Supply and Demand Responses to a Tax on Rental Housing: Evidence from Iran

David Albouy*
University of Illinois

Carlos Hurtado†
University of Richmond

Kaveh Nafari‡
Deloitte

July 21, 2021

Abstract

We use a unique administrative dataset on housing transactions in Tehran to provide evidence on the incidence and distortionary effects of taxes on rental properties. We exploit a particular feature of the tax code in the Tehran rental market, where the tax-exemption threshold depends on the property's size. Substantial bunching occurs below the tax cutoff, suggesting strong behavioral responses to the tax kink. We also find higher after-tax rents above the kink. Based on these variations, we develop a structural framework with property taxes and filing costs to estimate the price elasticities of housing size supply and demand. We estimate a mid-run (10-year) price elasticity of housing size supply of 1.36 and price elasticity of housing size demand of -0.17. We find high, but incomplete pass-through of the rental tax, implying that renters bear most filing costs.

Keywords: Housing Supply, Behavioral Responses, Tax Kinks, Structural Estimation
JEL Classification Numbers: R13, R31, R32, H22, H30, L23

*Department of Economics, University of Illinois at Urbana-Champaign, 214 David Kinley Hall, 1407 West Gregory Drive, Urbana, IL 61801, USA.Email: albouy@illinois.edu.

†Economics Department, Robins School of Business, 102 UR Drive, University of Richmond, VA 23173, USA. Email: churtado@richmond.edu.

‡Corresponding author. This paper previously circulated as "Behavioral Responses to the Tax Kinks in the Rental Housing Market: Evidence from Iran". Email: knafari@deloitte.com

1 Introduction

A large body of literature in public finance estimates structural parameters to measure behavioral responses to taxation. The majority of these studies consider supply or demand in isolation, assuming the other side of the market is perfectly elastic. This assumption is standard for the analysis of the housing market because most of the literature generally neglects the relationship between property taxes and housing supply (Lutz, 2015). Biased estimates of the structural parameters may result from such an assumption because the supply and demand responses to taxes show association with the share of the tax burden, not the full burden. This paper develops a structural model to estimate the price elasticities of housing size supply and demand simultaneously. Based on these estimates, we answer the classic question: "Who bears the property tax?"

A central challenge in estimating separate price elasticities of supply and demand is the requirement of observed tax-induced variations in both quantity and price. In the case of the latter, it involves the identification of how changes in taxes pass-through to producers and consumers. For example, consider an increase in the taxes on supply that does not pass-through to prices fully. Since demand responses correlate with the share of the tax burden that falls on them, estimation of the price elasticity of demand based on full pass-through can be downward biased. Pass-through hence is a key in determining elasticities, yet it is not straightforward to measure.

This study examines responses to taxation on rental properties using a distinctive feature of the tax code in Tehran, where taxes on owners depend on the size of their property. Specifically, the owner's tax liability becomes positive when the total cumulative size of her rental properties exceeds 150 m^2 ($\approx$ 1600 ft^2). This policy took place in 2001. Moreover, in Tehran, paying rental property taxes requires a specific filing process, different from filing income taxes.[1] Owners with zero rental income tax liability do not have to file taxes. Therefore, when the total size of owners' rental properties surpasses 150 m^2, the costs of filing taxes become positive for them.[2] In this analysis, we use a unique administrative dataset that includes over 600,000 rental and purchasing transactions in Tehran from 2012 to 2014. Tehran's rental market provides an advantageous setting because the quasi-experimental variation in rental prices around the cutoff allows for quantifying the extent to which the tax burden passes to renters.

We develop a theoretical framework in which taxes are on owners and depend on the

[1] Wage earners are exempt from filing income taxes.

[2] This contrasts with tax systems in the majority of developed countries where taxpayers file taxes even if they do not owe any taxes.

size of the rental unit. With our model, we capture the demand and supply responses to a discrete change in the marginal tax rates (a kink) on rental properties of a specific size, which we refer to as the "size kink" This framework allows for passing forward some of the tax burden to renters via higher rents. Moreover, it allows for tax-induced changes in the number of properties around the size kink. Also, we address the hassle costs of complying with taxes by assuming that this size kink adds extra costs for filing taxes in addition to owners' tax liability.

In our setup, two elements define the total tax liability: the fixed costs of filing taxes, and the marginal taxes on rental income. On the demand side, we identify renters' responses to taxation by assuming that renters only observe policy-induced changes in the rental prices above the cutoff. This model predicts that the size kink creates an incentive for both owners and renters to move from above the size kink, and locate at the tax-favored side or, in other words, to exhibit "bunching behavior." we show that the amount of bunching, the filing costs, and the policy-induced changes in the rent can characterize price elasticities of housing size supply and demand.

For the empirical analysis, we apply the structural model to Tehran rental market to identify price elasticities and pass-through rates. First, we estimate the discrete increase in the rent-value right above the size kink and the change in rent per square meters further away from the kink to identify filing costs and rent responses. The quasi-experimental design allows for using the average rent of properties below 150 m2 as a valid counterfactual for apartments above 150 m^2. The results present significantly higher rent (approximately 3.9 percent) right above the size kink in response to the filing costs. The results also show that a one square meter increase in rent per square meter above the cutoff is associated with 3,700 to 4,300 Rials (roughly $1 in 2015 dollars) increase in rent per square meter. Second, we estimate the excess bunching, defined as the difference between the empirical and counterfactual densities in the small interval below the size kink as in Saez (2010) and Kleven and Waseem (2013). The results indicate substantial bunching below the cutoff, suggesting strong behavioral responses to the size kink. We find evidence on heterogeneity by age and neighborhoods, with stronger responses for "old apartments" and low rent neighborhoods.

We find significant price elasticities of housing size supply, ranging from 0.243 to 0.616, and significant but small in magnitudes elasticities of demand, ranging from -0.015 to -0.025. To alleviate the effects of market frictions, we use the measure of bunching for the subsample of newly built properties for which owners can take into account tax policy before choosing the size of their properties. While the estimated price elasticities of housing size supply from the representative of the "frictionless" market are roughly two to six times bigger, elasticities of housing demand are at least ten times larger, ranging from 0.172 to 0.365. Estimation of the pass-through rate for the frictionless market shows that the majority of the economic incidence of taxation passes to renters in the form of higher rents.[3] Overall, the results provide clear evidence of bunching, substantial frictions, and higher after-tax rent, implying that size-based taxation on rental properties is highly regressive and distortionary.

This paper builds on and contributes to a growing body of literature on the distortionary effects of discrete changes in the marginal and proportional taxes. The existing literature estimates demand and supply responses in isolation. However, the main contribution of this paper is to develop a framework that incorporates pass-through of taxes and costs of filing them to estimate price elasticities of housing size demand and supply simultaneously.

Recent literature documents behavioral responses to taxes and transfers using bunching techniques (Saez, 2010; Chetty et al., 2011; Kleven and Waseem, 2013). A small body of work has also studied sources of frictions and has pursued different approaches to account for them (Chetty, 2009; Chetty et al., 2011; Chetty and Saez, 2013; Kleven and Waseem, 2013; Gelber et al., 2013). This literature typically concentrates on one side of the market, assuming the other side is perfectly elastic, which implies a complete pass-through of taxes.[4] This study adds to the existing literature by considering both supply and demand responses simultaneously.[5] This paper also provides quasi-experimental evidence, plausibly hinging on fewer modeling assumptions than elsewhere in the literature regarding the effects of frictions on the housing market's responses to property taxes.

Another strand of literature to which this paper relates uses transaction taxes to analyze behavioral responses to tax policies in the housing market (Kopczuk and Munroe, 2015; Slemrod et al., 2017; Best and Kleven, 2017). This paper departs from this literature by focusing on property taxes, which, compared to transaction taxes, represent a long-term tax commitment, and thus, arguably reveal long-run behavioral responses. Property taxes are also one of the primary sources of tax revenue for governments.[6] Also, this study analyzes the effects of taxes in the rental market, a subject targeted by a variety of urban policies, but one that remains understudied by the literature. The findings of strong evidence of pass-through of taxes to renters imply a regressive distributional burden. This finding of pass-through of taxes to renters is different from the incidence of transaction taxes (e.g.,

[3] In this study tax-incidence is defined as the ratio between the changes in consumer surplus and the changes in producer surplus due to a tax.

[4] Saez et al. (2012) mentions that studies on payroll taxes and income-tax reform typically assume employees bear the full tax burden.

[5] Several studies have recently examined the supply of housing and urban dynamics. See Green et al. (2005), Glaeser et al. (2005), Astyk et al. (2010), and Saiz (2010).

[6] In 2012, in the United States, transfer taxes compromise less than 2 percent of the total state tax revenues, while property taxes generated over $480 billion dollars (Census Bureau, Quarterly Sum of State and Local Tax Revenue).

Besley et al. (2014)) where both buyers and sellers are arguably from the same quantile of the income distribution.[7] Lastly, in contrast to the existing literature that focuses on developed countries (e.g., the United States and the United Kingdom), this paper provides evidence of behavioral responses to taxes in the housing market for an emerging country where raising tax revenue is more of an issue for policymakers.

A few other studies have documented estimates of the costs of filing taxes.[8] Benzarti (2015) suggests that the total burden of filing income taxes in the United States amounts to 1.25 percent of GDP.Kleven and Kopczuk (2011) model administrative hassle as a policymakers' instrument to screen out individuals with higher opportunity costs. Ramnath and Tong (2017) show that monetary incentives to file tax returns significantly increase individuals' participation in the tax system and increase their welfare in the long run. However, to our knowledge, no literature considers the pass-through burden of filing taxes - in particular, for property taxes. Our results suggest that renters bear the majority of the burden of complying with rental property taxes.

This paper is also related to relevant literature on the incidence of property taxes (Simon, 1943; Mieszkowski, 1972; Hamilton, 1976; Fullerton and Metcalf, 2002). Although, a large body of theoretical work attempts to find ways to choose between "old," "benefit," and "new" views, only a tiny body of empirical work addresses the effects of property taxes on rental housing (Carroll and Yinger, 1994; Muthitacharoen and Zodrow, 2012). To the best of our knowledge, this paper is the first to combine micro administrative data on rental properties with policy-induced quasi-experimental variation to analyze the incidence of property taxes. We find renters bear most of the costs of the policy. This result is of relevance because, in comparison to owners, renters usually are at the left side of the income distribution.[9]

The paper proceeds as follows. Section 2 describes the data sources and overviews the policy. Section 3 develops the theoretical framework. Section 4 describes the empirical methodology. Section 5 presents the results, and Section 6 concludes.

2 Data and Background

Taxes on rental properties are common around the world, however, tax policy on rental properties in Tehran is unusual because the tax depends on both the size of properties and

[7] In 2014, in the United States, renters' median income was $33,219, compared to $68,142 for owners (American Community Survey Five-Year Estimates). Accessed 7/4/2016.

[8] Slemrod (1989) and Benzarti (2015)

[9] Median household income in 2014 (in the United States) was $53,482.

their rental income.[10] This policy was implemented in 2001. Figure 1.1 presents the average annual tax paid with respect to size. Taxes are applied to properties located at the right side of the solid line; the taxes depend on the extra rental income, defined as the annual rental income gained from extra square meters above 150 m^2. Based on regulations enforced by the Iranian National Tax Administration (INTA), the policy is progressive, ranging from a low of 15 percent for an extra rental income less than or equal to 30 million Rials (approximately $857 in 2015 USD) to a high of 35 percent for part of an extra income that is over 1,000 million Rials (approximately $28,571 in 2015 USD). Paying rental property taxes requires a specific filing process, different from filing income taxes and owners with zero rental income tax liability are exempted from filing. Table 1.1 shows the percentage of tax that owners pay on their annual rental income for each tax bracket in which they qualify.

