Is the Rent Too High?
Land Ownership and Monopoly Power*

C. Luke Watson
FDIC

Oren Ziv
Michigan State University

February 2023

Click Here for Current Version

Abstract

Pricing power in real estate markets can reduce housing supply and redevelopment relative to the social optimum. We show how popular redevelopment subsidies, zoning regulations, and ownership concentration restrictions interact with pricing power. To test for the presence and quantify the scope of pricing power, we construct a new building-level dataset from New York City. First, using a synthetic tax instrument, we find cost pass-through rates that are inconsistent with competitive pricing and consistent with markups. Second, we find a 10% increase in Census tract ownership concentration is correlated with a 0.5% increase in rent. Finally, we estimate that markups account for between ten and thirty percent of rents in the city.

Keywords: monopolistic competition, market power, concentration, housing demand, redevelopment subsidies, zoning

JEL Classification: R31, R38, L13

*Corresponding author: Oren Ziv. Email: orenziv@msu.edu. Mailing Address: 110 Marshall-Adams Hall, Department of Economics, Michigan State University, East Lansing, Michigan 48824, USA. Phone: (517)-884-1370. Fax: (517)-432-1068. We thank Jason Barr, Rebecca Diamond, Nate Baum-Snow, Michael Conlin, Stacy Dickert-Conlin, Ingrid Gould Ellen, Jessie Handbury, Justin Kirkpatrick, Jeffrey Lin, Steve Matusz, Charles Nathanson, Leslie Papke, Luis Quintero, Stuart Rosenthal, Nathan Seegert, Ronit Levine-Schnur, Marten van Dijk, and John Wilson and seminar participants at the Gazit-Globe Real Estate Institute at the IDC Herzliya, the Urban Economic Association, the ASSA-AREUEA, the AREUEA National Conference, the Federal Reserve Bank of Philadelphia, and the NYU Furman Center for helpful comments. Views and opinions expressed in this paper reflect those of the authors and do not necessarily reflect those of the FDIC or the United States. All mistakes are our own.

1 Introduction

Property rights grant land owners exclusive use over parcels of land. Since Adam Smith, economists have considered whether this arrangement endows land owners with monopoly pricing powers.[1] The recent rise of institutional landlords has increased interest in the effects of concentration and pricing power. *A priori*, property rights need not generate monopoly power, and standard urban models assume perfect competition. However, the existence of pricing power has implications for urban policy analysis, estimates of housing production functions, and counterfactual estimation in urban settings. Moreover, to the extent that pricing power leads to reductions in available housing, it is a contributing factor to housing supply constraints and housing costs.

This paper investigates the economic impact of pricing power due to land rights. We answer two questions: how should pricing power alter our understanding of urban land use policies and is this power economically meaningful? We show how pricing power, derived from the combination of exclusive land ownership rights and idiosyncratic renter tastes, interacts with redevelopment incentives and zoning regulations and examine the possibility that restrictions on land ownership concentration can reduce rents. Using data on multi-unit residential rental buildings in New York City (NYC), we find cost pass-through rates and concentration-rent correlations consistent with the existence of landlord pricing power and that monopoly markups are at least a tenth of rental prices in the city.

We model the construction and rental of housing units in the presence of idiosyncratic preferences for locations, which (following Chamberlin, 1933) generates downward-sloping demand for units at individual plots or buildings, which we call buildings' *residual demand*. While aggregate demand can be downward sloping in competitive frameworks, when *residual* demand is downward sloping, landlords with exclusive right rights to rent at those plots have pricing power, even when profits from rents are capitalized into land values. This restricts supply on three margins: reducing the size of new buildings, removing existing units from the market when demand is low, and reducing the pace of redevelopment when demand is high, even when such redevelopment is socially opti-

[1]For Smith, that the land owners could rent unimproved land lead him to believe that rent was a "monopoly price" (Smith, 1776). Ricardo (1817) considered land a differentiated factor of production, so that rents reflected differentials in marginal product. Marx argued that monopoly land rents came from three sources: quality differences, markups designed to limit access to land, and extraction of rents from producers selling at markups (Evans, 1991).

mal given costs.[2] We call this third margin 'redevelopment failure.'[3] In our Theoretical Appendix, we adopt our model to a monocentric city and show how markups and these margins of supply constraints act as a dispersing force.

We explore the implications on three types of urban policies: redevelopment subsidies, ownership concentration, and zoning. First, because of redevelopment failure, subsidizing the decision to redevelop can improve welfare. We explore a low-information alternative to optimal subsidies that does not require knowledge of demand and supply elasticities: pairing lump-sump development subsidies with promised rent reductions. These policies echo the common pairing of local tax subsidies with inclusionary zoning. While such policies are often viewed as equity-oriented, we offer a potential efficiency justification.

Second, we explore restrictions on ownership concentration, as recently proposed in Berlin (Stone, 2019). With non-decreasing marginal cost, concentrated owners raise markups, internalizing the impact of one parcel's pricing decision on profits at other parcels.[4] We extend Nocke and Schutz (2018b) to find conditions under which increased concentration also generates increases in prices for all other products—in our case parcels. This provides a theoretical basis for work studying the impact of landlord and developer concentration (Cosman and Quintero, 2021; Raymond et al., 2016).

Third, markups amplify the effect of zoning, as zoning constraints at one parcel raise rents at other unzoned parcels through markups. At the same time, pricing power attenuates the impact of up-zoning through redevelopment failure, and because redeveloped upzoned parcels revert to monopolistic rather than efficient levels.

While these theoretical channels may exist, a separate question, over which the literature is silent, is whether they are empirically relevant. As clarified by our model, this question can be answered by testing for slope in buildings' residual demand curves. To investigate, we construct a new building-level dataset for multi-unit residential buildings in NYC using a combination of public and scraped data. Although NYC may be a unique real estate environment, we provide separate results for outer boroughs where density is similar to many other urban markets.

First, we test for the existence of pricing power using the pass-through of idiosyncratic

[2] Vogell (2022) documents the second margin in interviews with New York City landlords.

[3] This is related to the 'lock-in' effect of vintage capital in Boustan, Bunten, and Hearey (2018). Siodla (2015); Hornbeck and Keniston (2017) discuss redevelopment in the presence of natural disasters. A large previous literature (e.g., Rosenthal and Helsley, 1994) explores redevelopment under perfect competition.

[4] This result builds on Nocke and Schutz (2018a), part of a growing literature on multi-product oligopoly (Affeldt, Filistrucchi, and Klein, 2013; Jaffe and Weyl, 2013; Nocke and Schutz, 2018a)

cost shocks.[5,6] As we show in Appendices A.7 and A.8, *idiosyncratic* (as opposed to market level) cost shocks cannot be passed through to rents unless landlords face downward sloping residual demand. Using assessment procedure changes as a source of plausibly exogenous variation in building-level costs, we find evidence that increased expenses are passed on into rents. We find pass-through rates above 1-to-1, further affirming the presence of markups (Pless and van Benthem, 2019). Second, we find *non-causal* correlations in the data consistent with the predictions of our model: a 10% increase in Census tract concentration is correlated with a 0.4-0.6% increase in average building rents, even accounting for time-invariant building characteristics.

As a final quantification exercise, we estimate the structural parameters of our model to calculate building-level own-price elasticities (OPEs) of demand—not previously estimated—to evaluate the quantitative scope of markups.[7] In addition to the tax instrument described above, we estimate OPEs using two more sets of instruments with distinct sources of variation and identifying assumptions, as in Hornbeck and Moretti (2018). As is common in estimates of housing demand, we use rival characteristics ('BLP instruments') (Bayer, Ferreira, and McMillan, 2007; Davis et al., 2021; Almagro and Domınguez-Iino, 2019). Additionally, we use historic tax and construction costs as cost shifters. The complementary strategies yield similar parameter estimates, with median OPEs between $[-9, -3]$.

We apply these results to characterize markups. An important aspect of our empirical environment is the ubiquity of policy and other constraints on prices and quantities.[8] Our model indicates that markups can only be estimated from OPEs using the set of buildings in our sample which are recently constructed and not at a corner imposed by policy constraints. Among such buildings, which we call the *policy-unconstrained* sample, we find a median markup over marginal costs—including amortized purchase, maintenance, leasing costs and outside options—between one-tenth and one-third of the rent.[9]

[5]Our approach complements Weyl and Fabinger (2013); Pless and van Benthem (2019); Ritz (2019) who study *market* level cost shock pass-through. Pless and van Benthem (2019) show that *over*shifting of market cost shocks is a test for pricing power, and Ritz (2019) shows that monopolistic markets may have greater pass-through than competitive markets.

[6]Hughes (2022) finds pass-through of costs onto rents through a financing mechanism.

[7]Our estimation method is based on differentiated product demand estimation (e.g., Berry, 1994). Within urban housing demand literature, our work is most closely related to Bayer, McMillan, and Rueben (2004); Bayer, Ferreira, and McMillan (2007), who estimate housing demand and resident sorting within San Francisco. See Kuminoff, Smith, and Timmins (2013) for a literature overview.

[8]Appendix D discusses the policy environment in NYC, including zoning, rent controls, rent stabilization, and how we account for each in our estimates. Appendix G also provide robustness results where we drop parts of our sample which may bias results due to these policy restrictions.

[9]We exclude buildings where zoning regulations at the time of construction imply no additional units

Housing supply constraints have been implicated in large-scale economic losses (Hsieh and Moretti, 2019), largely blamed on policy wedges between costs and prices (Glaeser and Gyourko, 2018). This paper explores pricing power as a new source of supply constraint. While Proposition 2 shows that markups can amplify policy constraints in general equilibrium, pricing power also reduces supply in the absence of policy constraints and accounts for a 10-30% wedge between prices and costs. Appendix A.7 shows that pricing power acts as a dispersing force, flattening and widening the city. An implication of our findings is that reductions in policy constraints alone will not eliminate these wedges.

Our paper also has implications for work studying or using housing supply elasticities. Estimates of the production function for housing typically assume competitive markets (Combes, Duranton, and Gobillon, 2021; Baum-Snow and Han, 2019), as do papers undertaking counterfactual analyses involving housing supplies (Ahlfeldt et al., 2015; Severen, 2018). The latter mismeasure supply elasticities by not accounting for the impact of changing markups in counterfactuals. In the former, pricing power implies estimates based on competitive frameworks are mispecified and require additional supportive assumptions.[10] We provide a guide for how to account for these forces with additional structure on demand in conjunction with consideration of policy constraints.

Recent empirical work has focused on housing ownership concentration (Cosman and Quintero, 2021; Raymond et al., 2016). In addition to evidence in this vein, we provide a theoretical basis for this nascent work, establishing evidence of markups in housing and both a rationale for how and necessary conditions for when concentration impacts prices.

Pricing power in housing appears in two literatures. The first uses monopoly power to justify rent control (Arnott, 1989; Arnott and Igarashi, 2000; Basu and Emerson, 2003).[11] The second is on the dynamic pricing of single-family units, where search implicitly generates pricing power (Genesove and Han, 2012; Ngai and Tenreyro, 2014; Piazzesi, Schneider, and Stroebel, 2015; Glaeser and Nathanson, 2017; Gilbukh and Goldsmith-Pinkham, 2019, e.g.). Indeed, search and matching is an alternative microfoundation for downward-sloping demand in place of idiosyncratic preferences.[12] We explore the policy

of similar size can be built, where more than 50% of units are rent stabilized, and that were constructed more than 10 years prior. To assess whether a building is zoning constrained, we determine whether an additional minimum sized residential unit can be added given current floor-area-ratios and density limits.

[10] In Combes, Duranton, and Gobillon (2021), the existence of pricing power, with the added assumption of a constant elasticity of demand, alters the result in their equations (4) and (5) by a fixed proportion.

[11] Diamond, McQuade, and Qian (2019) consider rent controls' effects on exit, which we discuss in Appendix A.7.

[12] In a potentially more realistic dynamic setting, units stochastically become available and renters with idiosyncratic tastes search. As such, landlords posting prices face a trade-off of holding units longer for

and supply consequences of pricing power and estimate its empirical relevance.

While our estimates are consistent with previous demand elasticity estimates focused on *aggregate* demand—the housing-consumption trade-off—we are interested in substitution *between* rival buildings, estimating the first set of buildings' OPEs.[13]

2 Model

We first set up the optimization routines for each agent in our model. Developers are endowed with spatially differentiated parcels and decide whether to (re)develop before selling.[14] Landlords buy buildings and rent apartments to renters, who are endowed with income and choose residence locations. This structure allows us to consider how redevelopment may respond to long-run changes in demand and explore how pricing, leasing, and redevelopment decisions are impacted by pricing power. The static model here abstracts redevelopment decisions from dynamic rent flow considerations, but such a model is consistent with a dynamic model featuring a constant price of capital and no depreciation (see equation 2.5 in Rosenthal and Helsley, 1994). Appendix A.7 explores different extensions, including a competitive benchmark case, a version the following model embedded into a monocentric city, and the introduction of entry, exit, and risk.

2.1 Setup

Parcels, Developers, and Landlords The space, a city, is comprised of a set discrete parcels, $\mathcal{A} = \{a_0, a_1, a_2, \dots, a_J\}$, that differ according to their underlying quality a, drawn without replacement from a distribution $G(a)$. Higher values of a have higher amenity value to renters. We refer to a as "location quality" and differences in a as vertical differentiation in parcels. A location's realized quality a will also be used henceforth to index each location in the set $\mathcal{A}$. In the exposition that follows, we make the simplifying assumption that a is exogenous, while in our empirical work we consider that in the data building and parcel characteristics are a mix of endogenously chosen and exogenously given.[15] We set a_0 as living out of the city (i.e., an outside-option).

higher rents versus lowering expected vacancies, and in equilibrium offer a uniform price based on expected demand. This trade-off and the equilibrium are isomorphic to our simplified static setting.

