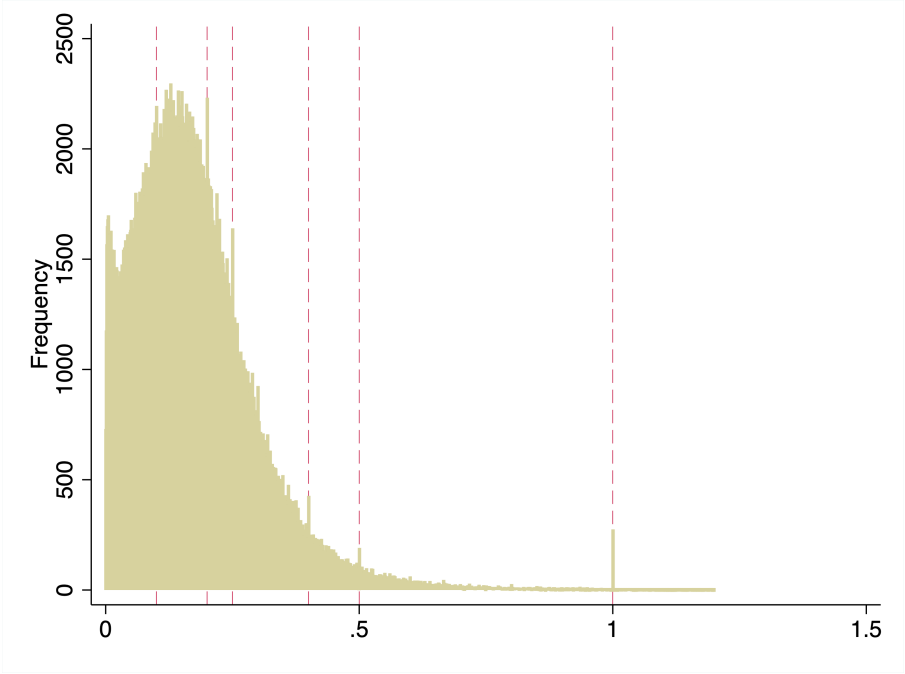
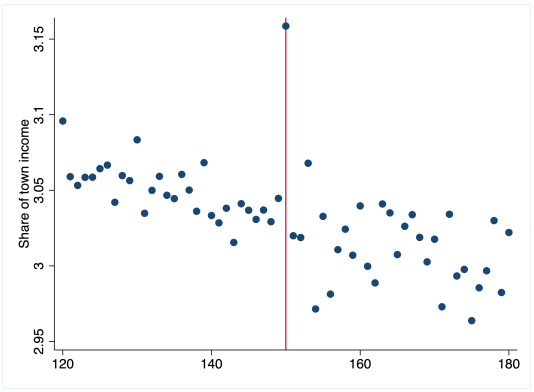
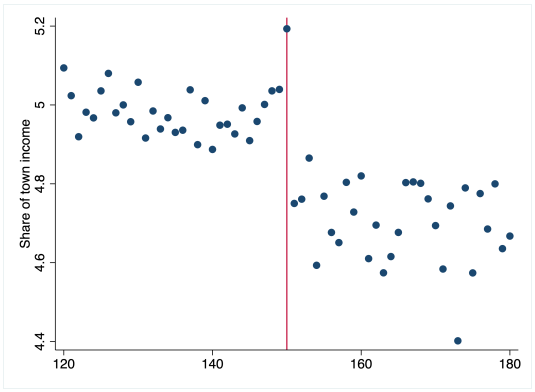


Figure C.20: **Distribution of the built-area ratio of new units, 2018-2019** The figure plots the distribution of the ratio of the square footage (*SDP*) to lot area for new units, from 2018 to 2019 in the Sit@del data. The histogram corresponds to the counts of units in each 0.001 width bin, while the vertical bars document common local binding built-area maximum ratios (0.1, 0.2, 0.25, 0.4, 0.5).