The primary data used in this paper are obtained from the Rahbar Informatics Services Company (RISC). Since 2009, the law requires all purchasing and rental transactions to be registered online.[11] Nearly all rental properties in Tehran are owned individually. Therefore, an owner typically leases her rental property through real estate agencies. If the owner and renter reach an agreement, the real estate agent will fill out specific forms online, including information such as rent or price, full address of the unit, size, age, ZIP Code, and date of contract.[12] we also used records on historical real estate listings in Tehran that come from *Iranfile* website, which is the largest real estate portal in Iran.[13] These records contain rich details of each listing, including the number of stories in the building, number of units in each floor, facing direction of the unit, kitchen materials (e.g., steel, wood, MDF, etc.), flooring (e.g. parquet, stone, ceramic, carpet, etc.), building façade materials, years since construction, floor number, number of bedrooms.[14]

Since owners of two or more rental properties respond to the size kink at 150 m^2 based on the total combined size of all their properties, one potential concern is that the observed distribution of properties does not capture all behavioral responses. The reason is that the multiple-rental-property owners remain unresponsive to the size kink at 150m^2. However, the aggregate data on homeownership in Tehran shows that only 4 percent of rental properties belong to owners who possess more than one property.[15] Therefore, their impacts on our

[10] Law of direct taxes 53-11 (http://download.tax.gov.ir/GeneralDownloads/DirectTaxLaw.pdf) Accessed 7/24/2016.

[11] http://www.iranamlaak.ir/Files/TasvibNameh.aspx

[12] Although personal information of the owner (seller) and tenant (buyer) are recorded, for reasons of confidentiality the provided data do not include this information. See Appendix A for more detail.

[13] www.iranfile.ir

[14] It also has information on number of phone lines, number of parking, storage, and balcony, type of heating/cooling system, and whether the building has elevator, yard, backyard, pool, sauna, and Jacuzzi.

[15] Rahbar Informatics Services Company (RISC) has provided this number by summarizing number of different rental transactions in each year for each owner, using owner's unique identification number.

estimations are negligible.

The raw data include 278,473 rental and 371,904 purchasing observations during the years 2012 – 2014. In the final data, we exclude transactions for which complete information is not available along with all nonresidential and non-apartment transactions.[16] Observations that the district number does not match with the Zip Code, possibly due to data-entering mistakes, are excluded as well. Moreover, to rule out the effects of outliers, we trim observations where the rent and price per square meter are in the least 1 percent and beyond the 99 percent levels. The final sample includes 243,144 rental and 344,774 purchasing observations from 2012 to 2014. Figure 2 shows the distribution of observations across Tehran to examine whether the RISC dataset is representative of the universe of properties in Tehran. As can be seen in Figure 1.2, each panel contains at least 2,800 housing observations for each of the 22 districts, indicating that the data are representative of nearly all neighborhoods.[17]

Another concern is misreporting of size by owners in order to evade taxation. Because owner-occupied units are exempted from taxation, there is no clear incentive for owners to misreport the size when they sell their properties.[18] Therefore, one way to test for misreporting is to check whether the reported sizes match in both rental and purchasing data. In doing so, we merge the two datasets on the basis of 10-digit ZIP Code, district, and floor number. The matched data, composed of the high-quality matches that result via this method, include 64,677 unique observations. we focus on properties in the proximity of the size kink $(140m^2, 150m^2]$, where the probability of misreporting is expected to be high. The matched data reveal that for over 87 percent of observations the reported size for the rental transaction is exactly the same as for the purchased one. More importantly, for only 4 percent of rental observations in $(140m^2, 150m^2]$ is the reported size for the purchasing transactions over $150m^2$, which suggests that owners do not strategically underreport the size of their rental properties.

Table 2 shows summary statistics for rental transactions. Although median size is well below the cutoff ($150m^2$), several thousand rental transactions are within 10 m^2 of the size-threshold. The jump in the average rent-value per square meter right above the size-threshold is evident here, as is the dwindling number of observations. Note that, median age of properties is 11 years, which implies the majority of constructions are fairly new in Tehran.

[16] An apartment in this study is defined as a unit that is owned individually, which is very similar to the definition of a condo in the U.S. housing market.

[17] Tehran is divided into 22 different districts.

[18] Misreporting the size of his rental property at the time of sale is a possible but difficult undertaking for an owner. The seller, buyer and real estate agent have to agree. Moreover, the average price of more than $1,000 per-square-meter serves as a disincentive for the seller to report a size that is smaller than the correct one.

3 Theoretical Framework

This section describes a model of behavioral responses to taxation in the rental-housing market; this motivates and underlies the empirical investigation. We analyze the distortion that a tax kink creates at a particular housing size. We define a *size kink* as an increase in the marginal tax rates on rental properties at a specific size. First, We develop a static model with cost of filing to measure the owners' responses to a size kink. Second, to calculate price elasticity of housing size demand, we construct a model for renters, who optimize their utility based on housing consumption and rent price. Finally, we describe the connection between price elasticities, tax-incidence, and pass-through rates.

3.1 Setup

Consider owners (providers) and renters (tenants) in the rental-housing market. Each owner owns a rental property and maximizes profits by choosing how much housing services to provide (e.g. square meter). Let us denote by s the size of an apartment per-unit of land, which represents units of housing services. Moreover, let us denote by p the gross equilibrium rent price per-unit of size.[19] Under this setup, an owner of a rental property with size s receives a total rent of sp. This analysis allows for heterogeneity on the costs of providing housing services at rent price p. Owners provide housing services using composite materials, M, and land-factor, L, according to a constant returns to scale Cobb-Douglas production function defined by $S(M,L) = AM^{\frac{\eta}{1+\eta}}L^{\frac{1}{1+\eta}}$, where A is a productivity parameter with a smooth density distribution $g(A)$.[20] Intuitively, the productivity parameter controls for qualitative differences such as age, land characteristics, and location across rental properties.

The housing services on a per-unit of land basis are:

$$s(m) = Am^{\frac{\eta}{1+\eta}}, \tag{1}$$

where $m = \frac{M}{L}$. Let us normalize the price per-unit of materials factors to one, and let us denote by r the land factor price. Solving for m in equation (1), the owner's profit per-unit of land is given by: [21]

$$\pi(s) = sp - \left(\frac{s}{A}\right)^{1+\frac{1}{\eta}} - r. \tag{2}$$

[19]In this study, each unit size is one square meter.

[20]It can be shown that given a smooth tax system, the smooth productivity distribution implies a smooth distribution of properties w.r.t size.

[21]For simplicity, we only consider one period by assuming that the discount rate for rental income $\beta = 0$. Considering a richer model with $\beta \neq 0$ only complicates the analysis, and it does not change the quantitative conclusion.

Suppose the introduction of a discrete increase in the marginal tax rate (a kink) for properties bigger than $\underline{s}$. Suppose further that the owners of rental properties larger than $\underline{s}$ pay taxes, τ, on the marginal rental income gained from the extra square meters above this threshold. In response to the size kink, each owner maximizes profits and relocates to the new optimal size in presence of taxes, assuming zero adjustment cost.[22] Moreover, assume that paying taxes adds extra filing costs on owners, denoted by f. Intuitively, the cost of filing taxes captures the aversion to filing taxes, time costs, record keeping, and tax-preparers' fees. We assume that owners with zero tax liability do not need to file any taxes, implying $f = 0$ for properties sized below or equal $\underline{s}$.

3.2 Elasticity of Housing Supply

A size kink imposes tax liabilities and filing costs to owners, which can be shifted forward to renters (i.e. pass-through). Let us denote by γ the pass-through of filing costs and tax liability to renters via discrete increase in the total rent for properties sized above $\underline{s}$. Hence, profits are given by:

$$\pi(s) = sp - \left(\frac{s}{A}\right)^{1+\frac{1}{\eta}} - r - \mathbb{1}(s > \underline{s}) \cdot \left[\tau\left(s - \underline{s}\right)p + (1-\gamma)\, f\right], \tag{3}$$

where $\mathbb{1}(s > \underline{s})$ is the indicator function that takes the value of one if $s > \underline{s}$, and zero otherwise, and τ denotes the tax on the marginal rental income gained from the extra square meters above $\underline{s}$. This is the owner's profit per-unit of land, equation (2), but with the possible additional cost of taxes and filing cost.

The first order condition yield the following supply function:

$$s = \left(\frac{\eta}{1+\eta}\right)^{\eta} A^{1+\eta}(1 - \mathbb{1}(s > \underline{s}) \cdot \tau)^{\eta} p^{\eta}. \tag{4}$$

Notice that $\eta = \frac{p}{s}\frac{\partial s}{\partial p}$ is the elasticity of housing supply in terms of size with respect to the rent price. Figure 1.3 illustrates the implication of this size kink in a production function diagram. Introduction of a size kink creates a discontinuity in the Iso-profit curve at $\underline{s}$ and make it steeper for $s > \underline{s}$. The gap in the Iso-profit curves at $\underline{s}$ implies that owners who would have chosen their rental properties in the range $(\underline{s}, \underline{s} + \Delta s)$, in the absence of the size

[22] Think of it as an owner selling his current rental property and buying another property of an optimal size where search costs of selling and buying are negligible. In practice, the adjustment costs are lower for newly built and very old properties. In the case of the former, an owner has the opportunity to take into account the effects of tax policy before choosing the optimal size of her rental property. In the case of the latter, the opportunity costs of demolishing properties and replacing them with properties smaller than the size kink are arguably lower for owners of old properties.

kink can optimize their profits by providing less housing services and bunch at $\underline{s}$. Let us subindex with l the owners with the lowest productivity, A_l, among those who choose $s = \underline{s}$. They would provide $\underline{s}$ both in the presence and absence of the size kink. We indicate with h the owners with the highest productivity, A_h, among those who bunch at the $\underline{s}$. They would provide $\bar{s} = \underline{s} + \Delta s$ when there is no size kink. In the presence of the size kink, they are indifferent between supplying $\underline{s}$ and $\bar{s}$. With not other frictions in the model, all owners with productivity parameters in the range (A_l, A_h) will bunch at the cutoff.[23]

Let us denote by p_0 the distorted gross equilibrium rent price of an apartment of size $\underline{s}$, and denote by p_1 the rent price of an apartment of size $\bar{s}$ in the presence of the size kink. Using equation (4), the marginal bunching individual provides $\bar{s} = \left(\frac{\eta}{1+\eta}\right)^{\eta} A_h^{1+\eta}(1-\tau)^{\eta} p_1^{\eta}$. From equation (3), there are two possible profits for the marginal bunching individual:

$$\pi_0 = p_0 \underline{s} - \left(\frac{\underline{s}}{A_h}\right)^{1+\frac{1}{\eta}} - r, \tag{5}$$

and

$$\begin{aligned}
\pi_1 &= \bar{s} p_1 - \left(\frac{\bar{s}}{A_h}\right)^{1+\frac{1}{\eta}} - r - \tau\left(\bar{s} - \underline{s}\right) p_1 - (1-\gamma) f \\
&= \bar{s} p_1 (1-\tau) - \left(\frac{\bar{s}}{A_h}\right)^{1+\frac{1}{\eta}} - r + \tau \underline{s} p_1 - (1-\gamma) f \\
&= \frac{\eta^{\eta}}{(1+\eta)^{1+\eta}} A_h^{1+\eta} (1-\tau)^{1+\eta} p_1^{1+\eta} - r + \tau \underline{s} p_1 - (1-\gamma) f.
\end{aligned} \tag{6}$$

If we denote by p^* the rent price in the absence of the size kink, from equation (4), the marginal buncher has $A_h^{1+\eta} = \frac{\bar{s}}{p^{*\eta}} \left(\frac{1+\eta}{\eta}\right)^{\eta}$. Plugging this expression in equation (6), and noting that $\pi_0 = \pi_1$, the relationship between price elasticity of housing size supply, rent responses, filing costs, and bunching is:[24]

$$\frac{\underline{s}}{\bar{s}} \left[\frac{p_0 - \tau p_1}{p^*} + \frac{(1-\gamma) f}{\bar{s} p^*}\right] = \frac{1}{1+\eta} \left[\frac{(1-\tau) p_1}{p^*}\right]^{1+\eta} + \frac{\eta}{1+\eta} \left(\frac{\underline{s}}{\bar{s}}\right)^{\frac{1+\eta}{\eta}}. \tag{7}$$

To solve equation (7) for η, we need to estimate the size responses $\bar{s}$, the pass-through rate γ, the filing costs f, the and the counterfactual rent price p^*. The remaining parameters $\underline{s}$, p_0, p_1 and τ are directly observable.