[13]Following Berry and Jia (2010), we estimate that if *all* building rents increased by 1%, aggregate rental demand responds with an elasticity between $[0.60, 2.4]$ (Albouy and Ehrlich, 2018). Using hedonic approaches, Gyourko and Voith (2000) and Chen, Clapp, and Tirtiroglu (2011) find elasticities above 1.

[14]Parcels may be "greenfield" with zero units or "brownfield" with some existing structure.

[15]In Appendix A.7.6 we allow a to be endogenously chosen.

Each parcel may have a building with an initial number of units, $q_{a,0} \geq 0$ and is owned by a unique developer, indexed by $\mathsf{d} \in \mathsf{D}$, who chooses whether to sell the parcel 'as-is,' in which case the number of units remain $q_{a,0}$, or redevelop to $q_{a,1}$ before selling to a landlord who leases the units.[16] We assume each developer—and subsequently each landlord—owns only one parcel, although we will relax this assumption in Section 3.3.

Redevelopment requires a cost $C_a^{\mathsf{d}}(q_{a,1})$ that is a-dependent, strictly positive, and differentiable with non-negative marginal cost denoted $c_a^{\mathsf{d}}(q_{a,1})$. $C_a^{\mathsf{d}}(q_{a,1})$ may include a fixed cost $C_a^{\mathsf{d}}(0) > 0$. Developers choose whether to redevelop and conditional on redevelopment, quantity $q_{a,1}$ to maximize profit:

$$\pi_a^{\mathsf{d}} = \max_{\mathbb{1}_{redev}, q_{a,1}} \begin{cases} s_a(a, q_{a,0}) & \text{if } \mathbb{1}_{redev} = 0 \\ s_a(a, q_{a,1}) - C_a^{\mathsf{d}}(q_{a,1}) + \mathsf{S}_a & \text{if } \mathbb{1}_{redev} = 1 \end{cases} \quad (1)$$
$$\text{s.t. } q_{a,1} \leq q_{a,z},$$

where $\mathbb{1}_{redev}$ is an indicator function for the choice to redevelop, s_a is the realized sale price of the building, which would be $s_a(a, q_{a,0})$ if sold 'as-is' or $s_a(a, q_{a,1})$ if sold after redevelopment to size $q_{a,1}$, and S_a is a parcel-specific redevelopment subsidy. Redevelopment is constrained by a plot-specific maximum quantity $q_{a,z}$ set by zoning regulations.

For each parcel, a competitive fringe of potential landlords, indexed by $\mathsf{f} \in \mathsf{F}$, bid for sole the right to lease units and set rents in the building at at that location. Landlords who purchase buildings provide a mass of renters housing at a positive, differentiable cost $C_a^{\mathsf{f}}(q_a^{\mathsf{f}})$ with positive marginal cost $c_a^{\mathsf{f}}(q_a^{\mathsf{f}})$, where q_a^{f} is the mass of renters the landlord accommodates in equilibrium. Landlord f's profit from parcel a is:

$$\pi_a^{\mathsf{f}} = r_a \cdot q_a^{\mathsf{f}} - C_a^{\mathsf{f}}(q_a^{\mathsf{f}}) - s_a \quad \text{s.t.} \quad q_a^{\mathsf{f}} \leq q_{a,\mathsf{d}}, \quad (2)$$

where total revenue is rent r_a collected times the quantity offered to renters q_a^{f}, which is constrained to be at or below the quantity chosen by the developer, $q_{a,\mathsf{d}}$.[17]

Renters A unit mass of heterogeneous renters, indexed by $i \in \mathsf{N}$, with utility derived from consumption and location amenities. Renters draw idiosyncratic tastes for each location,

[16]We refer to buildings, parcels, and plots interchangeably throughout.

[17]We do not allow for price discrimintion. Footnote 12 describes an alternative dynamic search setting where landlords price and market units individually that retains our static setting's results.

$\epsilon_{i,a}$, from a standard type-one extreme value distribution.[18] Thus, utility of renter i at a is:

$$U_i(a) = F(a, r_a) + \epsilon_{i,a}. \tag{3}$$

Rent is in the utility function because we have implicitly substituted the budget constraint for consumption. Renters choose among all locations a to maximize utility taking amenities, rents, and personal income as given.

Demand Market demand is a function of the vector of rents and building qualities:

$$q_a^D = D_a(\vec{\mathbf{a}}, \vec{\mathbf{r}}) = \frac{\mathsf{e}^{F(a,r_a)}}{\sum_{\tilde{a} \in \mathcal{A}} \mathsf{e}^{F(\tilde{a}, r_{\tilde{a}})}}. \tag{4}$$

We write $q_a^D = D_a(r_a)$, suppressing other arguments to ease notation. We can invert the system of demand equations to recover inverse demand functions for each building, $r_a = R_a(q_a)$, that are differentiable with respect to quantity, $\frac{\partial R_a}{\partial q_a}(q_a)$. We refer to building-level demand as the building's *residual demand*, in contrast to aggregate or market-level demand. Anticipating the price-setting decision, the equilibrium price elasticity of demand is:

$$\varepsilon_a = \frac{\partial D_a(r_a)/\partial r_a}{D_a(r_a)/r_a} = \frac{\partial F(a, r_a)}{\partial r} \cdot r_a \cdot (1 - D_a(r_a)) < 0. \tag{5}$$

The own-price elasticity of residual demand, which is derived from renters' idiosyncratic preferences for buildings, is key to pricing power and markups. Appendix A.7 explores an alternative model where this residual demand is completely elastic.

Social Welfare We define the *local* social welfare as the economic surplus at each location a. That is, the sum of both renter (consumer) surplus and developer/landlord (producer) surplus:

$$\mathsf{W}_a(q_a^e) = \int_0^{q_a^e} \left(R_a(q^e) - c_a^{\mathsf{f}}(q^e) - \mathbb{1}_{redev} \cdot c_a^{\mathsf{d}}(q^e) \right) \mathsf{d}q, \tag{6}$$

where q_a^e is the equilibrium quantity for building a, which depends on the redevelopment decision (i.e. value of $\mathbb{1}_{redev}$). We assume every other building is at its equilibrium quantity. Note that any redevelopment subsidy, S_a, is paid for *ex post* of all decisions and drops out from the local welfare calculation. We define *total* social welfare as the total economic

[18] We follow Chamberlin (1933) in founding pricing power for individual plots in heterogeneous preferences. Several alternative micro-foundations are possible, including search and matching frictions. Adopting these isomorphic stories would not change our estimation results, although doing so would naturally change their interpretation.

surplus in the housing market, where total social welfare is $\mathsf{W} = \sum_{a \in \mathcal{A}} \mathsf{W}_a$.

We consider a city planner who wishes to maximize W in order to achieve allocative efficiency in the city and can regulate and subsidize the rental market. However, the city planner does not know the preferences or opportunity costs of market participants and cannot use unobservable information when setting policies.

We define a *locally welfare improving redevelopment* to be a redeveloped structure that has higher local welfare relative to *the existing structure*; i.e., $\mathsf{W}_a(q_a^e(\mathbb{1}_{redev} = 1)) > \mathsf{W}_a(q_{a,0}^e)$. We define a *locally welfare improving policy* to be a subsidy S_a or additional policy such that $\mathsf{W}_a(q_a^e)$ is higher under the policy compared to *laissez faire*, and to be welfare improving overall if W is higher under the policy.

2.2 Equilibrium

An equilibrium is defined by a schedule of rents, quantities, and redevelopment decisions $\{(r_a, q_a), \mathbb{1}_{redev}\}_{a \in \mathcal{A}}$ that maximize developer and landlord profits, assign renters to locations a such that no renter can increase utility by choosing to pay rents at any other parcel, and clear the real estate market.

2.2.1 Joint Landlord-Developer Problem

Because it most closely tracks the canonical monopolist problem where quantities are set to maximize profit, we first consider the case of a single landlord-developer, maximizing the joint profits of the two agents. With the sale price transfer cancelling, the joint landlord-developer maximizes profits from renting net of costs of any redevelopment:

$$\pi = \max_{\mathbb{1}_{redev}, q_a} \begin{cases} r_a(q_a) \cdot q_a - C_a^{\mathsf{d}}(q_a) - C_a^{\mathsf{f}}(q_a) + \mathsf{S}_a & \text{if } \mathbb{1}_{redev} = 1 \\ r_a(q_a) \cdot q_a - C_a^{\mathsf{f}}(q_a) & \text{if } \mathbb{1}_{redev} = 0 \end{cases} \tag{7}$$

where quantity chosen is $q_a \equiv q_{a,0} \leq q_{a,0}$ if $\mathbb{1}_{redev} = 0$ and $q_a \equiv q_{a,1} \leq q_{a,z}$ if $\mathbb{1}_{redev} = 1$.

If the landlord-developer chooses not to redevelop, their maximum quantity is fixed at $q_{a,0}$, but they may choose not to rent all units. They will price on the demand curve at or below $q_{a,0}$, conscious of the fact that per-unit price is falling with quantity $\partial R_a(q_a)/\partial q_a < 0$.

Redevelopment and Redevelopment Failure Redevelopment occurs if the associated cost is less than the difference between the maximal marginal profits with and without it:

$$C_a^{\mathsf{d}}(q_{a,0}^*) < [r_a(q_{a,1}^*) \cdot q_{a,1}^* - C_a^{\mathsf{f}}(q_{a,1}^*)] - [r_a(q_{a,0}^*) \cdot q_{a,0}^* - C_a^{\mathsf{f}}(q_{a,0}^*)], \tag{8}$$

for an quantity $q^*_{a,1} \leq q_{a,z}$ that is optimal conditional on choosing redevelopment and a quantity $q^*_{a,0}$ that is optimal conditional on not redeveloping.

An immediate implication is that redevelopment only occurs when the optimal leasing quantity is higher than the original quantity: $q^*_{a,1} > q^*_{a,0}$. Furthermore, when zoning constraints bind on the initial building, $q_{a,z} < q_{a,0}$, there is no redevelopment.

If this criterion for redevelopment is met, then the problem becomes the typical monopolist problem with composite marginal cost $c^{\mathsf{d}}_a(q_a) + c^{\mathsf{f}}_a(q_a)$, so that the landlord-developer sets q^*_a such that $\frac{\partial R_a}{\partial q_a}(q^*_a)q^*_a + r_a(q^*_a) = c^{\mathsf{d}}_a(q^*_a) + c^{\mathsf{f}}_a(q^*_a)$. If the market was perfectly competitive, then landlords would set $q_a > q^*_a$ such that $r_a(q_a) = c^{\mathsf{d}}_a(q_a) + c^{\mathsf{f}}_a(q_a)$. This leads us to the following definition of what we term local redevelopment failure.

Definition 1. *Local redevelopment failure* occurs at location a if developers at a choose not to redevelop while the redevelopment would be locally welfare improving.

Note, our definition ignores additional competitive forces that might reduce rents and increase quantities at other buildings and thus increase social welfare.

Appendix A demonstrates that for any positive, increasing, and convex cost functions $C^{\mathsf{d}}_a(q)$ and $C^{\mathsf{f}}_a(q)$, there exists a demand system for location a that results in local redevelopment failure. When costs are especially high, neither the social nor private benefits of redevelopment to $q^*_{a,1}$ outweigh the redevelopment costs. Conversely, if demand is especially high or redevelopment costs are especially low, then redevelopment can be both socially and privately optimal. However, the reduction in rents from moving from $q^*_{a,0}$ act as an additional friction that may prevent landlord-developers from pursuing redevelopment in certain intermediate cases. For example, if a neighborhood is more in demand than when the building was originally constructed, then the planner may want to see redevelopment, as the total social benefits outweigh the redevelopment costs, but landlord-developer profit is maximized by renting the building *as-is*.

Notably, this discrepancy between socially optimal and privately optimal decisions only occurs with finitely elastic (i.e., downward sloping) building-level demand.[19] That is, the landlord and developer's decisions can only be distortionary to the extent to which a building's residual demand curve is downward sloping.

[19] We note that while social planners may also want to change the quantity set by the monopolist conditional on redevelopment (i.e. set $q_{a,1} > q^*_{a,1}$), we define redevelopment failure as the decision to redevelop or not, taking $q^*_{a,1}$ as given. As such, redevelopment failure never applies to buildings where the monopoly-optimal quantity is below the size of the existing structure. For these buildings, even if redevelopment did occur, developers would set $q^*_{a,1} < q_{a,0}$. For a greater theoretical discussion, see the above cited literature on rent control.

Mark-ups and quantity restrictions Depending on demand, the landlord-developer sets quantities at one of three levels. First, if demand is low enough relative to $q_{a,0}$, the landlord-developer chooses not to redevelop and further restricts quantities by holding units back from the market. In this case, they set $q_{a,0}$ such that $\frac{\partial R_a}{\partial q_a}(q_a) \cdot q_a + \frac{\partial R_a}{\partial q_a}(q_a) = c_a^{\mathsf{f}}(q_a)$. Here, the equilibrium rent is marked-up over the marginal cost of leasing, and can be calculated according to the Lerner rule: $1/\varepsilon_a$. Second, in the case where demand is high enough relative to $q_{a,0}$ to merit redevelopment, landlord-developers set $q_{a,1}$ such that $\frac{\partial R_a}{\partial q_a}(q_a) \cdot q_a + \frac{\partial R_a}{\partial q_a}(q_a) = c_a^{\mathsf{f}}(q_a) + c_a^{\mathsf{d}}(q_a)$. Here, the equilibrium rent is marked-up over the composite marginal cost of leasing *and* redevelopment, and can be calculated according to the Lerner rule. Finally, if demand is high enough such that $q_{a,0}^* = q_{a,0}$ yet redevelopment is still suboptimal for the landlord-developer, then no units will be held back and the price will be $r_a(q_{a,0})$. At this corner, the Lerner rule as a measure of markups does not apply.