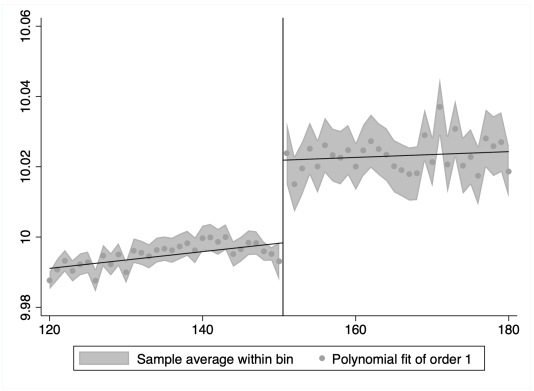


(a) Unemployment benefit share

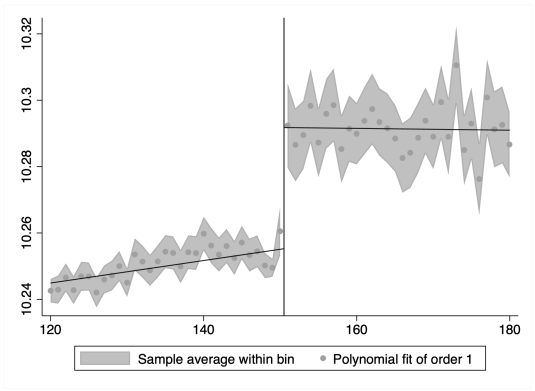


(b) Other social benefits share

Figure C.21: **Share of income in town derived from social transfers** The figure plots the average share of overall income in the town received, respectively from unemployment insurance (panel A) and from other social transfers (panel B), for each bin of square footage of new units, after the threshold was lowered to 150 square meters, in the Sitadel and *Filosofi* 2017 data.

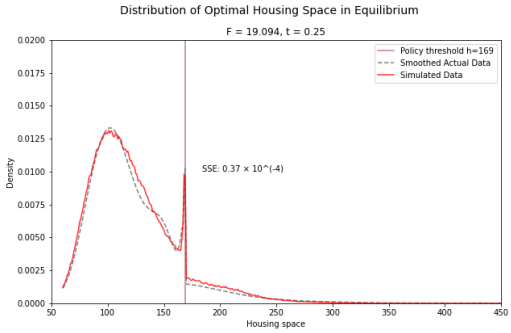


(a) Log Q2, income distribution

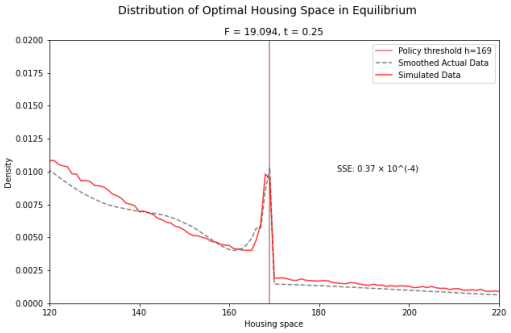


(b) Log Q3, income distribution

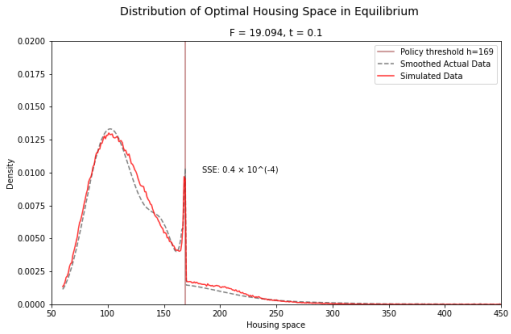
Figure C.22: **Town incomes, median and third quartile** The figure plots the average median and third quartile of the income distribution of the towns for each bin of square footage of new units, after the threshold was lowered to 150 square meters, in the Sitadel and *Filosofi* 2017 data.