We estimate the size responses, $\bar{s}$, using the total amount of bunching (Saez (2010)). The

[23]Note that the above analysis is concentrated on intensive margin responses and cannot identify extensive margin responses. Kleven and Waseem (2013) and Best and Kleven (2017) show that extensive margin responses converges to zero in the vicinity of the cutoff.

[24]Check appendix B for the details.

number of owners who decide to locate at $\underline{s}$ after the introduction of the size kink is:

$$B = \int_{\underline{s}}^{\bar{s}} h(s)ds \approx h(\underline{s})\Delta s, \tag{8}$$

where $h(\underline{s})$ is the counterfactual density of s without taxation. This approximation uses the standard assumption that $h(s)$ is roughly constant around the bunching interval. Hence, by estimating the amount of bunching B, and the counterfactual density $h(\underline{s})$ at the size-threshold, we numerically solve for Δs. Section 4.1 describes the empirical methodology for estimating B and $h(\underline{s})$.

For the remaining parameters, in section 3.4 we explain the relationship between price elasticities of housing supply and demand and the pass-through rates. Finally, in section 4.2 we develop the identification strategy to estimate rent responses and cots of filing.

3.3 Elasticity of Housing Demand

From the demand perspective, we model the individual preferences using a utility function that only depend on consumption. We divide consumption into two groups: consumption of housing and composition of all other goods. Consumption of other goods equals the total income net of rent. We use size as a proxy for housing consumption. Given all other variables, a larger property provides higher utility for a renter. We use the following quasi-linear and Iso-elastic utility function to represent individual preferences:

$$U(c, s) = c - \frac{\epsilon}{1-\epsilon}\alpha^{\frac{1}{\epsilon}} s^{1-\frac{1}{\epsilon}}, \tag{9}$$

where c is the consumption of market goods, ϵ is a positive constant different than one[25], s is the size of the apartment, and α is a measure of the relative housing preferences. The quasi-linearity assumption on the preferences rules out the income effects. Hence, the elasticity of housing size demand reflects only the substitution effects in response to rent changes induced by the size kink.[26] The Iso-elasticity assumption implies that elasticity of demand is constant. Given the assumption on preferences, renters spend their entire income, y, on rent and the composite good.

Although statutory incidence of taxes is on owners, renters bear part of the incidence that is passed into the rent. Let us consider a pass-through of the tax burden in the form of

[25] We will show in equation (11) that this constant is related to the elasticity of housing size demand because $\epsilon = -\frac{p}{s}\frac{\partial s}{\partial p}$

[26] Saez (2010) explains that income effects are negligible when changes in the marginal tax rates are small because income effects depend on the average tax rates.

a discrete increase in the total rent (equals to γf) for properties bigger than $\underline{s}$. Therefore, the budget constraint for renters is: $y = sp + c + \mathbb{1}(s > \underline{s}) \cdot (\gamma f)$, where $\mathbb{1}(s > \underline{s})$ is the indicator function that takes the value of one if $s > \underline{s}$, and zero otherwise. Replacing the budget constraint into equation (9), we get:

$$U(c, s) = y - sp - \mathbb{1}(s > \underline{s}) \cdot (\gamma f) - \frac{\epsilon}{1-\epsilon} \alpha^{\frac{1}{\epsilon}} s^{1-\frac{1}{\epsilon}}. \tag{10}$$

The discontinuity and nonlinearity in the budget constraint at the right side of the size kink creates incentive for renters to locate at $\underline{s}$ to increase their utility level. Figure 1.4 illustrates the mechanism, assuming heterogeneous housing preferences among individuals. A renter's first order condition (FOC) with respect to size leads to the following equation:

$$s = \alpha p^{-\epsilon}, \tag{11}$$

which shows an inverse relationship between gross rent and property size, as long as the compensated elasticity is negative (e.g., $\epsilon > 0$).

Let us subindex with l the renters with the lowest preferences, α_l, among those who bunch at the tax-cutoff. They would choose $\underline{s}$ both in the absence and presence of the size kink. We indicate with h the marginal renters with the highest preferences, α_h, among those who bunch at the $\underline{s}$. They are indifferent between $\underline{s}$ and $\bar{s}$ in the presence of the size kink. Their optimal choice in the absence of the size kink would be $\bar{s} = \underline{s} + \Delta s$. All renters with preferences between (α_l, α_h), who would rent properties with size in the range $(\underline{s}, \bar{s})$, bunch at the size kink. The utility level at $\underline{s}$ is:

$$\underline{u} = y - \underline{s} p_0 - \frac{\epsilon}{1-\epsilon} \alpha_h^{\frac{1}{\epsilon}} \underline{s}^{1-\frac{1}{\epsilon}}. \tag{12}$$

Using equation (11), we have $\bar{s} = \alpha_h (p_1)^{-\epsilon}$. Hence, the corresponding utility is:

$$\begin{aligned} \bar{u} &= y - \bar{s} p_1 - \gamma f - \frac{\epsilon}{1-\epsilon} \alpha_h^{\frac{1}{\epsilon}} \bar{s}^{1-\frac{1}{\epsilon}} \\ &= y - \alpha_h p_1^{1-\epsilon} - \gamma f - \frac{\epsilon}{1-\epsilon} \alpha_h p_1^{1-\epsilon} \end{aligned} \tag{13}$$

Let us denote by p^* the rent price in the absence of the size kink. In this case, individual h would choose a property with size $\bar{s}$, which implies $\alpha_h = \bar{s} p^{*\epsilon}$. Replacing α_h in equations (12) and (13), and using the condition $\underline{u} = \bar{u}$, the price elasticity of housing demand is an implicit function of size responses, the change in rent, and the filling cost:[27]

$$\frac{\underline{s}}{\bar{s}}\left[\frac{p_0}{p^*}-\frac{\gamma f}{\underline{s}p^*}\right]=\frac{1}{1-\epsilon}\left(\frac{p_1}{p^*}\right)^{1-\epsilon}-\frac{\epsilon}{1-\epsilon}\left(\frac{\underline{s}}{\bar{s}}\right)^{-\frac{1-\epsilon}{\epsilon}} \tag{14}$$

Upon market clearing assumption, the rent response, total volume of bunching, and size response are the same from both supply and demand perspectives. Therefore, using the same measure of rent and size responses from the previous section, we can numerically solve for ϵ.

3.4 Pass-Through and Incidence

Under perfect competition, the pass-through – marginal changes in prices due to a change in taxes – is a function of the relative elasticities of supply and demand (Weyl and Fabinger (2013)):

$$\gamma=\frac{dP}{d\tau}=\frac{1}{1-\frac{\epsilon}{\eta}}=\frac{\eta}{\eta-\epsilon}, \tag{15}$$

where P is the after-tax price. This equation intuitively means that the greater the price elasticity of one side of the market is, the more the tax burden is borne by the other side.[28] Pass-through itself is a key parameter to determine incidence ratio, I, defined as the ratio between the changes in consumer surplus (renters) and the changes in producer surplus (owners).

Applying the envelop theorem to the consumers, a decrease in the consumer surplus (renters) due to an increase in a tax is equal to the product of equilibrium quantity Q^*, and γ. Similarly, applying the envelop theorem to producers, the reduction in producer surplus (owners) is equal to Q^* times the change in producers' price $1-\gamma$. Therefore, we have:

$$I=\frac{\partial CS/\partial\tau}{\partial PS/\partial\tau}=\frac{\gamma}{1-\gamma}=-\frac{\eta}{\epsilon}, \tag{16}$$

where CS is the consumer surplus and PS is the producer surplus.[29] Intuitively incidence larger than one means the majority of the tax burden is borne by the demand side of the market. Therefore, under perfect competition, the relative elasticity of supply and demand can fully characterize the pass-through rates and tax incidence.

To numerically solve for η and ϵ, we use an iterative method with an initial guess for the

[27] See appendix C for the details on the derivation.

[28] Note that under imperfect competition, calculation of pass-through requires more information about the market structure and demand curvature (Ganapati et al. (2016)).

[29] These analyses are based on the assumption of infinitesimal changes in tax rates (begin from zero).

pass-through rate γ. This method generates successive approximations to solve equation (7) and (14), by updating γ using the previous approximations of γ and ϵ.

4 Empirical Methodology

This section presents the empirical methodology for the identification of excess bunching B, rent counterfactual rent p^*, and filing costs f around the size kink; the parameters required to estimate structural elasticities.

4.1 Estimation of Excess Bunching

The difference between the empirical and counterfactual densities around the size kink provides a measure of excess bunching. To recover the counterfactual density, defined as the density of rental properties w.r.t size in the absence of the size kink, we fit a smooth polynomial to the empirical density, and exclude the observations around the kink that are affected by the tax policy (Kleven and Waseem (2013)). The reason is that in the presence of the size kink, individuals in the range $(\underline{s}, \underline{s} + \Delta s]$ cluster at the left side of the size kink in the range $(s_o, \underline{s}]$.[30] Therefore, apartments are grouped into small size bins (i.e., 1 square meter) and estimate the following classical regression:

$$N_i = \sum_{j=0}^{k} b_j s_i^j + \sum_{r \in R} \rho_r \cdot \mathbb{1}\left(\frac{s_i}{5} \in \mathbb{N}\right) + \sum_{s=s_o}^{\underline{s}+\Delta s} e_s \cdot \mathbb{1}\left(s_i = s\right) + \nu_i, \tag{17}$$

where N_i is the number of apartments in bin i, the size-level is s_i, the order of the polynomial is k, and $\mathbb{1}\left(\frac{s_i}{5} \in \mathbb{N}\right)$ are indicator variables that controls for rounding effects.[31] The excess distribution is capture by the indicator $\mathbb{1}\left(s_i = s\right)$, for $s \in (s_o, \underline{s} + \Delta s]$.

The counterfactual density is the fitted value of the dependent variable from equation (17), excluded from the estimated values of dummies in the affected range. We estimate it using the classical regression:

$$\tilde{N}_i = \sum_{j=0}^{k} \tilde{b}_j s_i^j + \sum_{r \in R} \tilde{\rho}_r \mathbb{1}\left(\frac{s_i}{5} \in \mathbb{N}\right) + \varepsilon_i. \tag{18}$$

[30] In practice, excess bunching doesn't occur at one point, instead, it is spread over a tiny band $(s_o, \underline{s}]$. The optimal bunching segment is the one that the difference between the counterfactual and empirical distribution is minimum.

[31] One possible concern is that owners may tend to register the properties' size in round numbers, which can cause spikes at multiples of 5 in the empirical distribution. To address this issue we use the finite set of rounded sizes that are natural numbers $\mathbb{N}$, that is, $\phi = \left\{s | \frac{s}{5} \in \mathbb{N}\right\}$. We denote by R a set of index for ϕ.