2.2.2 Separate Landlord and Developer Problems

To solve the disjoint problem, we begin with the landlord's optimal pricing and supply strategy and work backwards to the redevelopment problem. If the developer can anticipate the landlord's problem, then the approaches are equivalent as the competitive fringe of landlords bid the price to the optimal monopolistic profit amount.

Once a building is sold, a landlord's maximum supply is bounded by $q_{a,1}$. The landlord prices on the demand curve at or below the quantity $q_{a,1}$ to maximize monopoly profits according to the rule $\frac{\partial R_a}{\partial q_a}(q_{a,f}) = c_a^{\mathsf{f}}(q_{a,f})$. Because potential landlords bid competitively on each plot, the sale price of such a plot becomes

$$s_a(q_{a,1}) = r_a(q_{a,f}^*) \cdot q_{a,f}^* - C_a^{\mathsf{f}}(q_{a,f}^*) \quad \text{s.t.} \quad q_{a,f}^* \leq q_{a,1}. \tag{9}$$

Substituting the expression for $s_a(q_{a,1})$ into the landlord's profit condition (eq. 2), it becomes clear that the profit maximizing choice of $q_{a,1}$ in this case is the same as in the joint landlord-developer decision. Although the landlord makes a separate decision, units above the optimal number to rent do not increase the sale price of the building. Were the joint decision-maker to choose not to redevelop, the landlord would choose a quantity $q_{a,f}^* \leq q_{a,0}$, and the developer sees no benefit from redevelopment. Were the joint decision maker to redevelop, the chosen quantity q_a is exactly the point where the marginal increase in sale price equals the marginal increase in cost. In this case, the landlord always chooses the corner $q_{a,f}^* = q_{a,1}^*$.[20] While the landlord appears to be choosing a quantity where

[20]Note of course that redevelopment $q_{a,f}^* < q_{a,1}^*$ would imply over-development.

marginal revenue is above marginal cost, the joint decision maker case instructs us that the quantity is at the point where marginal revenue equals the combined marginal cost of both landlord and developer.

2.3 Extensions: Monocentric City, Entry, Exit, and Risk

In Appendix A.7, we discuss several extensions of our model, such as adapting a monocentric city model, introducing entry and exit, and risk. Our results of markups of rent over marginal cost survives as long as our model includes downward sloping residual demand and landlord exclusivity in renting out the units. Without entry, our model in this section serves as a reasonable medium-run model of a built urban environment with use laws.[21] The Appendix details how entry and exit from other real estate markets (e.g., condominium or commercial markets) would generate a cross-market profit equalization condition but still feature markups. This holds when we allow free entry overall and when we adapt a monocentric city framework, where entry on a particular margin, the city's fringe, pins down the landlord-developer profit gradient. This latter model also makes clear how pricing power acts as a dispersing force reducing the supply of housing, flattening and widening the city. The Appendix also discusses how risk enters this model.

2.4 Summary Discussion

The price-setting power of landlords and developers affects supply in three ways. First, in cases where demand is low, landlords withhold units from the market. Vogell (2022) documents this behavior, which is also isomorphic to setting rent at a high enough level such that landlords endure nonzero vacancy spells when lower prices would find renters sooner. Second, redevelopment may occur in fewer cases than would be the case if redevelopment decisions were made on a socially optimal basis. Third, when buildings are redeveloped, developers reduce quantities relative to an efficient benchmark in order to maximize the combined profits of redevelopment and leasing.

Developers build to the size at which marginal increase in sale value meets marginal costs, and landlords rent out the full building at market rates, while making no profits. However, the joint problem demonstrates how this behavior is equivalent to a reduction in quantity relative to an efficient baseline. While in any given period of time, few buildings are redeveloped, the model instructs that at the time of construction, those buildings were constructed in a manner which restricted supply relative to the contemporary demand.

[21]In NYC, for example, fewer than 100 buildings in the city apply for condo conversions each year.

An implication of these findings is that the Lerner Rule only maps demand elasticities to markups in cases where redevelopment has recently occurred and where buildings are not zoning constrained, or where units are withheld from the market. In the former case, markups are over the combined marginal cost of development and leasing, while in the latter case markups are only over the cost of leasing. This informs the set of buildings on which we calculate markups in Section 6.

3 Policy Implications

We assess the effects of several policies in the context of monopoly markups. First, we discuss redevelopment subsidies.[22] Second, we discuss the impact of ownership concentration on markups and rents. Lastly, we discuss the impact of zoning in the presence of markups.

3.1 Redevelopment Subsidies

Subsidies for redevelopment exist at the federal, state, and local levels. At the Federal level, the Low-Income Housing Tax Credit gives tax credit for the construction or rehabilitation of low-income housing and has been given for over 36,000 buildings accounting for nearly 2.5 million housing units (HUD, 2021). Opportunity Zones subsidize construction and investment in targeted areas. While there is no central accounting of the number or size of subsidies given by state or local governments for redevelopment projects, with our understanding of the scope of the latter being especially poor, *ad hoc* tabulations indicate instances of state and local redevelopment subsidies number in the hundreds of thousands (Data provided by Good Jobs First, 2022).

Such policies are typically analyzed as place-based policies (Glaeser and Gottlieb, 2008) and rationalized under an equity-efficiency tradeoff. However, the presence of landlord pricing power and resulting redevelopment failure creates a potential efficiency argument for such subsidies. Of note, these subsidies, including those mentioned above, often target or are linked to below-market rents.[23] Our analysis below points to an interesting possibility that, while equity may be the impetus for these, operationally, price restrictions may improve subsidy efficiency in low-information environments.

We first discuss an optimal policy, and then move to describing an implementable welfare improving policy.

[22] We consider the effects of redevelopment subsidies, but we ignore distortions that finance these policies, which are beyond the scope of this paper.

[23] See Inclusionary zoning (Baum-Snow and Marion, 2009; Soltas, 2021) and (Thaden and Wang, 2017).

Optimal Local Redevelopment Subsidy Eliminating local redevelopment failure can be achieved by aligning the developer's profit function with the local social surplus through subsidizing redevelopment to any quantity $q_{a,1}$ by the change in local renter surplus:

$$\mathsf{S}_a^{\mathsf{Opt}} = \left[r_a(q_{a,0}) - r_a(q_{a,1})\right] \cdot q_{a,0} + \int_{q_{a,0}}^{q_{a,1}} r_a(q)\mathsf{d}q. \tag{10}$$

This subsidy is isomorphic to the landlord charging each renter their willingness-to-pay (i.e., perfect price discrimination), which achieves allocative efficiency. Because the planner only cares about total social surplus, the planner accepts 'spending' the entire renter surplus on the landlord if it achieves allocative efficiency. It is unrealistic to believe agents have the information required to implement this subsidy, especially the distribution of willingness-to-pay for individual parcels in the city.[24]

Implementable Policies Instead, we consider subsidies targeted at local redevelopment failure that use only information attainable by policy makers. Proposition 1 defines a specific subsidy and rent discount that—when combined—reduce (but do not eliminate) local redevelopment failures and are local social welfare improving, without using any unobservable information.

Policy 1. Provide a redevelopment subsidy $\mathsf{S}_a = C^{\mathsf{d}}(q_{a,0})$ to developer-landlords, i.e. set the subsidy at the reconstruction cost to the building *as-is*.

The intuition for this subsidy is that local redevelopment failure occurs because of the combination of rents on existing structures and positive redevelopment costs. Without the latter (e.g., when no structure exists *ex-ante*), the monopolist always chooses $q_{a,1}^*$. Such a subsidy will always lead to profitable redevelopment. Crucially, these rebuilding costs are already calculated and readily available on a building basis via insurance.

We show in Appendix A that implementing Policy 1 would eliminate local redevelopment failures. However, offering a no-strings-attached subsidy would lead to over utilization such that some redevelopment is local social welfare *dis*-improving (i.e., negative local social welfare change), which we call socially wasteful redevelopment. The city planner cannot *ex ante* tell these cases apart from welfare improving redevelopments. Thus, we consider a second policy to work in tandem with the first.

[24]This optimal subsidy definition assumes all other building rents and quantities remain fixed, and so does *not* account for competition induced benefits, which would require the planner to know additional unobservable information.

Policy 2. Require that any developer-landlord accepting a subsidy must set an average rent, $r_{a,\mathsf{S}}$, to satisfy the following rule: $\mathsf{S}_a \leq [r_{a,0} - r_{a,\mathsf{S}}] \cdot q_{a,0}$.

Policy 2 puts an upper bound on the new rent: $r_{a,\mathsf{S}} \leq r_{a,0} - \mathsf{S}_a/q_{a,0}$, and ensures that the local social surplus gain is substantial enough so that subsidies are only taken when socially desirable by future residents. Intuitively, the rule comes from the first term in equation 10, so that the maximal subsidy that is offered is bounded by the local renter surplus. However, because of this bounding, we cannot ensure all local redevelopment failure is eliminated.

Proposition 1. *Policies 1 and 2 jointly are implementable, reduce local redevelopment failure, and are locally social welfare improving.*

The proposition has three consequents. The first is that the policies only require three—observable—market quantities: $\{q_{a,0}, r_{a,0}, C^{\mathsf{d}}(q_{a,0})\}$. The second is that the policies reduce (but do not eliminate) local redevelopment failure. The third is that the policy induced redevelopment generate local social surplus that is greater than the subsidy *and* greater under the policies than the *laissez-faire* outcome. Appendix A proves the claim.

We highlight three points. First, similar to existing policies, Proposition 1 hints at an efficiency argument for pairing redevelopment subsidies with rent reductions. Second, as opposed to existing policies, Proposition 1 prescribes a precise size for both the subsidy and rent reductions with existing information: *ex ante* rents, units, and rebuilding costs (observable on insurance records). Third, because the subsidy is based on rebuilding costs of existing structures, in our framework there is no efficiency argument for development subsidies on empty lots.[25]

3.2 New Implications for Zoning

An immediate implication of the above model is that, even in the absence of spillovers, a policy of no zoning is not first-best. Because a monopolist landlord restricts quantity, the quantity difference between zoning-restricted and an identical, unrestricted parcel with a monopolist landlord is less than the difference between zoning-restricted parcels and a competitively priced parcel. Height minimums could reduce rents. Appendix A.7 further explores this point in the context of a monocentric city.

[25]We reiterate that both the optimal and implementable policies discussed here pertain to aligning incentives regarding the decision to redevelop, but take the quantity provided by the monopolist conditional on redevelopment, $q^*_{a,1}$ as given. We do not consider policies attempting to set $q_{a,1} > q^*_{a,1}$ such that $P = MC$. Recall that redevelopment failure does not apply to buildings where $q_{a,0} > q^*_{a,0}$, and this policy does not impact those buildings. Importantly, Policy 2 disincentivizes these landlords from requesting the subsidy.

What happens when zoning constraints are not binding everywhere? To the extent that zoning constrains bind at a particular parcel, the quantity must be restricted beyond the monopoly-optimal quantity, and rents as a result must be higher. However, in a city where only some parcels are constrained by zoning rules, those constraints also impact rents at unzoned parcels by affecting equilibrium pricing power at unconstrained parcels. The rent at a given parcel is inversely proportional to rents at other parcels. This leads to the following statement:

Proposition 2. *The imposition of binding zoning constraints on a given parcel increases the rent at all other parcels, including unzoned parcels and parcels where zoning constraints do not bind. When marginal cost is constant, markups at those parcels go up as well.*

Appendix A presents a proof. By raising rents at competing locations, binding zoning constrains have spillover effects on rents at unconstrained locations through monopoly pricing. Likewise, relaxing zoning constraints at one parcel brings down rents elsewhere.[26]

3.3 The Impact of Market Concentration

Consider only the joint developer-landlord problem, we now relax our model's assumption that each landlord owns only a single parcel. Under monopoly pricing, higher rents can generate a positive pecuniary externality on other landlords, and, by increasing demand and affecting the own price elasticity, monopoly markups at one parcel may positively impact markups, rents, and profits at other locations. When landlords own multiple parcels, they internalize those pecuniary externalities, which may result in higher markups and rents overall. Monopolists with greater market share may reduce quantity to a greater extent in order to maximize total profits.

These forces are analogous to those in the multi-product oligopoly settings. Extending Nocke and Schutz (2018b), we generate the following proposition:

Proposition 3. *All else equal, landlords with higher market share have higher markups and rents; an increase in the ownership share of one landlord will generate increases in markups and rents at all the landlord's parcels, and increases in rents at all other parcels.*

Because we cannot assume marginal cost is constant, we introduce an even more flexible cost function than those found in Nocke and Schutz (2018b,a). That, in turn,

[26]Of course, even when units are priced competitively, if marginal costs are increasing, by limiting supply at one location, zoning can impact rents and quantities at other locations. But Proposition 2 points out that pricing power exacerbates the price effects by changing optimal markups. In other words, even in a world of constant marginal costs, zoning constraints at one parcel would raise rents at all other parcels in the city by increasing monopoly markups.

requires an extension to the result on the relationship between own share and others' share on markup and rent. Appendix A provides a proof.[27]

An important implication of this result is that manipulating the ownership structure of parcels affects rents through monopoly pricing. In particular, under specific conditions, reducing ownership concentration will reduce rents. In Section 5.2, we look for evidence of scope for such policies in our New York City dataset.