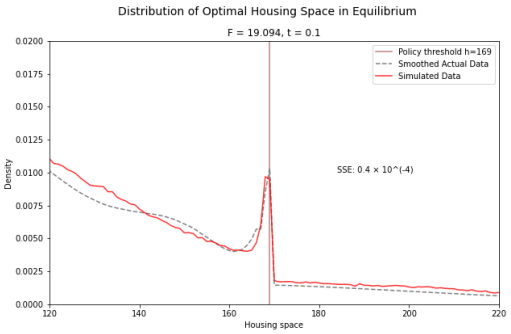
(a) t=0.25



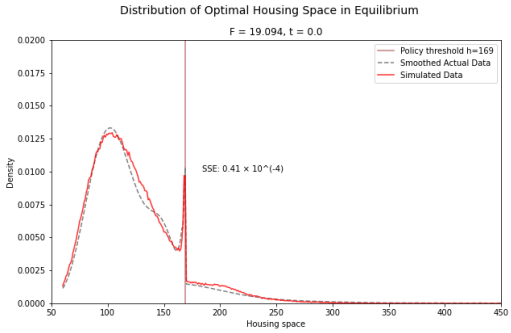
(b) t=0.25



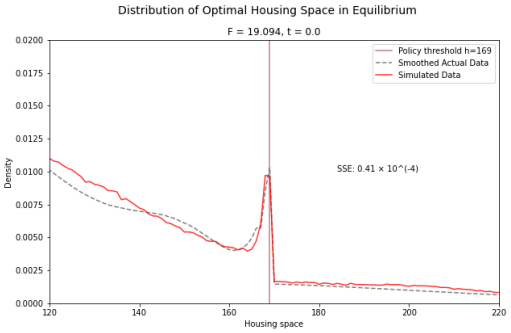
(c) t=0.10



(d) t=0.10

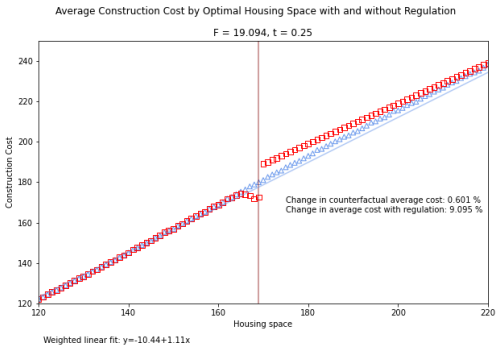


(e) t=0.0

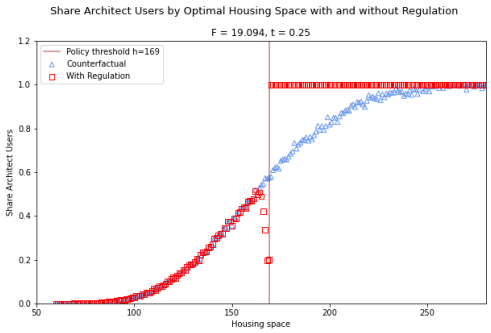


(f) t=0.0

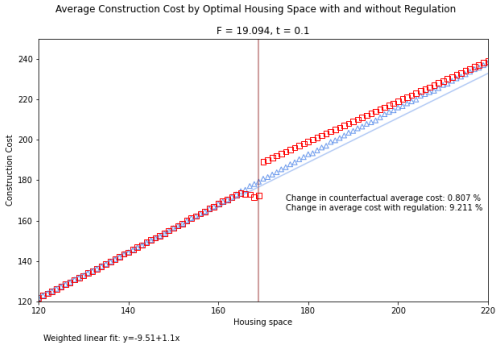
Figure C.23: **Model fit** Note: This figure plots the simulated distributions (colored lines) using structural parameters estimated via the method of simulated moments and the smoothed data distribution (grey dashed lines). The left panel shows the entire distribution of housing space, while the right panel focuses on the part of the distribution around the policy threshold. The set of estimated parameters used is $\widehat{\Theta}$ where $F = 19.094$. We simulate 30,000 households in a distribution and take the average of the simulated moments across 20 distributions. The weighting matrix used gives more weight to housing space bins near the policy threshold.



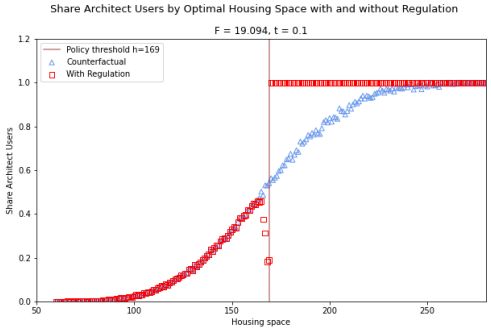
(a) Average construction cost, t=0.25



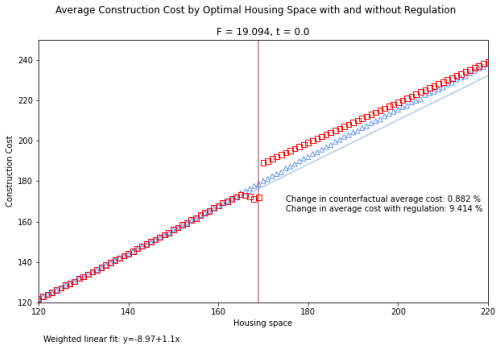
(b) Average share architect users, t=0.25



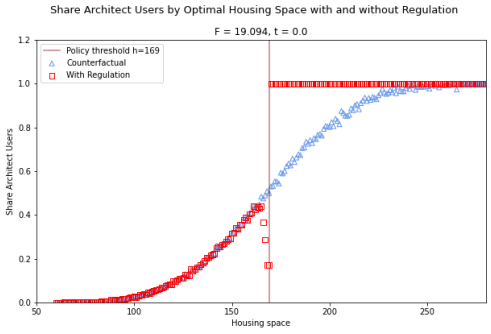
(c) Average construction cost, t=0.10



(d) Average share architect users, t=0.10



(e) Average construction cost, t=0.0



(f) Average share architect users, t=0.0

Figure C.24: **Model simulation** This figure plots simulated average costs and simulated share of architect users for each bin of housing space. The set of estimated parameters used is $\widehat{\Theta}$ where $F = 19.094$. I simulate 30,000 households in a distribution and take the average of the simulated moments across 20 distributions. The weighting matrix used gives more weight to housing space bins near the policy threshold.