As mentioned above, excess bunching is the difference between empirical and counterfactual densities for a range $(s_o, \underline{s}]$, that is: $\widehat{B} = \sum_{i \in (s_o, \underline{s}]} (N_i - \tilde{N}_i)$.[32] [33] We compute the standard errors of the excess bunching using a bootstrap procedure.

4.2 Estimating Rent Responses and Cost of Filing Taxes

As mentioned in the theoretical section, if owners can pass forward some of the burden of filing costs to renters, the expectation is to observe a discrete increase in total rent right above the size kink. Similarly, an increase marginal tax rates above the cutoff can be shifted forward to renters in the form of higher rent per square meter for extra size above the cutoff. Figure 1.5 graphically shows how the treatment effect is identified using evidence from data. Comparison between the mean annual rent at the left and right side of the size kink, presented in Panel A, provides clear evidence of a spike in rent payments for properties that are located right above the size kink. The figures provide evidence that a policy-induced spike exists in rent payments at the cut-off, however, to test this hypothesis, we estimate the following regression:

$$\begin{aligned}\left(Rent/m^2\right)_i = \beta_0 + \beta_1 SizeKink_i + \beta_2 SizeKink_i \times \left(Size_i - 150m^2\right) + \\ \beta_3 \left(Size - 150m^2\right) + \beta_4 Age_i + \beta_5 Age_i^2 + \\ + Zipcode_i + t + Q + \varepsilon_i \end{aligned} \quad (19)$$

where $(Rent/m^2)_i$ is the annual real rent per square meter for apartment i. $Size$, Age, and Age^2 control for the characteristics of the rental properties. $SizeKink$ is a dummy variable equal to one for properties larger than 150 m^2, and zero otherwise. Interaction of $SizeKink$ with $(Size - 150)$ captures the change in the slope of rent per square meter above 150 m^2. ZIP Code-level fixed effects are added to control for the neighborhood characteristics. In Iran, the 10-digits ZIP Code locates an address precisely. The first 5 digits of a ZIP Code can properly determine the neighborhood boundaries, which typically contain several blocks.[34] The data cover 2,601 neighborhoods in Tehran. Year fixed-effects t, control for business cycles and macroeconomic variables that may affect the overall rental housing market. Seasonal fixed

[32] One concern is that this method does not consider the shifting of the observed distributions above $\underline{s} + \Delta s$ to the right of the cutoff. However, Kleven (2016) describes that these effects are negligible in many applications, in particular, if the observed distribution is not steep.

[33] Note that if the number of owners with more than one rental property is significantly high, the estimated bunching underrepresents the true level; in this case our estimation of elasticities will be lower bound. However, in this sample, only 4 percent of properties belong to owners with more than one property.

[34] A block is defined as the smallest area surrounded by four streets.

effects Q, control for seasonal patterns in the rental market.[35]

The main coefficient of interest in equation (19) is β_1 that captures the differences of rent value between properties above and below the cutoff due to the pass-through of the filing costs. The other coefficient of interest is β_2, that capture the effects of marginal taxes on rent per square meter above the cutoff point. The coefficient of $SizeKink$, β_1, will do a better job in capturing the effects of filing costs around the cutoff because tax liability is very small. On the other hand, as the size gets further away from the cutoff, the tax liability becomes larger and β_2 can capture the effects of marginal taxes more precisely. Therefore, we estimate equation (19) for different samples: the entire sample, a sample that only include observations around the cutoff, and a sample that exclude the bunching area.

5 Results

5.1 Graphical Evidence

Figure 1.6 illustrates the distribution of rental properties with respect to size for the entire sample (panel A) and newly built properties (panel B) between March 2012 and September 2014 by bins of 5 m^2.[36] The size kink is denoted by a dashed line, which itself belongs to the tax-zero side of the kink. Two elements are worth noting in these panels. First, there is clear evidence of bunching right below the tax-exemption threshold, followed by a substantial drop in the number of properties above it. Second, sharper bunching at the kink point surfaces in the distribution of newly built properties for which owners have already taken into account the tax policy before choosing the size of their apartments.[37] This is consistent with the optimization friction theory of Kleven and Waseem (2013) that predicts larger responses in frictionless markets compared to the ones observed in the presence of frictions. Sample of newly built properties is a suitable representative of a frictionless market because the adjustment costs of choosing the optimal size are much smaller for owners, who purchase them for leasing. This also implies that more responsive supply leads to stronger bunching at the size kink.[38]

[35] The Box-Cox lambda transformation for our specification shows that qualitatively linear transformation is a better choice compared to log-log and log-linear transformations. The transformation parameter is 0.62.

[36] Newly built properties are defined as those for which the "year since construction" is zero at the time of transaction.

[37] The reduction in the number of apartments that occurs by moving from the bin $(145m^2, 150m^2]$ to the bin $(150m^2, 155m^2]$ is 59 percent for panel B, versus 52 percent for panel A.

[38] Appendix Figure A.1 illustrates the distribution of rental properties with respect to size for the entire sample by bins of 3 m^2. Appendix Figure A.2 shows the distribution of properties using the matched data described in Section 1.2.

Exploiting the longitudinal feature of the dataset, Figure 1.7 breaks down the full sample of properties into three consecutive years, 2012-2014, to illustrate the dynamics of bunching behaviors.[39] While all three panels show substantial bunching at 150 m^2, the contrast between panel A (year: 2012) and panel C (year: 2014) is still striking, suggesting that behavioral responses are magnified over time. One way of thinking about this transition is that the stock of existing properties, i.e. properties that were built before the implementation of tax-regulation (2001), decreases through time.[40] The share of existing properties for each year, presented in Table 1.3, demonstrates that sharper bunching is associated with the reduced share of existing stock.

To explicitly verify that the tax policy induces bunching, Figure 1.8 presents the comparison of the density of apartments that were constructed before the tax-regulation and newly built apartments in the owner-occupant market. Sample of newly built properties here is reduced to observations from 2014, which have the furthest time-distance from the tax implementation date.[41] The focus here is on the owner-occupant market that is not subject to the property taxes (as opposed to the rental market). As in the figure, for properties built before the introduction of the regulation, the density smoothly decreases over size and there is no evidence of systematic clustering below the size kink. Moreover, the absence of evident bunching in the density of old properties helps to rule out alternative explanations for bunching at the focal point. In fact, properties in both graphs are similar in all respects except age. In contrast, distribution of newly built properties in 2014 provides clear evidence of bunching at the size kink.

5.2 Estimation of Rent Responses and filing costs

We estimate equation (19) to measure the rent responses to the tax in Tehran rental market. Under the null hypothesis of no tax policy effects on rent, the coefficients on the dummy variable for size, β_1, and the interaction term, β_2, in equation (19) are zero: owners of properties larger than 150 m^2 cannot shift forward the burden of filing costs and marginal taxes to renters through higher rent. On the other hand, as long as supply is not perfectly inelastic, the prediction is that the size kink creates a spike in the rent value right above the tax-cutoff, followed by linear increase in rent per square meter afterward.

[39] Data are broken down into a three-year period based on Iranian calendar in which the new year starts on March 21$^{\text{st}}$.

[40] Here, we count an apartment as existing if it has been completely constructed before 2004, assuming that those between 2001 and 2003 had already been partly built at the time of the change in the regulation. However, changing the cut-off criteria from 2004 to 2003 or 2002 does not noticeably affect the graphs or results.

[41] Appendix Figure A.3 shows the distribution of newly built apartments for all years 2012 – 2014.

Table 1.4 presents the OLS estimates of β_1 and β_2 for various versions of equation (19). All specifications include year, seasonal, and 5-digit ZIP Code fixed effects. Results for the entire sample, presented in Columns (1) and (2), suggest that introduction of the size kink at 150 m^2 lead to discrete increase in the rent value, and positive change in rent per square meter for each extra square meter above the cutoff. The positive and significant coefficients for β_1 and β_2 imply that some of the tax burden is passed forward to renters. Column (3) and (4) present the results for the sample that removes observations in the range $(140m^2, 160m^2)$. The point estimate of the interaction term in column (4) is larger in magnitude, suggesting that the effects of marginal taxes on rent per square meter tend to enhance further away from the cutoff.

Column (5) and (6) report estimates from specifications that restrict the sample to only include observations within 10 square meters of the cutoff. This restriction plausibly isolates the effects of filing costs on rent.[42] The results in column (5) and (6), which are not significantly different from their counterparts in column (3) and (4), show that the burden of filing taxes is associated with a 140,000(approximately \$3.9 in 2015 dollars) Rials increase in rent per square meter.[43] Considering average rent per square meter of 3,600,000 Rials (approximately \$100 in 2015 dollars) per square meter below the cutoff, this number can be translated to 3.9 percent increase in rent value right above the cutoff. This is also consistent with findings of Benzarti (2015) and Ramnath and Tong (2017) that show individuals compromise significant amount of money to avoid burden of filing taxes.

5.3 Estimation of Excess Bunching

Figure 1.9 presents the results of excess bunching by comparing the empirical and counterfactual distributions of properties with respect to size for different samples. Counterfactual distributions in all panels are estimated based on equation (17). Panel A shows the results for the entire sample. Panel B focuses on newly built properties in the rental market where greater bunching is happening arguably due to more elastic supply. Panel C, on the other hand, presents the same graphs in the owner-occupant market by combining purchasing transactions of newly built properties for years 2012 to 2014. Each panel shows the estimation of excess bunching which is defined as the proportion of excess bunching to the counterfactual frequency in the small interval above the kink.[44]

[42] This restriction also rules out the alternative explanation that observations with both large size and high rents are driving the results.

[43] Wald test results cannot reject the null hypotheses of restricting the point estimates in column (4) and (6) to be the same.

[44] As a robustness check, we use different orders of polynomials toestimate the counterfactual distributions. The results appear to be insensitive to the order of polynomials.

The main findings from these panels are the following. First, excess bunching for all panels is highly significant varying from 1 to 5 times the height of the counterfactual distributions. Second, the estimated parameter is larger for the newly built apartments in both rental and owner-occupant markets, thus supporting the idea that attenuation of frictions leads to stronger responses. Third, the difference in magnitude of excess bunching in panel A and B also suggests that stronger bunching responses are associated with the more elastic supply.

Examining the heterogeneous bunching responses across different type of properties, Figures 1.10 and 1.11 present excess bunching based on property's age and rent-value. Panel A in figure 1.10 includes rental properties that were built at least 5 years before the tax regulation. Panel B presents the same graphs for older rental properties by trimming the dataset further to only include rental properties that were built at least 15 years before the regulation. Figure 1.11 presents excess bunching for high- and low- rent regions. In doing so, the full sample is split into two subsamples, one that include only properties located in postal regions with average rent above the median, and the other one that includes the rest of observations.

There is evidence of heterogeneity by property's age that suggests increasing relationship between age and volume of bunching. This is consistent with the hypothesis that housing deteriorates with age (Brueckner and Rosenthal (2009)). Therefore, older dwellings (with probably lower quality) larger than 150 m^2 can be torn down and replaced with new dwellings with size below 150 m^2 at arguably lower costs. Moreover, Figure 1.11 illustrates that the bunching for apartments in low-rent neighborhoods is strongly larger compared to high rent neighborhoods. This contrast can be interpreted as evidence that owners and renters in low-rent neighborhoods might have higher price elasticities. These figures may suggest that some of the responses are along other margins such as quality. In section 1.5.5, we compare the housing characteristics of properties at the two side of the cutoff to explore this possibility further.[45]

To rule out alternative explanations for bunching at the focal point, we formally check for the presence of a density discontinuity at the size kink in the owner-occupant market, by performing the McCrary test separately for the distributions of the full sample of newly built properties, and properties built before the regulation (McCrary (2008)). The results are consistent with the graphical evidence, suggesting that the log-difference between the frequencies of newly built properties just below and above the size kink are statistically significant, while the null hypothesis that the discontinuity at the size kink is zero cannot be rejected for already built properties.[46] The contrast between these two distributions confirms

[45] Saez et al. (2012) and Kopczuk and Munroe (2015) argue that tax-induced responses along other margins still indicate the efficiency costs of taxation.