4 Data

Sources Our main data are derived from public administrative building-level records, as well as scraped data, from several New York City departments, including the Departments of City Planning, Finance, and Housing Preservation & Development. This dataset combines the Primary Land Use Tax Lot Output (PLUTO) and the Final Assessment Roll (FAR) for all buildings in NYC, as well as Multiple Dwellings Registration and Contacts (MDRC) datasets (with prior years graciously provided to us by the NYU Furman Center). The PLUTO and FAR provide location, zoning, market value, and other building characteristics, and the MDRC reveals common ownership across buildings.

We merge these with data derived from communications between the DOF and building owners, scraped off the Property Tax Public Access web portal, which we call the Notice of Property Value (NPV) dataset. It includes information mailed to building owners including gross revenue and cost estimates and the number of rent stabilized units.

We use the American Community Survey to allocate rental households to buildings to estimate building vacancies.[28] To determine the size of each rental market, we use the total number of renter households that are in buildings with four or more units relative to renters in the borough.

Sample Our data spans from 2007 to 2019, where we are able to link all datasets together. We use all private buildings classified as multi-family rental buildings in the Bronx, Brooklyn, Manhattan, and Queens with four or more units, where all units are residential

[27]Note that Proposition 3 relies on the assumption that marginal costs are non-decreasing and when there are no systematic variations in individual valuations by individual characteristics; i.e., no sorting. Intuitively, if landlords can raise profits by forcing more individuals into one parcel, generating scale, or if they can affect the sorting equilibrium through manipulations to the rents of multiple parcels, they may find it optimal to reduce, rather than increase rents and markups.

[28]To allocate rental households, we multiply building residential units by the block-group level rental occupancy rate. This method assumes that vacancy rates are uniform within Census block-groups.

units and there is no missing data.[29] In all regressions, we exclude mixed-use buildings because we cannot separate income due to residential versus commercial tenant sources.

Based on Section 2.2, we create an unconstrained subsample that excludes rent stabilized buildings and zoning constrained buildings.[30] We further limit the unconstrained sample to new buildings that are less than ten years old. For details, see Appendix C.

Geographic Units We use Census tracts as a unit of observation for ownership concentration. The large number of tracts provides us greater variation in the data. In addition, as discussed in Appendix E, ownership concentration is more easily calculated at the tract level, a feature which will help us in Section 5.2. An obvious downside to this choice is that markets are likely geographically continuous. Individuals at tract borders are more likely to search at adjacent tracts than in other neighborhoods, likely attenuating results.

Building Rental Income We use scraped data from communications between the city and landlords about building income. In NYC, rental buildings are assessed based on their income generation. The DOF collects annual revenue and cost information for all rental buildings as the basis of a building's tax assessment. Every year, the DOF sends a letter to building owners for each building that includes this information, which we parse for our dataset.[31]

We divide building income by the number of units for average annual unit rent in a building, and again by twelve for average monthly rent. A limitation of our data is that we do not see unit-level income.

Other Variables We link buildings using their unique, parcel-specific "borough-block-lot" (BBL) identification codes, with additional verification based on lot characteristics.[32] The building-level characteristics that we include are ten-year building age group indicators, log miles to nearest subway station, log years since the last major building renovation, log average unit square-feet, and whether the building has an elevator, and lot size quartiles. For location controls we use Census tract by year fixed effects.

[29]We use these four counties and the term New York city interchangeably as we omit Staten Island due to its relatively low number of large renal buildings.

[30]Specifically, a building is rent stabilized if more than 50% of units are rent stabilized, and is zoning constrained if the building would not be allowed to create an additional unit based on building floor-area-ratios and building density requirements.

[31]The letters exist to inform owners how their income and cost information is used to calulate market value and their ultimate tax liability.

[32]Most parcels contain a single building, but large parcels can contain multiple buildings with open space between them (e.g., a multi-building apartment complex). We refer to buildings, parcels, plots, and BBLs interchangeably throughout.

Summary Statistics Table 1 presents summary statistics for NYC rental buildings. Each column represents a cut of the data that we use. The first is the single-use residential sample of buildings that we use in the paper (i.e., excluding mixed-use and non-residential buildings), and the second is the set of policy-unconstrained buildings that are 10 years old or less in a given year.[33] Figure 1 plots the mean unit rents and concentration by Census tract.

Table 1: Summary Stats:
2007-2019 NYC Rental Buildings

	Tract Level	
Aggregate HHI	0.20	
	Building Level	
	Residential (1)	Unconstrained & New (2)
Owner Share in Tract	3.2%	3.5%
Leave-Out HHI in Tract	0.08	0.12
Median Rent	$ 1059	$ 1199
Median Rent by Median Income	0.18	0.23
Residential Units	19.2	14.6
Years Since Construction	88.2	5.0
Years Since Renovation	69.4	5.0
Avg Unit Sqft	821.5	924.5
Pct w/ Elevator	12%	19%
Miles to Subway	0.3	0.3
Currently Zoning Constrained	64%	0%
Initially Zoning Constrained	77%	12%
Pct Units Rent Stabilized	38%	0%
Pct Built in Last 10 Years	2%	100%
Unique Buildings	58,374	214

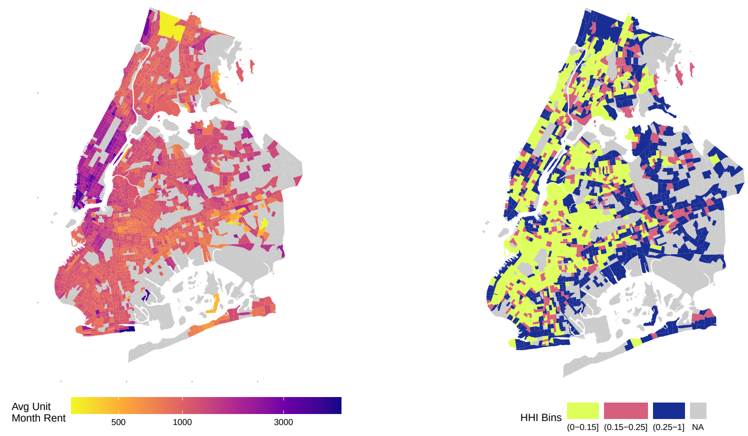
Note: The table reports summary statistics for all single-use residential buildings with four or more units and sub-samples. The first column contains all residential, single-use buildings. The second column subsets the data to only include buildings that are less than ten years old, where less than 50% of units are rent-stabilized, and that are able to add an additional unit according to zoning regulations, building floor-area-ratios, and minimum unit area requirements. Building data from PLUTO, NPV, FAR, and MDRC files. Census tract HHI defined using shares in equation 14. Owner share in tract is building level average. Leave-out building HHI defined using adjusted shares in equation 15. Monthly rent is building income divided by residential units divided by 12. Median borough income from ACS. All dollar values in nominal terms. Years since construction / renovation equal the year minus the construction year / most recent major renovation year. Avg Unit Sqft is total building area divided by units. Geodesic distances are in log miles based on building coordinates.

5 Reduced Form Evidence

Here, we present two sets of reduced form evidence of the pricing power in the New York city rental market. First, we present our primary, quasi-experimental evidence for pricing

[33] In unreported results, we have reweighted this subsample to better match the residential sample and found no quantitative difference in results.

Figure 1: Distribution of New York City Rents & Concentration



Note: The figure displays the geographic distribution of monthly rent and ownership concentration (measured by HHI) for 2010 Census tracts minus Staten Island. The top plot is the 2007-2015 average building monthly rent tract average in 2019 dollars. The bottom plot is the 2008-2015 average tract HHI value; note, according the the US Federal Trade Commission, HHI values between 0.15-0.25 are 'moderately concentrated' and above 0.25 are 'highly concentrated.' Dark blue tracts indicate higher rents (log scale) and concentration. Missing values (in light-gray) are Census tracts where we have insufficient data, in part due to the exclusion of mixed-use buildings. Data from PLUTO, FAR, NPV, and MDRC as described in text.

power by showing that building-level idiosyncratic cost shocks are passed through to rents, which, as we discussed below, is inconsistent with marginal cost pricing. Second, we show that greater concentration within a Census tract is positively correlated with rents. These correlations are non-causal but accord with the predictions of Proposition 3.

5.1 Pass-Through of Idiosyncratic Cost Shocks

As discussed in Section 2, the extent to which markups are priced into rents, and the extent to which landlord-developer decisions can distort quantities, hinges on the slope of buildings' residual demand curve. Our goal is therefore to test whether each building's residual demand curve—demand faced by each landlord for spots in their building—is perfectly elastic or downward sloping. Were each building's residual demand curve perfectly elastic, there could be no pass-through of truly idiosyncratic (i.e. building-level) cost shocks. Appendices A.7 and A.8 elaborate on this point by exploring a competitive benchmark and graphically demonstrating how pass-through works in such a model.[34]

We find that landlords do pass-through idiosyncratic cost shocks onto tenants (raising

[34]Our approach complements results from Weyl and Fabinger (2013); Pless and van Benthem (2019); Ritz (2019), who study *market level* pass-through, by highlighting that under pure competition an *idiosyncratic* shock cannot affect a good's price; rather, such shocks can only affect the quantity choice of the firm. Pless and van Benthem (2019) describe how market level cost shocks pass-through in purely competitive markets and show that overshifting is a sign of pricing power. Ritz (2019) show more competitive markets can generate lower pass-through of market-wide shocks. By contrast, the *idiosyncratic* shocks we focus on, which hold fixed market level variation, cannot be passed through by competitive landlords.

rents and incurring additional vacancies to profit maximize), rejecting that buildings face perfectly elastic demand. Moreover, our results imply pass-through rates over 100%—over-shifting incompatible with marginal cost pricing but consistent with pricing power in conjunction with sufficiently convex demand (Pless and van Benthem, 2019).[35]

To operationalize our test for pass-through, we rely on both large and small shifts in the tax code resulting in idiosyncratic variation in tax burdens across buildings.

Preliminary Evidence from a Tax Regime Shift We first leverage a tax code change which impacted the differential tax burden of larger (11+ unit) buildings after 2011. Between 2009-2011, taxes for large and small buildings were calculated using gross income multipliers (GIM). Then, starting with taxes due in 2012 (calculated using 2011 income), larger buildings were assessed using building-specific capitalization rates, a regime which had been in place prior to 2009.[36] This change resulted in a large differential increased tax burden on larger buildings. Examining a narrow bandwidth along the size threshold at which the tax regime changed such that buildings on either side of the threshold are identical in all respects other than the tax regime, cost pass-through should widen the difference between buildings on either side of the size threshold after the regime change.[37]

In Figure 2, blue dots represent tax burden differences for buildings with between 4-10 units vs those with 11-15 units, which, accordingly, jump after the regime shift, indicating that the relative tax burden indeed did shift to larger buildings that year. At the same time, unit rents differentials for larger buildings, in red, increase after the regime shift and do not converge again until the last year of our data, 2019. Unfortunately, 2012 communications between DOF and landlords of smaller buildings did not include income information and we are unable to measure rent differences in that year.

We lack power to shrink the size window to buildings just above or below the threshold. Because 4-unit buildings are meaningfully different in other ways from 15 unit buildings, we risk conflating market-level cost changes with idiosyncratic cost shifts. To more clearly identify idiosyncratic cost shifts, we construct a synthetic tax instrument capturing smaller, building-specific changes in assessment procedures made after the regime shift.

Calculating a Tax Instrument based on Assessment Changes: Larger buildings' idiosyncratic capitalization rates are calculated using year-specific formulas.[38] We use these

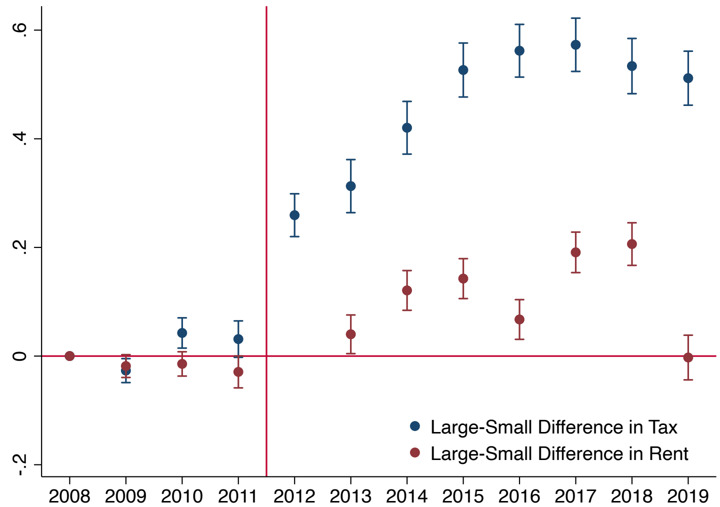
[35]Appendix A.8 also gives a graphical demonstration of this point.

[36]Appendix F.2.1 documents these changes in assessment procedures in greater detail.

[37]We lack pre-2007 income data to assess whether the previous regime threshold, from cap-rates to GIM had a similar impact in the reverse direction.