[46] Point estimates of the McCrary tests for distributions in Figure 8 are as follows: Newly built properties:

that the supply of new housing strongly responds to the tax policy. This finding also provides evidence of tax spillovers – i.e. the impact of a tax policy in one market on others – in the housing market.

5.4 Estimation of Elasticities and Pass-Through

The measures of rent responses, bunching, and costs of filing around the kink point ($150m^2$) allow me to calculate the separate estimation of elasticities of housing size demand and supply using the structural framework introduced in Section 1.2. Table 1.5 presents estimated elasticities for different choices of bunching segments. The table is organized in five columns. Columns (1) and (2) report the price elasticities of housing demand and supply using equation (7) and (14), respectively. Columns (3) and (4) present estimated elasticities, using the measure of bunching from subsample of newly built properties, the representative of the frictionless market. Column (5) takes the estimated elasticities from column (3) and (4) and embeds them into equation (15) to measure the pass-through rate.

The results for the entire sample show that both elasticities of supply and demand are almost always statistically significant with the expected signs for all specifications, consistent with the graphical evidence presented earlier.[47] The estimated elasticities of supply for the subsample of newly built properties, the representative of the frictionless market, are 2 to 6 times as large as their counterparts in column (1). This contrast highlights the substantial role of frictions in attenuating the housing supply responses. The estimates of housing demand elasticities, reported in columns (2) and (4), are smaller, but still significant. Results here suggest that the estimation of price elasticity of housing size demand highly depends on the magnitude of bunching responses. Column (5) presents the estimation of the pass-through rates that range between 0.88 and 0.91 across different choice of bunching segments, meaning that the incidence ratio is over one.[48]

0.451 (0.039); Built before the regulation: 0.074 (0.045). Optimal bin size and bandwidth as in McCrary (2008).

[47]Although estimated elasticities based on the measure of bunching from the entire sample are small, they are consistent with the literature on behavioral responses to transaction taxes, which finds relatively small elasticities in spite of large housing price responses (e.g. Best and Kleven (2017).

[48]While the results do not seem to be very sensitive to the choice of the bunching segment, increasing the length of the bunching segment lead to inclusion of lower and upper band densities around the size kink that are probably affected by the tax policy (Saez (2010)). Therefore, one would expect to see higher elasticities when the length of bunching segments is increased. As a result, the baseline estimations that rely on small bunching segment around the kink are lower-bound estimates.

5.5 Robustness Checks

This section contains additional estimations to ensure that potential biases in the sample or alternative explanations do not drive the results. One alternative explanation is that some of the local response to the size-kink may be due to supply side and demand side adjustment along the quality margin. Although our concentration is on a narrow band around the tax cutoff, it is possible that properties below and above the cutoff are significantly different along housing characteristics other than size. To investigate this possibility, we use records on real estate listings in Tehran for years 2014 to 2016.

Table 1.6 presents the summary statistics for the 875 listings. Column (1) and (2) present the housing characteristics for observations in the size range $(140m^2, 150m^2]$ and $(150m^2, 160m^2]$, respectively. Each row presents the mean value of housing characteristics for both groups. Column (3) presents the results for the mean difference between 2 groups. The t-statistics are in parentheses. Column (4) reports the *p-value*. Note that the average rent per square meter for apartments above the cutoff is 4,894 thousand Rials, which is significantly different from those located below (or equal) the cutoff. On the other hand, for mostly all key housing characteristics there is no significant difference between the two groups of observations. In fact, the computed Benjamini-Hochberg *p-values* only reject the null hypothesis for one characteristic.[49] Although there is no direct way to fully capture the quality of housing, attributes such as facing direction, kitchen materials, flooring, building façade, and age plausibly reflect the quality of housing. Hence, the results here are reassuring that the base results for the rent responses and costs of filing are not significantly biased by the quality adjustment.

We also run placebo tests to investigate the causality concerns regarding the effect of the tax policy on rent. If my results reflect a treatment effect of the tax kink, then the results should disappear if we falsely assume that my treatment occurs at 10 square meters before or after the actual kink-point. For these tests, we run two additional regressions, one for observations within interval (130 m^2, 150 m^2) assuming 140 m^2 is the size kink, and another one for observations within the interval (150 m^2, 170 m^2) assuming 160 m^2 is the size kink. Results of these regressions, presented in Table A.1 indicate that the coefficients estimates on the falsified kink dummies are insignificant. We do two additional placebo tests for intervals (120 m^2, 140 m^2) and (160 m^2, 180 m^2). As in the previous test, results again indicate that falsified dummies are not significant. Therefore, the placebo tests show my baseline results are robust to subsample choices and the size kink has a causal effect on rent values.

[49] Although the difference for the number of bedrooms between the two groups is significant, the magnitude is small.

6 Conclusion

This study has taken advantage of rich micro administrative data on rental properties in Tehran and quasi-experimental variation in marginal taxes to estimate the price elasticities of housing demand and supply simultaneously. Using the estimated elasticities, this paper then examined the pass-through rate of the size kink. My analysis reveals strong evidence of behavioral responses through bunching below the size kink, and a rent spike above it. Using the measure of bunching from newly built properties, for which frictions are less and supply is more elastic, the elasticities of housing supply and demand are at least 10 times larger compared to estimates using the entire sample. The high but incomplete estimation of pass-through rates suggest that owners are able to pass forward the majority of the tax burden in the form of higher rents.

This paper shows the importance of considering the supply responses to uncover structural elasticities of demand. Additional conclusions are reached on elasticities' estimations because the setting accounts for the effects of incomplete pass-through in attenuating demand responses. The results from the representation of the "frictionless" market highlight the effects of frictions on attenuating behavioral responses. Moreover, this may be of broader interest in other fields that generally assume completely elastic supply and full pass-through. My estimation of incidence ratio above one implies that renters who normally are at the bottom tail of the income distribution are the ones who bear most of the cost of the policy. That is, size-based taxes on rental properties might be highly regressive. Finally, the findings show that rental taxation policy not only distorts the owners' and renters' decisions in the rental market, but also induces large distortionary responses in the owner-occupant market.

In this paper, we provided a framework to estimate separate price elasticities of housing supply and demand using evidence of bunching and incidence. Here, we focus on effects of taxation on locations around the kink-point where agents chiefly react through the intensive margin. It would be interesting to use this evidence to examine the extensive responses to the size kink. We also provided evidence that a size-based tax policy will increase the supply of smaller apartments of a size below the cutoff, which can ultimately lead to higher urban density. Another interesting research question would be to consider the tax-induced variation in urban density to analyze its impacts on labor markets and urban characteristics such as innovation rate, local climate, and energy consumptions.

Tables

Table 1: Rental Income Tax Schedule

Bracket (000 Rials)	Marginal Tax Rate
0 - 30,000	15%
30,000 - 100,000	20%
100,000 - 250,000	25%
250,000 - 1,000,000	30%
Over 1,000,000	35%

Note: Taxable rental income is shown in thousands of Rials, with the IRR-USD exchange rate varying from 15,000 to 39,000 during these years. For owners of rental properties with combined total size over 150 m^2, each bracket cutoff is associated with a jump in the marginal tax rate.

Table 2: Summary Statistics for Rental Transactions

	Number of Observations	Mean Annual Rent/ m^2 (000 Rials)	Mean Age (Year)	Mean Size (m^2)
Entire Sample	243,144	3,046	11	79.4
		(2.69)	(0.02)	(0.07)
In the range (140 m^2, 150 m^2]	3,951	3,635	14.4	146.0
		(25.9)	(0.20)	(0.05)
In the range (150 m^2, 160 m^2)	1,813	3,853	13.7	154.9
		(38.09)	(0.27)	(0.06)

Note: This table presents the summary statistics for sample of residential apartments that were rent during the March 2012 to September 2014. Rent values are deflated to reflect year 2015 prices using the Statistical Centre of Iran Housing Price Index. Data is obtained from Rahbar Informatics Service Corporate (RISC). IRR-USD exchange rate was between 15,000 – 39,000 during these years.

Table 3: Existing Stock of Housing

Year	#Apts built before 2004	#Apts built after 2004	Share of existing stock (before / (before + after))	Difference (%) in #Apts between bin 150m^2 and 155m^2
Q2 2012 - Q2 2013	52,322	25,940	66.9%	49.3%
Q2 2013 - Q2 2014	49,958	49,444	50.3%	51.9%
Q2 2014 - Q3 2014	30,585	34,895	46.7%	56.1%
Total	132,865	110,279	54.6%	52.2%

Note: This table presents the breakdowns of the number of apartments by year and time of construction. Sharper shrink in the number of apartments above the kink-point is associated with a reduced share of existing stock of housing.

Table 4: The Effects of Taxation on Rent

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Rent/m^2		Rent/m^2		Rent/m^2	
	Entire Sample		Excluding (140 m^2- 160 m^2)		(140 m^2- 160 m^2)	
Size > 150 m^2	238.62***	143.66***	293.37***	153.43***	140.09*	125.38
	(26.04)	(29.84)	(29.25)	(35.58)	(81.62)	(86.23)
(Size > 150m^2) ×(Size - 150m^2)		3.78***		4.30***		5.71
		(0.57)		(0.63)		(17.07)
(Size - 150m^2)	-3.90***	-4.36***	-4.19***	-4.69***	-17.74**	-19.20**
	(0.19)	(0.21)	(0.20)	(0.21)	(7.21)	(8.74)
Observations	243,144	243,144	237,380	237,380	5,764	5,764
R-squared	0.51	0.51	0.51	0.51	0.54	0.54

Note: The dependent variable is log of total annual real rent per-square-meter. Regressions are based on equation (1.16) using the entire sample (March 2012 to September 2014). SizeKink is a dummy variable equal to one for properties larger than 150 m^2. Column 3 includes the interaction of size and size-threshold. All specifications include 5-digit ZIP Code, year, and seasonal fixed effects. Standard errors in all columns are clustered by 5-digit ZIP Code and stars indicate statistical significance level. * = 10 percent level, ** = 5 percent level, *** = 1 percent level.

Table 5: Housing Elasticities Estimates

VARIABLES	Measure of bunching from the entire sample		Measure of bunching from the "frictionless" market (Newly-built apartments)		
	Elasticity of Housing Demand	Elasticity of Housing Supply	Elasticity of Housing Demand	Elasticity of Housing Supply	Pass Through Rate [illegible]
	(1)	(2)	(3)	(4)	(5)
Bunching Segment (145 [illegible] - 155 [illegible])	-0.015	0.243	-0.172	1.368	0.884
	(0.002)	(0.041)	(0.052)	(0.555)	(0.001)
Bunching Segment (145 [illegible] - 160 [illegible])	-0.017	0.291	-0.211	1.794	0.889
	(0.002)	(0.051)	(0.068)	(0.769)	(0.017)
Bunching Segment (140 [illegible] - 155 [illegible])	-0.024	0.544	-0.302	2.913	0.902
	(0.003)	(0.122)	(0.098)	(1.301)	(0.001)
Bunching Segment (140 [illegible] - 160 [illegible])	-0.025	0.616	-0.365	3.765	0.0907
	(0.003)	(0.174)	(0.113)	(1.579)	(0.001)

Note: This table presents estimates of elasticities of housing demand and supply using measure of bunching from the entire sample in columns (1) and (2). Columns (3) and (4) present the same estimates using measure of bunching from the market of newly built properties. Column (5) presents the pass-through rates based on column (3) and (4). Each row shows the results for a different choice of bunching segment. Standard errors are presented in parentheses.

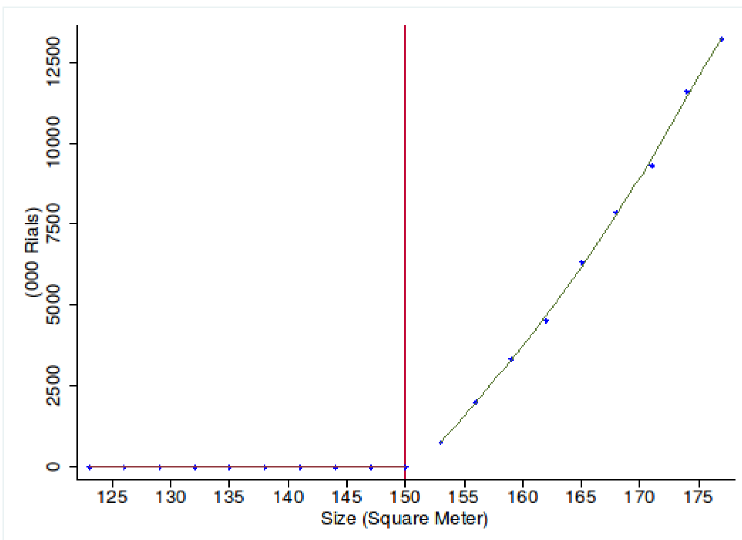
Table 6: Summary of Housing Characteristics

Variables	(1) (140○a,150○a]	(2) (150○a,160○a]	(3) Mean difference	(4) P-Value
# of stories in the building	4.79	5.14	0.35	0.145
			(1.46)	
# of units in each floor	2.11	1.96	-0.15	0.260
			(-1.13)	
View	0.228	0.253	0.025	0.391
			(0.86)	
Floor number	2.71	2.79	0.086	0.639
			(0.47)	
# of Bedrooms	2.81	2.90	0.092	0.001
			(3.47)	
Age	12.17	12.25	0.054	0.932
			(0.09)	
Kitchen Materials				
Metal, Half-wooden, High Gloss	0.11	0.08	-0.037	0.082
			(-1.74)	
MDF	0.80	0.85	0.047	0.078
			(1.76)	
High-end	0.081	-0.071	-0.01	0.583
			(-0.55)	
Flooring (1 to 7)				
Carpet	0.40	0.36	-0.035	0.305
			(-1.03)	
Ceramic	0.025	0.036	0.011	0.322
			(0.99)	
Laminate, Mixed Parquet	0.099	0.105	0.005	0.791
			(0.27)	
High-end stone	0.422	0.451	0.029	0.389
			(0.86)	
Building Façade Materials				
Stone	0.77	0.76	-0.014	0.627
			(-0.49)	
Roman design	0.038	0.046	0.008	0.547
			(0.60)	
Bricks	0.076	0.092	0.017	0.384
			(0.87)	
Cement	0.036	0.029	-0.005	0.68
			(-0.41)	
Granite	0.031	0.034	0.003	0.792
			(0.26)	
Kenitex	0.025	0.019	-0.006	0.517
			(-0.65)	
Travertine - Composite	0.014	0.012	-0.002	0.796
			(-0.26)	
Parking	0.88	0.88	0.006	0.787
			(0.27)	
Storage	0.87	0.90	0.032	0.156
			(1.42)	
Balcony	0.54	0.51	-0.033	0.355
			(-.092)	
Pool, Sauna, or Jacuzzi	0.1	0.14	0.032	0.141
			(1.47)	
Yard	0.235	0.277	0.043	0.156
			(1.42)	
Elevator	0.547	0.61	0.068	0.047
			(1.99)	
# of Observations	552	323		

Note: Rent is the total rent per square meter. View is a dummy variable equal to one if the unit faces more than one direction. Kitchen Materials, Flooring, Building Façade Materials, Parking, storage, balcony, yard, elevator are dummy variables that get one if the unit has them and zero otherwise. Pool, Sauna, and Jacuzzi is a dummy variable that gets value of one if the unit has a pool, sauna, or Jacuzzi. *t-statistics* in parentheses.

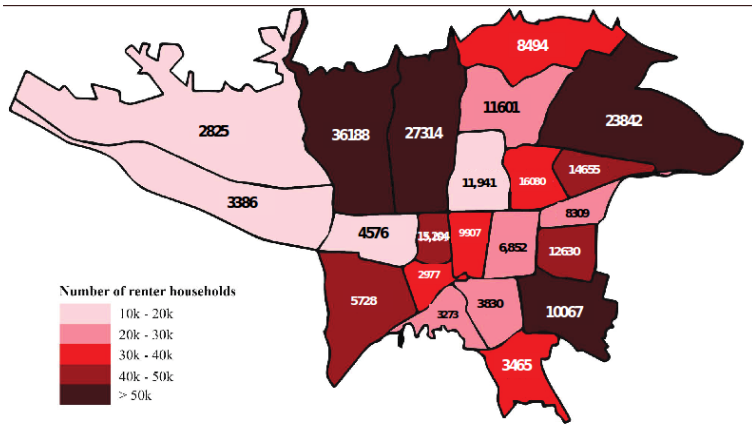
Figures

Figure 1: Average Annual Tax

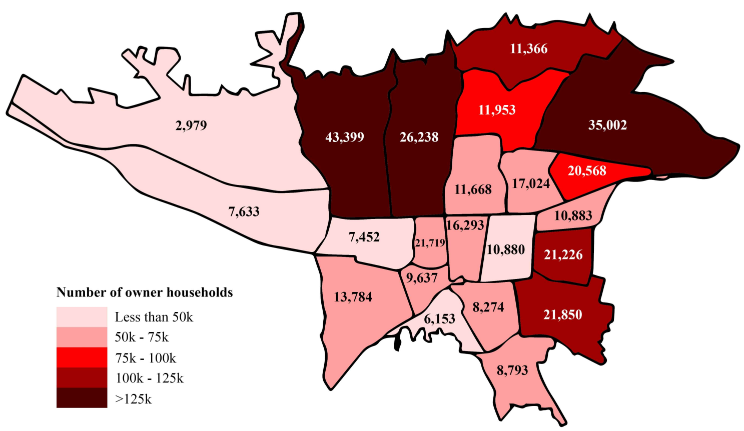


Note: This figure shows the average annual tax liabilities per square meter w.r.t. size for the entire sample. The red line shows the point where taxation begins. Owners of rental properties with total combined size over 150 m^2 are exposed to the rental income tax. The line itself is in the tax-zero side of the kink. Rent values are deflated to reflect year 2015 prices using the Statistical Centre of Iran Housing Price Index. IRR-USD exchange rate was between 15,000 – 39,000 during the years 2012 - 2014.

Figure 2: Distribution of Observations



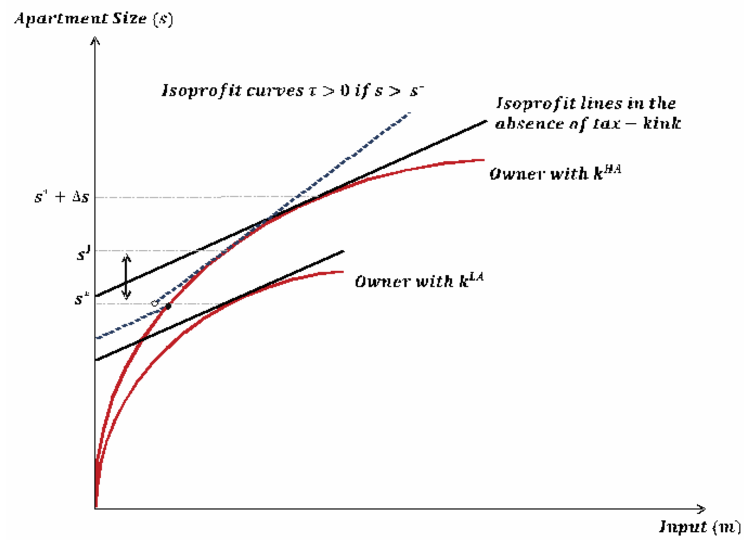
(a) Rental Market



(b) Owner-occupant Market

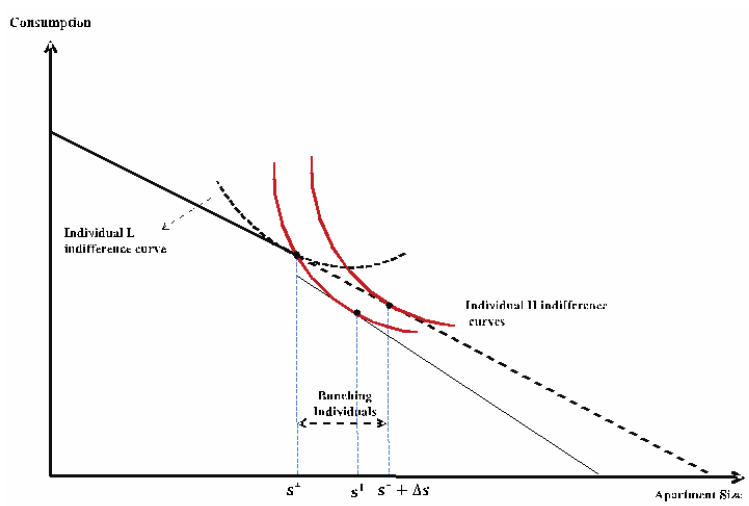
Note: Panel 2a shows the number of rental observations in each district for time period March 2012 – September 2014. Panel 2b shows the number of purchasing observations in each district for the same time period. Colors in panel 2a and 2b illustrate the number of actual renter and owner households in each district, respectively.

Figure 3: Bunching at the Size Kink



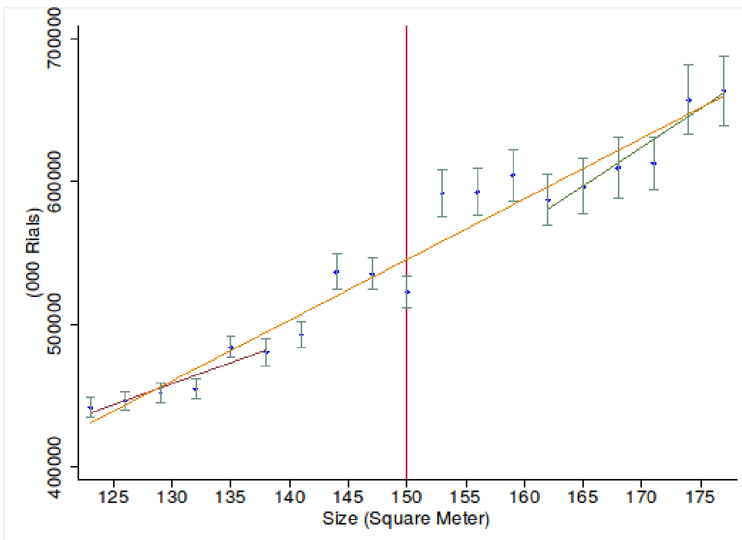
Note: This figure illustrates the impact of a size kink on owners' profits and their decisions on their properties' size. Red curved lines show the production functions. Black solid lines show the Iso-profit curves in the absence of tax. Blue dashed lines show the Iso-profit curves in the presence of the size-kink. Owner *HA* is the marginal bunching individual who would choose a property with size $s^* + \Delta s$ in the absence of size-threshold. In the presence of the size kink, she is indifferent between s^I and s^*. Individual LA, who is not affected by the size kink, chooses a property with size s^* both in the absence and presence of the size kink.