[38]These can be found in F.2.1

Figure 2: Tax Burden Pass-through



Note: The figure plots the differences in average tax due (in blue) and unit rent (in red) between large (11-15 unit) and small (4-10 unit) buildings in each year, relative to a base year of 2008. The vertical red line indicates the year taxes due moved from a gross income to capitalization rate regime for larger (11+ unit) buildings. Differences in rent cannot be reliably calculated for 2012 due to changes in DOF communication letters to landlords in that year.

annual formula changes to create a simulated tax instrument by calculating the counterfactual property tax rate for each building every year given that year's tax formulas and the base year's rent.[39] This captures the mechanical effect of the assessment changes by holding fixed any behavioral responses, and is akin to asking what is the expected property tax revenue after a capitalization rate change assuming the landlord did not alter the building or rent. Appendix F discusses more details of these formula changes and our tax instrument construction.

Specifications: We now use each buildings' counterfactual tax as a shock to leasing costs. We are interested both in the reduced form and two stage least squares. First, we regress building rents on the cost shock using the following reduced form specification:

$$\ln[r_{j,g,t}] = \gamma_1 Z_{j,g,t} + \gamma_2 X_{j,g,t} + \gamma_3 D_j + \gamma_4 D_{g,t} + \nu_{j,g,t}, \tag{11}$$

where $Z_{j,g,t}$ is our instrument, and we are additionally controlling for building fixed-effects, via D_j, as well as changes in observable building characteristics, $X_{j,g,t}$.[40] In addition, we

[39]We use 2007 as the prior period, omitting the interceding years and structural changes used in the preliminary analysis 2009-2011.

[40]These include log miles to the nearest subway, log average unit area, the percent of units that are rent stabilized, an elevator indicator, 25 age group indicators, and indicators for various abatement programs.

control for Census tract-year fixed effects, via $D_{g,t}$.

How large is this pass-through? To interpret the results of the above specification, we estimate an additional two-stage least squares specification:

$$\text{First Stage:} \quad \ln[\mathsf{TC}_{j,g,t}] = \pi_1 Z_{j,g,t} + \pi_2 X_{j,g,t} + \pi_3 D_j + \pi_4 D_{g,t} + \varepsilon_{j,g,t} \tag{12}$$

$$\text{Structural Eq:} \quad \ln[r_{j,g,t}] = \beta_1 \ln[\mathsf{TC}_{j,g,t}] + \beta_2 X_{j,g,t} + \beta_3 D_j + \beta_4 D_{g,t} + \upsilon_{j,g,t} \tag{13}$$

where $\mathsf{TC}_{j,g,t}$ is the total reported building costs, including taxes and other annual expenses.[41] This two-stage least squares approach can be considered a re-scaling of the reduced-form result by the proportion of $Z_{j,g,t}$ in buildings' total cost.

Exclusion Restriction In order to interpret the coefficients in the above specification as the effect of an *idiosyncratic* cost shock on price, and therefore as informative on the slope of residual demand, a key assumption is that any *shifts* in building's residual demand curves are absorbed by our controls, and therefore that the remaining variation in our cost shock is truly idiosyncratic. Our controls must therefore absorb and exclude market-level fluctuations that both result in positive shifts in residual demand and are positively correlated with our instrument. Put another way, the exclusion restriction in our estimation is that changes to the building's relative tax burden due to year to year changes in the city's building-specific capitalization rate calculation are uncorrelated with changes in the building's demand. This would be violated if, after controlling for tract-year fixed effects, buildings that happen to experience relatively higher tax burden increases also experience increases in demand, within tracts.

While shifts in the residual demand curve could come from multiple sources, a key source of concern is market-level fluctuations such as increased prices at competitors. Crucially, if a local rental market that a building belongs to geographically encompasses multiple tracts, then tract-year fixed effects are sufficient to absorb demand shifts from market-level fluctuations. However, if markets are smaller than tracts, the threat that bias from correlated market-level shifts remains. We search for but do not find any correlation between changes in the tax instrument and market-level price shifts, dividing up the data into markets into the finest possible geographies as well as by other non-geographic groupings. Appendix G details these results.

Results: Table 2 displays our results. Columns (1) and (2) are reduced form results, where column (1) includes no time-varying controls while column (2) does. We find that

[41]Only a subset of buildings report expenses, which reduced our sample size.

Table 2: The Pass-through of Costs Shocks onto Rent

	$\ln[$Average $r_{j,g,t}$ $]$			
	Reduced Form		2SLS	
	(1)	(2)	(3)	(4)
Log Cf Tax	0.03	0.03		
	(0.00)	(0.00)		
Log Total Cost			1.25	1.25
			(0.11)	(0.11)
Robust F Stat			48.46	53.47
Robust AR Stat			96.56	107.81
One-Side Test			0.01	0.01
Time-varying controls	N	Y	N	Y
Tract-year FEs	Y	Y	Y	Y
Building FEs	Y	Y	Y	Y
Observations	195,194	195,192	113,024	113,023

Note: The table reports multiple regressions using log building income as the dependent variable. Columns (1) and (2) are reduced form regressions using the instrumental variable directly; columns (3) and (4) are two stage least squares regressions where the lot total cost is instrumented. We use log counterfactual taxes as the instrument All regressions are at the building-year level with standard errors are clustered at the tract level, and include building and year fixed effects. Columns (1) and (2) omit time-varying controls, and columns (2) and (4) include log building age, log years since a renovation, and log average unit square feet. The sample is all single use residential buildings in New York City.

a 10% increase in tax policy or expected expenses leads to a roughly 0.3% increase in rent. Columns (3) and (4) are two stage least squares results where we instrument total building costs in order to estimate a total pass-through rate. We find that a pass-through rate of roughly 125% into rents. Again, this over-shifting is consistent with variable markups in the presence of sufficiently convex demand.

Appendix G details several robustness checks, including robustness to excluding all rent stabilized units and using only large buildings.

5.2 Concentration and Rents in New York City

We examine the correlation in the data between ownership concentration and rents. We note that results in this section are not causally identified. However, in line with Proposition 3 we find increased concentration is correlated with modest rent increases.

To examine whether the data are consistent with the predictions of Proposition 3, we first construct ownership shares at the Census tract level, and compare the ten-year change in HHI from 2009 to 2019 on rents to estimate the long-run relationship.[42] Section

[42]Given available data, reliable ownership data cannot be constructed before 2009. We calculate concen-

4 summarizes the trade offs of tract-level analysis, as well as our construction of tract-level ownership data, in tandem with Appendix E.

Using our recovered ownership structure, we calculate owners' market share:

$$\mathsf{s}^f_{g,t} := \frac{\left(\sum_{j\in\mathcal{A}_{f,g,t}} D_{j,t}\right)}{\sum_{f'\in\mathsf{F}_{g,t}}\left(\sum_{j\in\mathcal{A}_{f',g,t}} D_{j,t}\right)}. \tag{14}$$

where $\mathcal{A}_{f,g,t}$ is the set of j buildings owned by landlord f in tract g in year t, and $\mathsf{F}_{g,t}$ is the set of landlords in that tract and time. Figure 1, plots tract-level HHI measures for NYC, where HHI is the sum of squared owners' shares, $\mathsf{HHI}_{g,t} := \sum_{f'\in\mathsf{F}_{g,t}}\left(\mathsf{s}^{f'}_{g,t}\right)^2$.

However, to match Proposition 3, which links surrounding ownership concentration to rents, we construct a modified "leave-out" HHI index. For each landlord f, we calculate surrounding concentration as the sum of rival hs' market shares:

$$\mathsf{HHI}_{f(j),g,t} := \sum_{h\in\mathsf{F}^{\neg f}_{g,t}}\left(\tilde{\mathsf{s}}^h_{f,g,t}\right)^2 := \sum_{h\in\mathsf{F}^{\neg f}_{g,t}}\left(\frac{\left(\sum_{j\in\mathcal{A}_{h,g,t}} D_j\right)}{\sum_{f'\in\mathsf{F}^{\neg f}_{g,t}}\left(\sum_{j\in\mathcal{A}_{f',g,t}} D_j\right)}\right)^2, \tag{15}$$

where $\mathsf{F}^{\neg f}_{g,t}$ is the set of rivals to landlord f.[43]

We then test whether rent increases in concentration. Our main specification estimates

$$\ln[\mathsf{r}_{j,g,t}] = \gamma_0 + \gamma_1\cdot\ln[\mathsf{HHI}_{f(j),g,t}] + \gamma_2\cdot X_{j,g,t} + \upsilon_{j,g,t}, \tag{16}$$

where $\mathsf{r}_{j,g,t}$ is the average unit rent of building j in tract g at time t, $X_{j,g,t}$ are control variables described below, and υ is an econometric error term.[44] We also include $\ln[\mathsf{s}^{f(j)}_{g,t}]$ in some specifications to test for the impact of owners' shares on rents at their own buildings.

Results Table 3 presents our estimates of equation (15). Columns (1-3) use the log of the leave-out HHI measure and columns (4-6) add the log of the building owner's market share as a control. All columns use year fixed effects.

Columns (1) and (4) include borough fixed effects. We report statistically insignificant

tration off of the full sample of buildings in each year but restrict our sample to single use buildings with matched ownership information.

[43] In Appendix E, we use the more standard construction of HHI and shares in Equation (14). An alternative to using tracts is to estimate location or building-specific markets where competitor's distance-weighted shares are aggregated using distance elasticities derived from LODES commuting flows.

[44] While we use general subscripts $\{j,g,t\}$ for $X_{j,g,t}$, in specific specifications some controls will be time invariant; e.g., when using building fixed effects.

Table 3: The Relationship Between Ownership Concentration and Rent

	$\ln[\text{Average } r_{j,g,t}]$					
	(1)	(2)	(3)	(4)	(5)	(6)
Log Leave-Out Tract HHI	-0.02	0.03	0.05	-0.00	0.03	0.05
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)
Log Owner Share in Tract				-0.03	-0.01	0.01
				(0.00)	(0.00)	(0.01)
Time-varying controls	Y	Y	Y	Y	Y	Y
Borough FEs	Y	N	N	Y	N	N
Tract FEs	N	Y	N	N	Y	N
Building FEs	N	N	Y	N	N	Y
Observations	63,156	63,087	41,842	63,156	63,087	41,842

Note: The table reports the results from regressions of log of building average unit monthly rent on the log of the 'leave-out' HHI index, calculated at the building level by leaving out the building owner's units. The regression features two time periods, 2009 and 2019, to estimate the long run relationship between tract ownership concentration and rents. Time-varying controls include log building age, log years since renovation, log average unit sqft, and an indicator for having an elevator. Regressions are at the building-year level using all single use rental buildings in New York City. Standard errors are clustered at the Census tract level for all columns.

negative correlations. However, because these columns treat the data as a repeated cross section and suffer from omitted variable bias, we refrain from interpreting the small and insignificant resulting coefficient. Columns (2) and (5) introduce tract-level fixed effects, which remove unobserved time-invariant tract-level variation like neighborhood quality. In column (2), we estimate that a 10% increase in tract concentration index is associated with a 0.3-0.4% increase in rents across all buildings. Columns (3) and (6), our most stringent specifications, include building-level fixed effects, which remove unobserved time-invariant building characteristics. Similar to columns (2) and (5), a 10% increase in competitors' concentration is associated with a 0.5% increase in rents across all buildings The coefficient on own share of the tract is inconclusive.

Because market structure is endogenous and we are unable to observe changing tract and building conditions that are correlated with both rents and ownership concentration, we caution against interpreting these coefficients causally, but instead we take reassurance from the concordance between Proposition 3 and the stylized fact that increases in concentration around a building are correlated with increases in rents.

6 Quantification Exercise: Elasticities and Markups

Our final empirical exercise gauges the effect of markups on prices. To do so, we estimate demand parameters from our model, generate building-level OPEs (without imposing any specific firm conduct assumptions), and then use our results in Section 2 to isolate the set of buildings for which the OPE provides relevant information on the markup.[45]

First, we estimate utility parameters using the logit demand structure from Section 2.1 to calculate building-level OPEs. To identify the demand parameters, we use variation from three sources. Our first strategy uses variation based on competition from similar buildings using 'BLP instruments' adapted to our setting. This approach is common in the literature (Bayer, Ferreira, and McMillan, 2007; Davis et al., 2021; Almagro and Domınguez-Iino, 2019). To allay concerns of potential exclusion restriction violations, we supplement these results with estimates from two different cost-shifting instruments with separate sources of variation and identifying assumptions: our counterfactual tax instrument from Section 5.1 as well as historic construction costs. The results of these three approaches largely complement and reinforce each other, as in Hornbeck and Moretti (2018).

Empirical Specification Let (j, b, t) index building j in borough b in year t, s be the building market share, r be the average building rent, and X be building controls. Our estimation strategy follows that of Berry (1994). Individuals, $i \in \mathsf{N}_{bt}$, choose to either rent a unit at a building or some outside option in the borough.[46] Parameterizing the model in Section 2.1, renter's indirect utility is a linear function of rent and building characteristics:

$$U_{ijbt} = \beta_0 + \beta_1 \cdot X_{jbt} + \alpha_{bt} \cdot \mathsf{r}_{jbt} + \delta_{jbt} + \epsilon_{ijbt}, \tag{17}$$

where δ is a building characteristic that is observed by the market but not in our dataset, $\alpha_{bt} = \alpha / \bar{y}_{bt}$ captures how rent affects utility and is parameterized as a single parameter divided by median borough income, X_{jbt} is a set of observable building characteristics including log distance to the nearest subway station, log average unit square feet, log years since a major renovation, and an indicator for whether a building has an elevator, and a tract-year fixed effects, and ϵ is the individual level idiosyncratic taste shifter (distributed Type-1 Extreme Value). Aggregating individual demands yields the logit market demand:

$$D_{jbt}(r, X, \delta) = \frac{\mathsf{e}^{\beta_0 + \beta_1 \cdot X_{jbt} + \alpha_{bt} \cdot \mathsf{r}_{jbt} + \delta_{jbt}}}{1 + \sum_{k \in \mathcal{A}_{bt}} \mathsf{e}^{\beta_0 + \beta_1 \cdot X_{kbt} + \alpha_{bt} \cdot \mathsf{r}_{kbt} + \delta_{kbt}}}. \tag{18}$$

[45] An alternative theory-free approach is to find a single OPE as a local average treatment effect in a standard log-log two stage least squares regression. We include these specifications in Appendix G.3. While these log-log regressions point to a similar average OPE as our main results, we caution against their use in calculating an average markups, as the OPE estimate includes constrained and non-redeveloped buildings for which the OPE is not informative for markups.