Figure 4: Renters' Budget Set Diagram



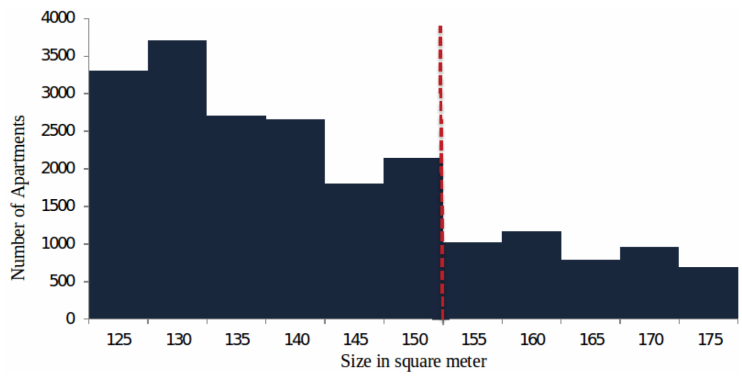
Note: This figure illustrates the impact of a size kink on renters' budget sets and their properties choices. Dashed curved line shows renter's L indifference curve. Solid curved lines show renter's H indifference curves.

Figure 5: Mean Annual Rent around the Kink

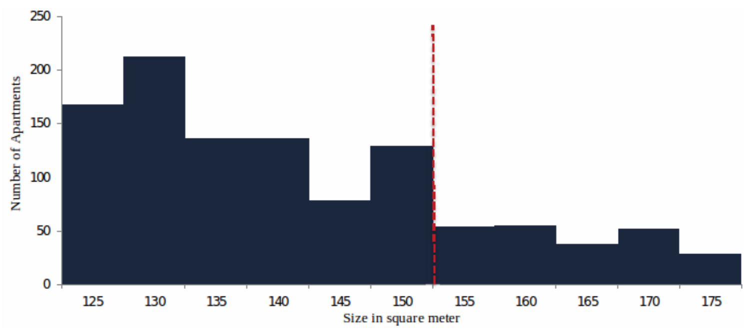


Note: This figure shows the mean annual real rent/m^2 and 90% confidence intervals for rental transactions from March 2012 to September 2014. The vertical line shows the point where taxation begins. The line itself is in the tax-zero side of the kink. The red (green) curved line displays the linear fit for properties with size $s \leq 150m^2$ ($s > 150m^2$). The inclined line (orange) displays the linear fit. IRR-USD exchange rate was between 15,000 and 39,000 during the years 2012 - 2014.

Figure 6: Apartments Distribution and the Taxation Point



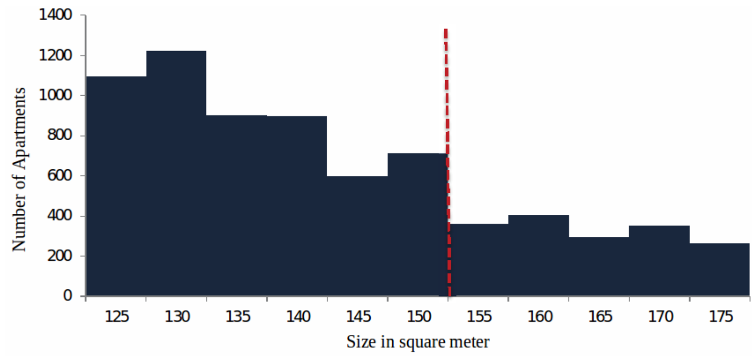
(a) Entire Sample from 2012 - 2014



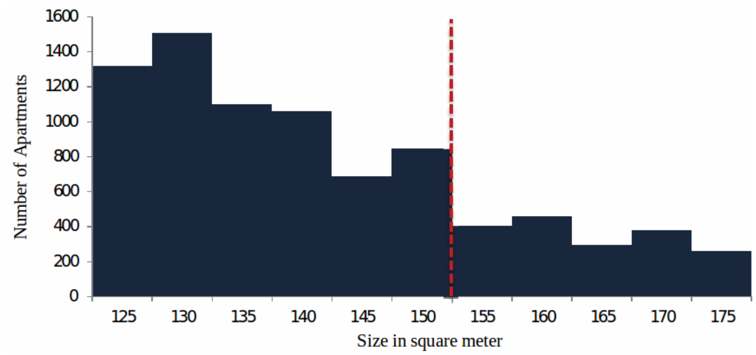
(b) Newly Built Apartments

Note: This figure displays the histogram of properties' size (by 5 m^2 bins). Panel 6a includes all observations from March 2012 to September 2014 for segment $(120m^2, 180m^2)$. Panel 6b is reduced to include only newly built apartments. The dashed line shows the starting point of taxation. The line itself belongs to the tax-zero side of the kink. The numbers next to the dashed line are the percentage reduction in the number of apartments that occurs by moving from the bin $(145m^2, 150m^2]$ to the bin $(150m^2, 155m^2]$.

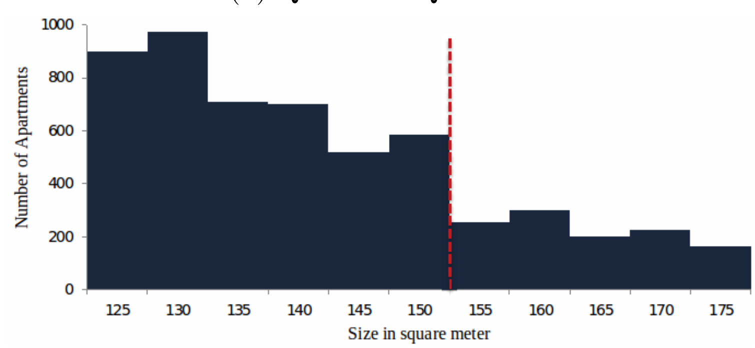
Figure 7: Dynamics of Bunching Behaviors



(a) Q2 2012 – Q2 2013



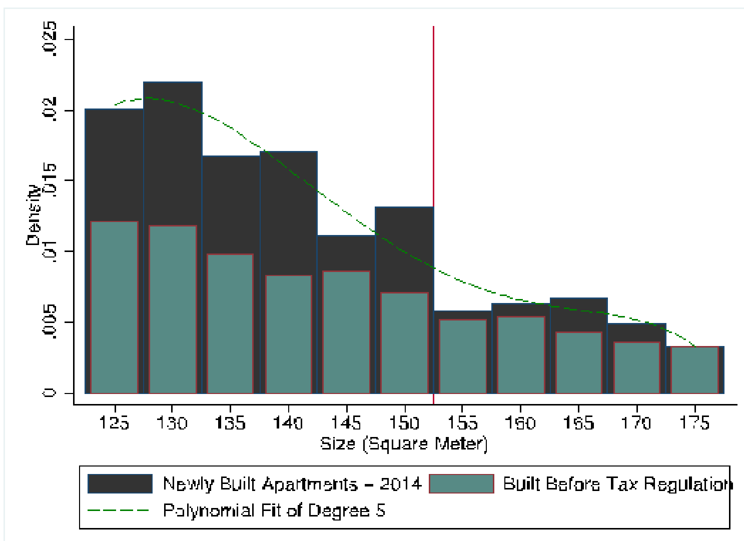
(b) Q2 2013 – Q2 2014



(c) Q2 2014 – Q3 2014

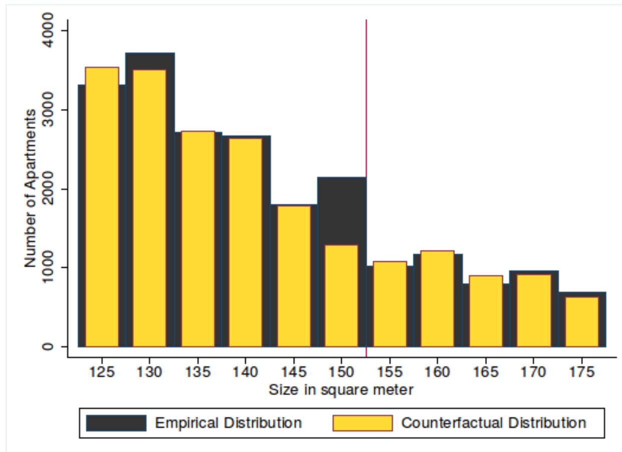
Note: Histogram of apartments' size for three consecutive years, separately. The solid line shows the starting point of taxation. The line itself belongs to the tax-zero side of the kink. The numbers next to the dashed line are the percentage reduction in the number of apartments that occurs by moving from the bin $(145m^2, 150m^2]$ to the bin $(150m^2, 155m^2]$.

Figure 8: Apartments Distribution in the Owning Market

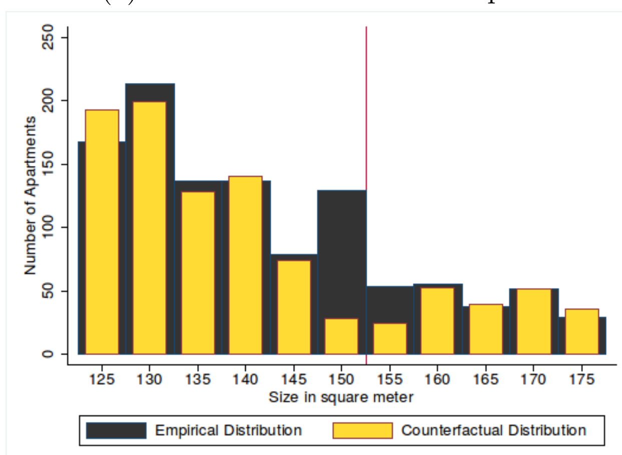


Note: This figure shows the density of newly built and old properties for the owner-occupant market by 5 m^2 bins. The sample of newly built apartments is reduced to include only observations from 2014. The dashed line displays the polynomial fit of degree of five for newly built apartments. The solid line shows the starting point of taxation. The line itself is on the tax-zero side of the kink.

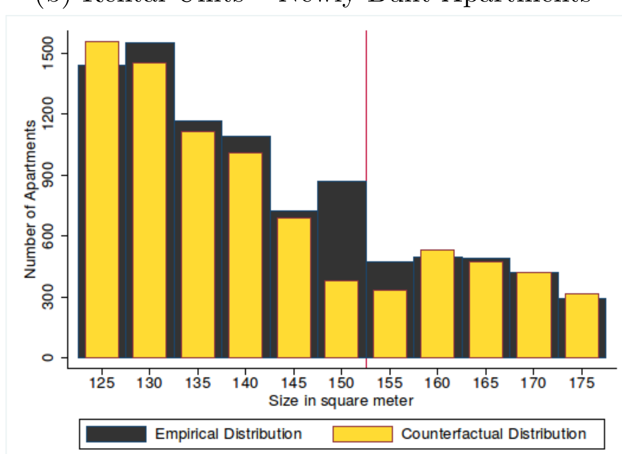
Figure 9: Empirical and Counterfactual Distributions around the Size kink



(a) Rental Units – Entire Sample



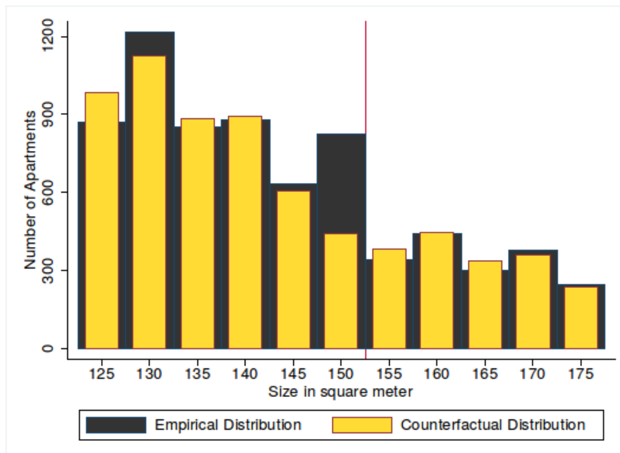
(b) Rental Units – Newly Built Apartments



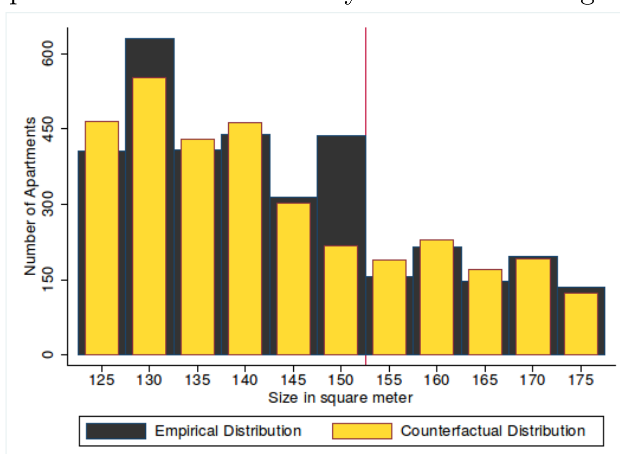
(c) Owner-Occupied Units – Newly Built Apartments

Note: This figure illustrates the empirical and counterfactual distributions of apartments in Tehran for years 2012 to 2014. The counterfactual distribution is estimated for each panel separately based on equation (1.16), by fitting a fifth-order polynomial to the empirical distribution and excluding the bunching segment. The solid line shows the starting point of taxation. The line itself is on the tax-zero side of the kink. The excess bunching B is the difference between the empirical and counterfactual densities in the small interval below the size kink in proportion to the average counterfactual distribution right above the cutoff.