[46] We specify that each borough-year is an urban rental market.

We use the analytic inversion of Berry (1994) to arrive at our estimation equation:

$$\ln[\mathsf{s}_{jbt}] - \ln[\mathsf{s}_{0bt}] = \beta_0 + \beta_1 \cdot X_{jbt} + \alpha_{bt} \cdot \mathsf{r}_{jbt} + \delta_{jbt}, \tag{19}$$

where s_{0bt} is the market share of the borough's 'outside good' (i.e., not choosing a rental property). As in the pass-through model, there is a potential correlation between the rent and the unobserved building characteristic, which leads us to instrument for rent.

Instruments We use three approaches to identify the demand parameters.[47] First, we use the characteristics of rival buildings that shift prices through markups, commonly called 'BLP instruments.' The degree to which a landlord can markup rent is attenuated when renters have more similar choices. Conditional on a building's own characteristics, the 'closeness' of its rivals' characteristics should only affect rent through competition. To construct the instruments, we follow Gandhi and Houde (2018) calculating the sum of squared differences for the continuous variables and using a count of rivals for indicator variables, and then we reduce the resulting instruments to a single instrument following Bayer, McMillan, and Rueben (2004) and Davis et al. (2021).[48] We use the count of all rivals, count of all rivals with elevators, and all rivals that are mixed-use buildings and the sum of square differences in age and in distance to closest subway entrance.

The exclusion restriction holds if, when controlling for the characteristic of the building itself, the building's unobserved characteristic is orthogonal to rivals' characteristics: $\mathsf{E}[\delta_j \mid X_k] = 0 \;\forall\; j,k$. A major concern is that unobserved neighborhood characteristics are correlated with rivals' observable amenities. Accordingly, we omit rivals from 1 kilometer around each building from the calculation of that building's instrument value. Still, the possibility of long-lagged spatial auto-correlation between observables and unobservables poses an unknowable threat to identification here (as throughout this literature), which is the impetus for our second set of strategies.

Second, we use variation tied to landlord costs using plausibly exogenous idiosyncratic cost variation from assessment procedures. As we discuss in Section 5.1, this strategy posits that an increase in unit costs through structural changes to assessment policy, are passed through to renters. Section 5.1 describes the measure, source of variation, and exclusion restriction. We note that this specification omits building level fixed effects.[49]

[47] For details on construction see Appendix F.

[48] Specifically, we regress rent on the BLP instruments alone, and then use that fitted value as an instrument for rent in the full estimation equation with the controls listed above.

[49] Including fixed effects yields greater but noisier estimates of markups.

Third, we use variation in costs at the time of buildings' construction. Buildings built in higher cost years faced higher construction and projected leasing costs. We match buildings by year of construction to cost indices for unskilled labor and materials cost and NYC real estate tax rates (Barr, 2016) and use the three, net of linear cohort trends, as instruments for price.[50] Although we place little weight on these results because of the possibility that construction costs are correlated with unobservables, we include this complementary specification because the direction of bias is unlikely to be the same as that of the BLP or tax instruments.

Markup Calculations with Supply-Side Restrictions While our elasticity estimation is cost agnostic, to derive markups from demand elasticities, we must account for how landlords set rents and quantities in our setting. As discussed in Section 2.4, a building's OPE is informative of its markup only for a subset of buildings: the newly built, policy-unconstrained sample. While we report median OPEs for the full sample, we stress and only interpret pricing power using our results for unconstrained, new buildings.[51]

The logit demand elasticity (Equation 5) is $\varepsilon_{jbt} = \alpha_{bt} \cdot \mathsf{r}_{jbt} \cdot (1 - \mathsf{s}_{jbt})$. If landlords use a Bertrand price competition game to set rents, then the Lerner rule, $\mathsf{L}_{jbt} = (-1/\varepsilon_{jbt})$, reveals the proportion of rent due to markups: $\mathsf{L} = (\mathsf{r} - c)/\mathsf{r}$ for the new, unconstrained sample.[52]

Aggregate Demand Consensus housing demand estimates are inelastic (Chen, Clapp, and Tirtiroglu, 2011; Albouy, Ehrlich, and Liu, 2016). These estimates are from measuring the change in total housing consumed with a change in (aggregate) rents, rather than the OPEs we target, ε_j. To connect our setting to these previous estimates, we calculate the responsiveness of renters to a 1% increase in rent for all buildings, which we refer to as the "aggregate price elasticity" (Berry and Jia, 2010; Conlon and Gortmaker, 2019):

$$\varepsilon_{bt}^{\text{Agg}} = \sum_{j \in \mathcal{J}_{bt}} \left. \frac{D_{jbt}(\{\mathsf{r}_k + \Delta \mathsf{r}_k\}_{k \in \mathcal{J}_{bt}}) - D_{jbt}}{\Delta} \right|_{\Delta = 1\%} . \tag{20}$$

Results Table 4 presents our main empirical results. Column (1) reports our OLS estimate of α, which is positive but small, and likely biased due to unobserved amenities.

[50] We are grateful to Jason Barr for sharing data on these historic measures.

[51] We reiterate here that supply constraints like zoning constraints do not bias our estimates of demand parameters, and we use the full sample to estimate the demand parameters of our model, which requires only that the market for each building clears at the existing supply and price. Appendix D discusses the NYC policy environment in depth. Appendix G also replicates our results omitting any rent-stabilized units.

[52] We use Bertrand pricing only for interpretation but not estimation.

Column (2) reports the 2SLS estimates using BLP instruments. Here α is roughly -13, which corresponds to a median markup on the unconstrained sample of roughly one-third. Our other two specifications, using our synthetic tax instrument (Column 3) and historic cost shifters (Column 4), vary in magnitude, estimating α as roughly -15 to -36, and with a median markup on the relevant sample of 28% and 11%, respectively. One reason the estimates vary could be due to differences in sample, as the Tax IV requires observing buildings' base-income in 2007.[53] Overall, were units priced at the marginal cost reflective of the production and maintenance of buildings, we would expect rents to be about 66-90% of their current levels.

We report first stage effective F statistics (Olea and Pflueger, 2013) and the Anderson-Rubin F statistic for rent. Our three IV specifications broadly agree that α is negative but bounded away from an extreme value which would imply no pricing power.[54]

Since monopoly pricing is inconsistent with inelastic demand, observing whether buildings in our sample are elastic is a useful check. Across all 2SLS specifications, all buildings have elastic demand. On the other hand, the BLP and Historic Costs specifications estimate *aggregate* elasticities to be roughly -0.6 and -0.7, respectively, within the consensus range of $(-0.7, -0.3)$, while results from the Tax IV are more elastic, -1.7.[55]

Figure 3 plots the full distribution of the own-price elasticities and Lerner rule for each of our specifications. The figure highlights that the BLP IV and the Historic Cost IV estimates are more inelastic (and subsequently larger markups) while the Tax IVs find more elastic demand (and thus lower markups).

7 Conclusion

While previous housing and urban literatures have considered the scope for pricing power, we believe we are the first to quantify its importance in urban rental markets, finding that its scope appears economically significant and policy relevant. Using a synthetic tax instrument, we find reduced form evidence that landlords face downward sloping residual demand from renters. Furthermore, a 10% increase in Census tract level ownership concentration correlates to a 1% increase in building rents, and that in NYC rental markets markups account for between a tenth and a third of rents.

[53]Imposing the same sample restriction on the BLP generates similar coefficients with the Tax IV, while doing so with the Historic IVs does not change the coefficient. Both estimates become significantly noisier.

[54]Appendix G, estimates a "reduced-form, across-building" OPE using a log-log regression; we estimate this parameter between $[-6.3, -2.7]$ using our instruments. This LATE pools across all buildings, both constrained and unconstrained, and is not directly interpretable based on our model.

[55]Gyourko and Voith (2000); Chen, Clapp, and Tirtiroglu (2011) also find elastic estimates.

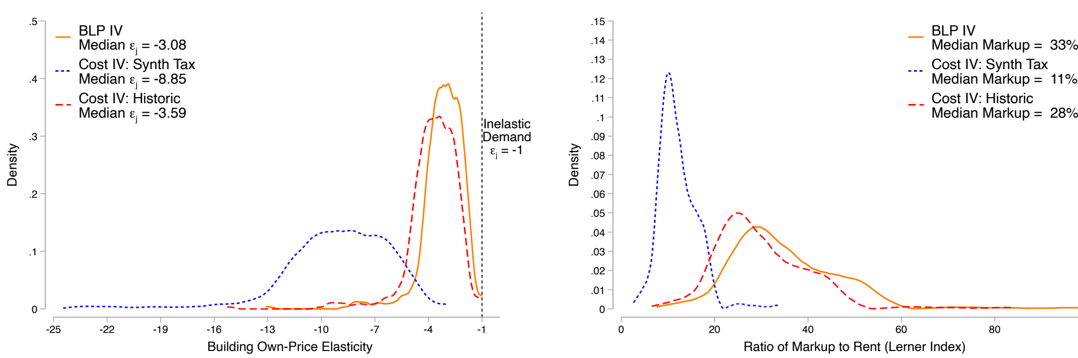
Table 4: Demand Estimation Results

	OLS (1)	BLP (2)	Tax (3)	Historic Costs (4)
α	1.01	-12.72	-36.61	-14.85
	(0.11)	(2.54)	(2.68)	(2.19)
Robust F Stat	-	57.54	233.15	33.50
Robust AR Stat for Rent	-	56.81	1468.04	101.59
Observations	354,435	354,435	183,210	336,139
Med(ε_{jbt})	0.18	-2.22	-6.40	-2.60
Med(ε_{jbt} | Unconst., New)	0.24	-3.08	-8.85	-3.59
Pct Elastic	0.00%	1.00%	1.00%	1.00%
Med(L_{jbt} | Unconst., New)	0.00	0.33	0.11	0.28
Avg(ε_{bt}^{Agg})	0.05	-0.59	-1.70	-0.69

Note: The table displays parameter estimates from Logit demand models. The own-price elasticity is ε, the Lerner rule is $-1/\varepsilon$, and the aggregate price elasticity, ε^{Agg}, is based on Berry and Jia (2010). Buildings are 'unconstrained' if *not* rent stabilized and *not* zoning-constrained; buildings are considered new if less than 10 years old. We estimate an (1) OLS model and three just-identified IV models using (2) 'BLP instruments', (3) the synthetic tax instrument, and (4) historic cost instruments based on the year of building construction. All models include Census tract-year fixed effects, controls for log distance to nearest subway station, building age, years since renovation, average unit square-feet, and an indicator for having an elevator. Standard errors are clustered by Census tract and the first stage F statistic and the Anderson-Rubin F statistic for the estimated coefficients are cluster robust as well.

Figure 3: Distribution of Results

(a) Own-Price Elasticity (b) Markup as a Percent of Rent



Note: The figure plots the kernel density plot of own-price elasticities (Panel (a)) and markups / Lerner rule (Panel (b)) based on reults from Table 4. The solid orange line uses the BLP IVs (column 2), the short-dash blue line uses the Cost IV using counterfactual tax per unit (column 3), and the long-dash red line uses the Cost IV using historic building costs (column 4). The sample is all single-use residential buildings in the four boroughs with with four or more units, where unconstrained means all buildings that are not zoning constrained and where less than 50% of units are rent stabilized and where new buildings are 10 years old or less. The vertical line in Panel (a) indicates elasticities greater than -1, which would be incompatible with monopolistic pricing; these elasticities are excluded from Panel (b). The models and estimation are described in the text.

Second, we explore the link between monopoly pricing, ownership concentration and urban policies: redevelopment subsidies and zoning. We discuss a welfare improving policy that is implementable without requiring any structural estimates. Additionally, we show the theoretical links between ownership concentration and zoning constraints on the markups for a given building and its rivals.

References

Affeldt, Pauline, Lapo Filistrucchi, and Tobias J Klein. 2013. "Upward Pricing Pressure in Two-Sided Markets." *The Economic Journal* 123 (572):505–523.

Ahlfeldt, Gabriel M, Stephen J Redding, Daniel M Sturm, and Nikolaus Wolf. 2015. "The Economics of Density: Evidence from the Berlin Wall." *Econometrica* 83 (6):2127–2189.

Albouy, David and Gabriel Ehrlich. 2018. "Housing Productivity and the Social Cost of Land-Use Restrictions." *Journal of Urban Economics* 107:101–120.

Albouy, David, Gabriel Ehrlich, and Yingyi Liu. 2016. "Housing Demand, Cost-of-Living Inequality, and the Affordability Crisis." Tech. rep., National Bureau of Economic Research.

Almagro, Milena and Tomás Domınguez-Iino. 2019. "Location Sorting and Endogenous Amenities: Evidence from Amsterdam." *mimeograph* .