Figure 10: Apartment Distributions by Property Age



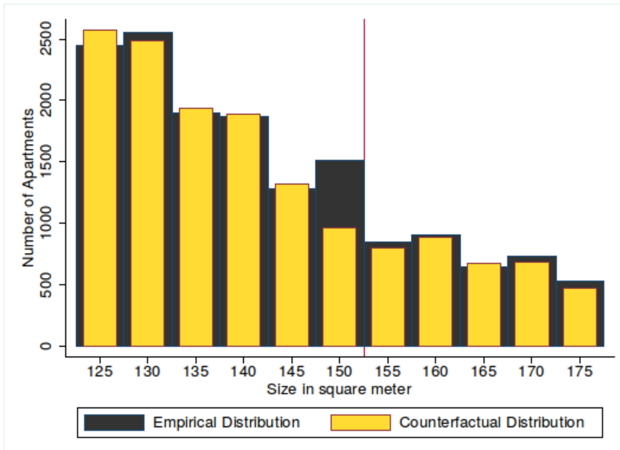
(a) Apartments built at least 5 years before the regulation



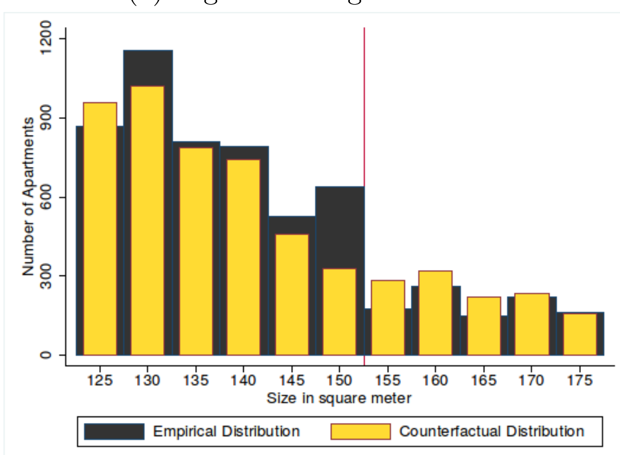
(b) Apartments built at least 15 years before the regulation

Note: This figure illustrates the empirical and counterfactual distributions of apartments in Tehran for years 2012 – 2014. Panel 10a includes rental apartments that were built at least 5 years before the tax regulation. Panel 10b presents the same graphs for older rental apartments by trimming the dataset further to only include apartments that were built at least 15 years before the regulation. The counterfactual distribution is estimated for each panel separately based on equation (1.16) by fitting a fifth-order polynomial to the empirical distribution and excluding the bunching segment. The solid line shows the starting point of taxation. The line itself is on the tax-zero side of the kink. The excess bunching B is the difference between the empirical and counterfactual densities in the small interval below the size kink in proportion to the average counterfactual distribution right above the cutoff.

Figure 11: Apartment Distributions across Different Neighborhoods



(a) High-rent Neighborhoods



(b) Low-rent Neighborhoods

Note: This figure illustrates the empirical and counterfactual distributions of apartments in Tehran for years 2012 to 2014. Panel 11a includes only properties that are located in postal regions with average rent above the median, and Panel 11b includes the rest of observations. The counterfactual distribution is estimated for each panel separately based on equation (1.16) by fitting a fifth-order polynomial to the empirical distribution and excluding the bunching segment. The solid line shows the starting point of taxation. The line itself is on the tax-zero side of the kink. The excess bunching B is the difference between the empirical and counterfactual densities in the small interval below the size kink in proportion to the average counterfactual distribution right above the cutoff.

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Appendices

B Derivation of Equation (7)

$$A_h^{1+\eta} = \frac{\bar{s}}{p^{*\eta}}\left(\frac{1+\eta}{\eta}\right)^{\eta} = \frac{\bar{s}}{p^{*\eta}}\left(\frac{1}{\delta}\right)^{\eta} \tag{20}$$

Plugging this expressions in equations (5) and (6), we get:

$$\begin{aligned}
\pi_0 &= p_0\underline{s} - \left(\frac{\underline{s}}{A_h}\right)^{1+\frac{1}{\eta}} - r \\
&= p_0\underline{s} - \frac{\underline{s}^{\frac{1+\eta}{\eta}}}{A_h^{\frac{1+\eta}{\eta}}} - r \\
&= p_0\underline{s} - \frac{\underline{s}^{\frac{1+\eta}{\eta}}}{\bar{s}^{\frac{1}{\eta}}} p^*\delta - r \\
&= p_0\underline{s} - \delta\bar{s}p^*\left(\frac{\underline{s}}{\bar{s}}\right)^{\frac{1}{\delta}} - r,
\end{aligned} \tag{21}$$

and

$$\begin{aligned}
\pi_1 &= (1-\delta)\delta^{\eta}A_h^{1+\eta}(1-\tau)^{1+\eta}p_1^{1+\eta} - r + \tau\underline{s}p_1 - (1-\gamma)f \\
&= (1-\delta)\frac{\bar{s}}{p^{*\eta}}(1-\tau)^{1+\eta}p_1^{1+\eta} - r + \tau\underline{s}p_1 - (1-\gamma)f \\
&= (1-\delta)\bar{s}p^*\left(\frac{(1-\tau)p_1}{p^*}\right)^{\frac{1}{1-\delta}} - r + \tau\underline{s}p_1 - (1-\gamma)f.
\end{aligned} \tag{22}$$

Equating expressions (21) and (22) we get:

$$\begin{aligned}
\underline{s}(p_0 - \tau p_1) + (1-\gamma)f &= (1-\delta)\bar{s}p^*\left(\frac{(1-\tau)p_1}{p^*}\right)^{\frac{1}{1-\delta}} + \delta\bar{s}p^*\left(\frac{\underline{s}}{\bar{s}}\right)^{\frac{1}{\delta}} \\
\frac{\underline{s}(p_0 - \tau p_1)}{\bar{s}p^*} + \frac{(1-\gamma)f}{\bar{s}p^*} &= (1-\delta)\left(\frac{(1-\tau)p_1}{p^*}\right)^{\frac{1}{1-\delta}} + \delta\left(\frac{\underline{s}}{\bar{s}}\right)^{\frac{1}{\delta}}
\end{aligned}$$

Finally, we can return to our original notation to get the relationship between price elasticity of housing size supply, rent responses, filing costs, and bunching as:

$$\frac{\underline{s}}{\bar{s}}\left[\frac{p_0 - \tau p_1}{p^*} + \frac{(1-\gamma)f}{\underline{s}p^*}\right] = \frac{1}{1+\eta}\left(\frac{(1-\tau)p_1}{p^*}\right)^{1+\eta} + \frac{\eta}{1+\eta}\left(\frac{\underline{s}}{\bar{s}}\right)^{\frac{1+\eta}{\eta}}$$

If $p^* = p_0$, then

$$\frac{\underline{s}}{\bar{s}}\left[1 - \tau\frac{p_1}{p_0} + \frac{(1-\gamma)f}{\underline{s}p_0}\right] = \frac{1}{1+\eta}\left(\frac{(1-\tau)\,p_1}{p_0}\right)^{1+\eta} + \frac{\eta}{1+\eta}\left(\frac{\underline{s}}{\bar{s}}\right)^{\frac{1+\eta}{\eta}}$$

C Derivation of Equation (14)

In the absence of the size kink, individual h would choose a property with size $\bar{s}$, which implies $\alpha_h = \bar{s}p^{*\epsilon}$. Replacing α_h in equations (12) we get

$$\begin{aligned}\underline{u} &= y - \underline{s}p_0 - \frac{\epsilon}{1-\epsilon}\alpha_h^{\frac{1}{\epsilon}}\underline{s}^{1-\frac{1}{\epsilon}} \\ &= y - \underline{s}p_0 - \frac{\epsilon}{1-\epsilon}\bar{s}^{\frac{1}{\epsilon}}p^*\underline{s}^{1-\frac{1}{\epsilon}} \\ &= y - \underline{s}p_0 - \frac{\epsilon}{1-\epsilon}p^*\bar{s}\left(\frac{\underline{s}}{\bar{s}}\right)^{1-\frac{1}{\epsilon}}. \end{aligned} \tag{1}$$

Similarly for equation (13) we get

$$\begin{aligned}\bar{u} &= y - \alpha_h p_1^{1-\epsilon} - \gamma f - \frac{\epsilon}{1-\epsilon}\alpha_h p_1^{1-\epsilon} \\ &= y - \bar{s}p^{*\epsilon}p_1^{1-\epsilon} - \gamma f - \frac{\epsilon}{1-\epsilon}\bar{s}p^{*\epsilon}p_1^{1-\epsilon} \\ &= y - \bar{s}p^*\left(\frac{p_1}{p^*}\right)^{1-\epsilon} - \gamma f - \frac{\epsilon}{1-\epsilon}\bar{s}p^*\left(\frac{p_1}{p^*}\right)^{1-\epsilon} \\ &= y - \frac{1}{1-\epsilon}\bar{s}p^*\left(\frac{p_1}{p^*}\right)^{1-\epsilon} - \gamma f \end{aligned} \tag{2}$$

Equating expressions (1) and (2) we get:

$$\begin{aligned}\underline{s}p_0 + \frac{\epsilon}{1-\epsilon}p^*\bar{s}\left(\frac{\underline{s}}{\bar{s}}\right)^{1-\frac{1}{\epsilon}} &= \frac{1}{1-\epsilon}\bar{s}p^*\left(\frac{p_1}{p^*}\right)^{1-\epsilon} + \gamma f \\ \frac{\underline{s}p_0 - \gamma f}{\bar{s}p^*} &= \frac{1}{1-\epsilon}\left(\frac{p_1}{p^*}\right)^{1-\epsilon} + \frac{\epsilon}{\epsilon-1}\left(\frac{\underline{s}}{\bar{s}}\right)^{\frac{\epsilon-1}{\epsilon}}\end{aligned}$$

which simplifies to:

$$\frac{\underline{s}}{\bar{s}}\left[\frac{p_0}{p^*} - \frac{\gamma f}{\underline{s}p^*}\right] - \frac{1}{1-\epsilon}\left(\frac{p_1}{p^*}\right)^{1-\epsilon} - \frac{\epsilon}{\epsilon-1}\left(\frac{\underline{s}}{\bar{s}}\right)^{\frac{\epsilon-1}{\epsilon}} = 0$$