Amemiya, Takeshi. 1977. "The Maximum Likelihood and the Nonlinear Three-Stage Least Squares Estimator in the General Nonlinear Simultaneous Equation Model." *Econometrica* 45 (4):955–968.

Arnott, Richard. 1989. "Housing Vacancies, Thin Markets, and Idiosyncratic Tastes." *The Journal of Real Estate Finance and Economics* 2 (1):5–30.

Arnott, Richard and Masahiro Igarashi. 2000. "Rent Control, Mismatch Costs and Cearch Efficiency." *Regional Science and Urban Economics* 30 (3):249–288.

Barr, Jason M. 2016. *Building the Skyline: The Birth and Growth of Manhattan's Skyscrapers*. New York: Oxford University Press.

Basu, Kaushik and Patrick M Emerson. 2003. "Efficiency Pricing, Tenancy Rent Control and Monopolistic Landlords." *Economica* 70 (278):223–232.

Baum-Snow, Nathaniel and Lu Han. 2019. "The Microgeography of Housing Supply." *Mimeograph, University of Toronto* .

Baum-Snow, Nathaniel and Justin Marion. 2009. "The effects of low income housing tax credit developments on neighborhoods." *Journal of Public Economics* 93 (5):654–666.

Bayer, Patrick, Fernando Ferreira, and Robert McMillan. 2007. "A Unified Framework for Measuring Preferences for Schools and Neighborhoods." *Journal of Political Economy* 115 (4):588–638.

Bayer, Patrick, Robert McMillan, and Kim Rueben. 2004. "An Equilibrium Model of Sorting in an Urban Housing Market." Tech. rep., National Bureau of Economic Research.

Berliant, Marcus and Masahisa Fujita. 1992. "Alonso's discrete population model of land use: Efficient allocations and competitive equilibria." *International Economic Review* :535–566.

Berry, Steven. 1994. "Estimating Discrete-Choice Models of Product Differentiation." *The RAND Journal of Economics* 25 (2):242–262.

Berry, Steven and Panle Jia. 2010. "Tracing the Woes: An Empirical Analysis of the Airline Industry." *American Economic Journal: Microeconomics* 2 (3):1–43.

Berry, Steven, James Levinsohn, and Ariel Pakes. 1995. "Automobile Prices in Market Equilibrium." *Econometrica* 63 (4):841–890.

Bilbiie, Florin O, Fabio Ghironi, and Marc J Melitz. 2008. "Monopoly power and endogenous product variety: Distortions and remedies." Tech. rep., National Bureau of Economic Research.

Boustan, Leah, Devin Bunten, and Owen Hearey. 2018. "Urbanization in American economic history, 1800–2000." *The Oxford Handbook of American Economic History, vol. 2* :75.

Capozza, Dennis and Yuming Li. 1994. "The intensity and timing of investment: The case of land." *The American Economic Review* :889–904.

Chamberlain, Gary. 1987. "Asymptotic Efficiency in Estimation with Conditional Moment Restrictions." *Journal of Econometrics* 34 (3):305–334.

Chamberlin, Edward Hastings. 1933. *The Theory of Monopolistic Competition*. Cambridge; Harvard University Press.

Chen, Ruoyu, Hanchen Jiang, and Luis Quintero. 2022. "Measuring the Value of Rent Stabilization and Understanding its Implications for Racial Inequality: Evidence from New York City." *Available at SSRN 4077292* .

Chen, Yong, John M Clapp, and Dogan Tirtiroglu. 2011. "Hedonic Estimation of Housing Demand Elasticity with a Markup Over Marginal Costs." *Journal of Housing Economics* 20 (4):233–248.

Combes, Pierre-Philippe, Gilles Duranton, and Laurent Gobillon. 2021. "The Production Function for Housing: Evidence from France." *Journal of Political Economy* 129 (10):2766–2816.

Conlon, Christopher and Jeff Gortmaker. 2019. "Best Practices for Differentiated Products Demand Estimation with pyblp." *Unpublished Manuscript* .

———. 2020. "Best Practices for Differentiated Products Demand Estimation with PyBLP." *The RAND Journal of Economics* 51 (4):1108–1161.

Cosman, Jacob and Luis Quintero. 2021. "Fewer players, fewer homes: concentration and the new dynamics of housing supply." *Johns Hopkins Carey Business School Research Paper* (18-18).

Davis, Morris A., Jesse Gregory, Daniel A. Hartley, and Kegon T. K. Tan. 2021. "Neighborhood effects and housing vouchers." *Quantitative Economics* 12 (4):1307–1346.

Diamond, Rebecca, Tim McQuade, and Franklin Qian. 2019. "The Effects of Rent Control Expansion on Tenants, Landlords, and Inequality: Evidence from San Francisco." *American Economic Review* 109 (9):3365–94.

Evans, Alan W. 1991. "On Monopoly Rent." *Land Economics* 67 (1):1–14.

Gandhi, Amit and Jean-François Houde. 2018. "Measuring Substitution Patterns in Differentiated Products Industries." *Unpublished Manuscript* .

Genesove, David and Lu Han. 2012. "Search and matching in the housing market." *Journal of Urban Economics* 72 (1):31–45.

Gilbukh, Sonia and Paul S Goldsmith-Pinkham. 2019. "Heterogeneous real estate agents and the housing cycle." *Available at SSRN 3436797* .

Glaeser, Edward and Joseph Gyourko. 2018. "The Economic Implications of Housing Supply." *Journal of Economic Perspectives* 32 (1):3–30.

Glaeser, Edward L and Joshua D Gottlieb. 2008. "The Economics of Place-Making Policies." *Brookings Papers on Economic Activity* :155–239.

Glaeser, Edward L and Charles G Nathanson. 2017. "An extrapolative model of house price dynamics." *Journal of Financial Economics* 126 (1):147–170.

Good Jobs First. 2022. "Subsidy Tracker." Data from Subsidy Tracker, https://subsidytracker.goodjobsfirst.org provided by Good Jobs First.

Gyourko, Joseph and Richard Voith. 2000. "The Price Elasticity of the Demand for Residential Land: Estimation and Implications of Tax Code-Related Subsidies on Urban Form." Tech. rep., Lincoln Institute of Land Policy.

He, Zhiguo and Péter Kondor. 2016. "Inefficient investment waves." *Econometrica* 84 (2):735–780.

Hornbeck, Richard and Daniel Keniston. 2017. "Creative destruction: Barriers to urban growth and the Great Boston Fire of 1872." *American Economic Review* 107 (6):1365–98.

Hornbeck, Richard and Enrico Moretti. 2018. "Who benefits from productivity growth? Direct and indirect effects of local TFP growth on wages, rents, and inequality." Tech. rep., National Bureau of Economic Research.

Hsieh, Chang-Tai and Enrico Moretti. 2019. "Housing Constraints and Spatial Misallocation." *American Economic Journal: Macroeconomics* 11 (2):1–39.

HUD. 2021. "Low-Income Housing Tax Credit dataset." Data retrieved from Low-Income Housing Tax Credit program, https://www.huduser.gov/portal/datasets/lihtc.html.

Hughes, Samuel K. 2022. "How Mortgage Financing Costs Affect Rental Housing: Pass-Through Pricing." *Mimeograph, University of Pennsylvania* .

Jaffe, Sonia and E Glen Weyl. 2013. "The First-Order Approach to Merger Analysis." *American Economic Journal: Microeconomics* 5 (4):188–218.

Kuminoff, Nicolai V, V Kerry Smith, and Christopher Timmins. 2013. "The New Economics of Equilibrium Sorting and Policy Evaluation Using Housing Markets." *Journal of Economic Literature* 51 (4):1007–62.

Mirrlees, James A. 1971. "An exploration in the theory of optimum income taxation." *The review of economic studies* 38 (2):175–208.

Ngai, L Rachel and Silvana Tenreyro. 2014. "Hot and cold seasons in the housing market." *American Economic Review* 104 (12):3991–4026.

Nocke, Volker and Nicolas Schutz. 2018a. "An Aggregative Games Approach to Merger Analysis in Multiproduct-Firm Oligopoly." Tech. rep., National Bureau of Economic Research.

———. 2018b. "Multiproduct-Firm Oligopoly: An Aggregative Games Approach." *Econometrica* 86 (2):523–557.

Olea, José Luis Montiel and Carolin Pflueger. 2013. "A robust test for weak instruments." *Journal of Business & Economic Statistics* 31 (3):358–369.

Piazzesi, Monika, Martin Schneider, and Johannes Stroebel. 2015. "Segmented housing search." Tech. rep., National Bureau of Economic Research.

Pless, Jacquelyn and Arthur A van Benthem. 2019. "Pass-through as a test for market power: An application to solar subsidies." *American Economic Journal: Applied Economics* 11 (4):367–401.

Raymond, Elora L, Richard Duckworth, Benjmain Miller, Michael Lucas, and Shiraj Pokharel. 2016. "Corporate landlords, institutional investors, and displacement: Eviction rates in singlefamily rentals." *FRB Atlanta community and economic development discussion paper* (2016-4).

Ricardo, David. 1817. *On the Principles of Political Economy and Taxation*. London; John Murray.

Ritz, Robert. 2019. "Does competition increase pass-through?" *Working Paper* .

Rosenthal, Stuart S and Robert W Helsley. 1994. "Redevelopment and the urban land price gradient." *Journal of Urban Economics* 35 (2):182–200.

Severen, Christopher. 2018. "Commuting, Labor, and Housing Market Effects of Mass Transportation: Welfare and Identification." .

Siodla, James. 2015. "Razing San Francisco: The 1906 disaster as a natural experiment in urban redevelopment." *Journal of Urban Economics* 89:48–61.

Smith, Adam. 1776. *An Inquiry into the Nature and Causes of the Wealth of Nations*. London; William Strahan and Thomas Cadell.

Soltas, Evan. 2021. "The Price of Inclusion: Evidence from Housing Developer Behavior." *Manuscript* .

Stone, Jon. 2019. "Berlin Set to Hold Referendum on Banning Big Landlords and Nationalising Private Rented Housing." *The Independent* [News article].

Thaden, Emily and Ruoniu Wang. 2017. "Inclusionary housing in the United States: Prevalence, impact, and practices." Tech. rep., Lincoln Institute of Land Policy, working paper WP17ET1.

Titman, Sheridan. 1985. "Urban land prices under uncertainty." *The American Economic Review* 75 (3):505–514.

Vogell, Heather. 2022. "Rent Going Up? One Company's Algorithm Could Be Why." *Pro Publica* URL https://www.propublica.org/article/yieldstar-rent-increase-realpage-rent.

Weyl, E Glen and Michal Fabinger. 2013. "Pass-through as an economic tool: Principles of incidence under imperfect competition." *Journal of Political Economy* 121 (3):528–583.

Online Appendix of
Is the Rent Too High? Land Ownership and Monopoly Power

C. Luke Watson and Oren Ziv

A Theoretical Appendix

In this section, we provide proofs of and expanded analyses of our theoretical results.

A.1 Local Redevelopment Failure Details

We claimed that given any set of costs, we could construct a demand schedule such that redevelopment failure occurs. Here, we show this in four steps. Note, we ignore 'landlord services' costs, $C^{\dagger}$, for ease of notation.

First, choose any development cost function $C : \mathcal{R} \to \mathcal{R}$ such that $C(\cdot)$ is continuous, convex, and strictly increasing. Now, fix some initial quantity: q^0.

Second, we choose an inverse demand function $r : \mathcal{R} \to \mathcal{R}$ such that $r(\cdot)$ is continuous, differentiable, and strictly decreasing. We also choose this demand function, given $C(\cdot)$ and q^0, such that it satisfies three properties: [1] $q^* = \arg\max\{r(q) \cdot q - C(q)\}$, [2] $q^0 < q^*$, and [3] $r(q^*) \cdot q^* - C(q^*) > r(q^0) \cdot q^0$. From these properties, $r(q^*) \cdot q^* - C(q^*) > r(q^*) \cdot q^0$ as $r(q^*) < r(q^0)$. We can rearrange the inequality: $r(q^*)(q^* - q^0) - \int_{q^0}^{q^*} C'(q)\mathrm{d}q - C(q^0) > 0$. By assumptions on $r(\cdot)$: $\int_{q^0}^{q^*} r(q)\mathrm{d}q > r(q^*)(q^* - q^0)$,[56] and so $\int_{q^0}^{q^*} \left(r(q) - C'(q)\right)\mathrm{d}q > C(q^0)$.

So far, from an arbitrary cost function and initial quantity, we created an inverse demand function such that redevelopment is both profitable and socially desirable.

Third, we consider a new inverse demand function, $\tilde{r}(q) = r(q) - A$, where $A \in \mathcal{R}$. For any $A \neq 0$, this new demand schedule creates to a new initial rent, $\tilde{r}(q^0)$, and a new monopoly point, $(q^A, \tilde{r}(q^A))$. Thus, manipulating the A term allows us to adjust the social surplus of redevelopment.

Fourth, we choose a specific A such that $\int_{q^0}^{q^S} \left(\tilde{r}(q) - C'(q)\right)\mathrm{d}q = C(q^0)$. That is, we use A to vertically shift the inverse demand down until the the area under its curve is equal to the fixed amount $C(q^0)$. Thus, redevelopment is now marginally socially desirable. However, by definition of the integral and the demand assumptions: $\tilde{r}(q^S)(q^S - q^0) < C(q^S)$, so redevelopment is no longer profitable to the landlord. □

A.2 Policy 1 Eliminates Local Redevelopment Failure

Here we prove our claimed that Policy 1 eliminates local redevelopment failure. Suppose that $\int_{q^0}^{q^*} (r(q) - c(q))\mathrm{d}q - C(q^0) > 0$ but $r(q^*) \cdot q^* - C(q^*) < r(q^0) \cdot q^0$, so that redevelopment is socially optimal but privately not profitable. Redevelopment failure is solved if the

[56] That is, the area under a continuous curve (with negative slope) is greater than the rectangle within it.

subsidy, S, causes redevelopment to be net-profitable: $r(q^*) \cdot q^* - C(q^*) + \mathsf{S} - r(q^0) \cdot q^0 > 0$. Recall that $q^* = \arg\max\{r(q) \cdot q - C(q)\}$, so by definition $r(q^*) \cdot q^* - C(q^*) > r(q^0) \cdot q^0 - C(q^0)$. If $\mathsf{S} = C(q^0)$, then we have satisfied the claim. $\square$

A.3 Proof of Proposition 1

Proposition 1 has three consequents. The first is that the policy is implementable using only observable market information. The second is that local redevelopment failure is reduced. These two consequents are obvious from inspection.

The third is that the policies together are local social welfare improving. This claim implicitly has two parts: first, that the subsidies are never larger than the social surplus created from redevelopment (no socially wasteful expenditure); second, that the policies lead to positive social welfare relative to *laissez-faire* outcome (we never distort privately optimal redevelopments). Below, we prove this claim, again ignoring $C^{\mathsf{f}}(\cdot)$ for notational ease.

A.3.1 Subsidized Redevelopment is Welfare Improving

Recall, Policy 2 introduces the following rule: $q \cdot (r - r^{\mathsf{S}}) \geq \mathsf{S} = C(q^0)$. This rule states that the landlord must commit to a specific lower rent such that $r^{\mathsf{S}} \leq r - C(q^0)/q^0$. To show that this rule ensures no socially wasteful expenditure occurs, we specify three cases. Let q^{S} be the chosen quantity by the landlord under the subsidy regime. Once rent is fixed by Policy 2 and the landlord is guaranteed at least the subsidy amount, we allow for the possibility of an arbitrary choice of quantity as long as it is revealed as profitable to the landlord.

Case One: $r^{\mathsf{S}} \geq r(q^*)$ — In this case, the rent commitment is not binding, so the landlord will choose the profit maximizing allocation $(q^*, r(q^*))$. The social surplus of this allocation is $\int_{q^0}^{q^*} (r(q) - C'(q))\, \mathsf{d}q > 0$. We know that:

$$\int_{q^0}^{q^*} (r(q) - C'(q))\, \mathsf{d}q > (r(q^*) - C'(q^*)) \cdot \left(q^* - q^0\right) > \left(r(q^0) - r(q^*)\right) \cdot \left(q^0\right) = C(q^0). \quad (21)$$

The first inequality is by assumptions on functional forms (demand is convex decreasing, cost is convex increasing), the second inequality is by profit maximization, and the equality is the definition of subsidy. Thus, the net social surplus is greater than the subsidy.

Case Two: $r^{\mathsf{S}} < r(q^*)$ & $q^{\mathsf{S}} \geq q^*$ — We note that the landlord will never choose to set q^{S} such that the rent is less than the marginal cost; else, the landlord faces a net loss on these units. Next, we note that from Case One redevelopment to q^* is socially desired, and that the point where marginal cost equals rent is the allocation where social surplus is maximized: $(q^{\mathsf{Opt}}, r(q^{\mathsf{Opt}}))$. By continuity and strict monotonicity of $r(\cdot)$ and $C(\cdot)$, it must be that net social surplus is positive for all $q^{\mathsf{S}} \in (q^*, q^{\mathsf{Opt}})$. In fact, net social surplus is greater when $q^{\mathsf{S}} > q^*$.

Case Three: $r^{\mathsf{S}} < r(q^*)$ & $q^{\mathsf{S}} < q^*$ — In this case, we rely on the revealed preference of the landlord to take the subsidy versus the *status quo*; i.e., that the subsidized profit with redevelopment is greater than leaving the building as-is.

First, the landlord will never choose to set $q^{\mathsf{S}} < q^0$. To see this, consider the case where $q^{\mathsf{S}} = q^0 - e$, $e > 0$. The subsidized profit condition yields:

$$r^{\mathsf{S}} \cdot (q^0 - e) - C(q^0 - e) + C(q^0) > r^0 \cdot q^0 \tag{22}$$

$$q \cdot (r^{\mathsf{S}} - r^0) - e \cdot r^{\mathsf{S}} - \int_{q^0 - e}^{q^0} c(q)\mathsf{d}q > 0 \ \rightarrow\leftarrow . \tag{23}$$

Thus, $q^{\mathsf{S}} \in (q^0, q^*)$.

Next, to show that the social surplus is still be greater than the subsidy, we again use the profit condition:

$$r^{\mathsf{S}} \cdot q^{\mathsf{S}} - C(q^{\mathsf{S}}) + C(q^0) > r^0 \cdot q^0 \tag{24}$$

$$\Longrightarrow r^{\mathsf{S}} \cdot q^{\mathsf{S}} - C(q^{\mathsf{S}}) > r^0 \cdot q^0 - C(q^0) = r^{\mathsf{S}} \cdot q^0 \tag{25}$$

$$\Longrightarrow r^{\mathsf{S}} \cdot (q^{\mathsf{S}} - q^0) - C(q^{\mathsf{S}}) > 0 \tag{26}$$

$$\Longrightarrow r^{\mathsf{S}} \cdot (q^{\mathsf{S}} - q^0) - \int_{q^0}^{q^{\mathsf{S}}} c(q)\mathsf{d}q - C(q^0) > 0 \tag{27}$$

$$\Longrightarrow r^{\mathsf{S}} \cdot (q^{\mathsf{S}} - q^0) - \int_{q^0}^{q^{\mathsf{S}}} c(q)\mathsf{d}q > C(q^0) \tag{28}$$

$$\Longrightarrow \int_{q^0}^{q^{\mathsf{S}}} r(q)\mathsf{d}q - \int_{q^0}^{q^{\mathsf{S}}} c(q)\mathsf{d}q > C(q^0) = \mathsf{S}. \tag{29}$$

Thus, subsidized redevelopment to $q^{\mathsf{S}} \in (q^0, q^*)$ is still socially desirable given our rent commitment rule and that the landlord selects into redevelopment.

A.3.2 No Private Redevelopment is Distorted

We have just shown that any redevelopments that are subsidized must be locally welfare improving relative to the initial building. Here, we show that under Policies 1 and 2, if redevelopment is privately profitable without a subsidy, then the subsidy does not distort this decision towards less development.

Consider three allocations: 'initial' (r_0, q_0), 'monopoly' (r_1, q_1), and 'subsidy' $(r_\mathsf{S}, q_\mathsf{S})$. The monopoly point is a *laissez-faire* profit maximizing allocation, and the subsidy point is the profit maximizing allocation under the policies. For notational ease, we denote terms like profit, marginal cost, and average as π_j, c_j, a_j for $j \in \{0, 1, \mathsf{S}\}$.

Recall that $\pi_1 = (r_1 - a_1) \cdot q_1$, $\pi_0 = r_0 \cdot q_0$, and $\pi_\mathsf{S} = (r_\mathsf{S} - a_\mathsf{S}) \cdot q_\mathsf{S} + \mathsf{S}$, where $\mathsf{S} = a_0 \cdot q_0$. As before, we ignore costs from landlord services to focus on the redevelopment decisions. Next, recall that Policy 2 is that $(r_0 - r_\mathsf{S}) = a_0$ or equivalently $r_\mathsf{S} = r_0 - a_0$. Finally, note that our logit demand function is convex / concave-up in price, which implies that the inverse demand function is convex / concave-up in quantity, so $\partial^2 r / \partial q^2 > 0$.

We want to show that under Policies 1 and 2, $\pi_1 - \pi_0 \geq 0 \implies \neg\{q_\mathsf{S} \leq q_1 \wedge \pi_1 - \pi_\mathsf{S} \leq 0\}$. The proof of this is shown in two cases.

Case One: suppose that $c_a \leq a_\mathsf{S}$. Then:

$$\begin{aligned}
\pi_1 - \pi_\mathsf{S} &= (r_1 - a_1) \cdot q_1 - [(r_\mathsf{S} - a_\mathsf{S}) \cdot q_\mathsf{S} + \mathsf{S}] && (30)\\
&= (r_1 - a_1) \cdot q_1 - [(c_\mathsf{S} - a_\mathsf{S}) \cdot q_\mathsf{S} + a_0 \cdot q_0] && (31)\\
&> (r_1 - a_1) \cdot q_1 - a_0 \cdot q_0 && (32)\\
&> (r_1 - a_1) \cdot q_1 - r_0 \cdot q_0 = \pi_1 - \pi_0 \geq 0. && (33)
\end{aligned}$$

Case Two: suppose that $c_a > a_\mathsf{S}$. We introduce four minor results. First is Lemma 1:

Lemma 1. *If $c(q) - a(q) \geq 0$, then $(c(q') - a(q')) \geq (c(q) - a(q))$ for all $q' \geq q$, and is strict if $q' > q$.*

This can be seen through differentiation and noting that $C^{\mathrm{d}}(q)$ is convex. Lemma 1 implies that $(c_1 - a_1) \geq (c_\mathsf{S} - a_\mathsf{S})$ and is strict if $q_1 > q_\mathsf{S}$. Next, Lemma 2 states that the Policy 2 rent is based on the marginal cost curve:

Lemma 2. $r_S = c(q_S)$.

Recall that r_S is fixed, so the marginal revenue is perfectly elastic and equal to r_S.[57] Next, Lemma 3 describes profit condition $(\pi_1 - \pi_S)$ as a function of q_S:

Lemma 3. $(\pi_1 - \pi_S)$ *is continuous and strictly decreasing in* q_S.

Define $\Psi(q_S) = (\pi_1 - \pi_S) = A - [c(q_S) - a(q_S)] \cdot q_S$, and so:

$$\frac{\partial \Psi}{\partial q_S} = -[(c'(q_S) - a'(q_S)) \cdot q_S + (c_S - a_S)] < 0. \tag{34}$$

Finally, using Lemma 3, we can state the following:

Lemma 4. *If* $q_S = q_1$ *and* $\Psi(q_S) > 0$*, then* $\Psi(q_S) > 0$ *for all* $q_S < q_1$.

Thus, to prove our claim, we only need to show that, along with other assumptions for this case, $q_S = q_1$ implies $\Psi(q_S) > 0$. Note that $q_S = q_1$ implies the following:

1. $c_S = c_1 > a_1 = a_S$, and
2. $r_S = (r_0 - a_0) \implies a_0 = (r_0 - c_1)$.

Now, see that:

$$\begin{aligned}
(\pi_1 - \pi_S) &= (r_1 - a_1) \cdot q_1 - [(r_S - a_S) \cdot q_S + \mathsf{S}] && (35)\\
&= (r_1 - a_1) \cdot q_1 - [(c_1 - a_1) \cdot q_1 + (r_0 - c_1) \cdot q_0] && (36)\\
&= [(r_1 - c_1) + (c_1 - a_1)] \cdot q_1 - [(c_1 - a_1) \cdot q_1 + (r_0 - c_1) \cdot q_0] && (37)\\
&= (r_1 - c_1) \cdot q_1 - (r_0 - c_1) \cdot q_0 && (38)\\
&= (r_1 - c_1) \cdot (q_1 - q_0) - (r_0 - r_1) \cdot q_0. && (39)
\end{aligned}$$

Thus $(\pi_1 - \pi_S) \geq 0 \iff (r_1 - c_1) \cdot (q_1 - q_0) - (r_0 - r_1) \cdot q_0 \geq 0$. We next manipulate the right

[57] Thus, if $r < c$, then by reducing q profit goes up since the additional units lose revenue; if $r > c$, then by increasing q profit goes up since additional units earn revenue.

hand inequality:

$$\iff (r_1 - c_1) \cdot (q_1 - q_0) \geq (r_0 - r_1) \cdot q_0 \tag{40}$$

$$\iff \frac{(r_1 - c_1)}{r_1} \cdot r_1 \geq \frac{(r_0 - r_1)}{r_0} \cdot \frac{q_0}{(q_1 - q_0)} \cdot r_0 \tag{41}$$

$$\iff \frac{-r_1}{\varepsilon_1} \geq \frac{-r_0}{\frac{(q_1-q_0)}{(r_1-r_0)}\frac{r_0}{q_0}} \tag{42}$$

$$\iff \frac{-r_1}{\frac{\partial q}{\partial r}\Big|_{q_1}\frac{r_1}{q_1}} \geq \frac{-r_0}{\frac{(q_1-q_0)}{(r_1-r_0)}\frac{r_0}{q_0}} \tag{43}$$

$$\iff \frac{-q_1}{\frac{\partial q}{\partial r}\Big|_{q_1}} \geq \frac{-q_0}{\frac{(q_1-q_0)}{(r_1-r_0)}} \tag{44}$$

$$\iff \frac{q_1}{q_0} \geq \frac{-\frac{\partial q}{\partial r}\Big|_{q_1}}{-\frac{(q_1-q_0)}{(r_1-r_0)}}. \tag{45}$$

Finally, we note that $\partial^2 r/\partial q^2 \geq 0$ implies $\frac{q_1}{q_0} \geq 1 \geq \frac{-\frac{\partial q}{\partial r}\big|_{q_1}}{-\frac{(q_1-q_0)}{(r_1-r_0)}}$. That is, since the first derivative is negative, a positive second derivative implies the absolute value of the first derivative is getting smaller (towards zero from negative infinity). It is relatively straight-forward to show for convex / concave up functions that:

$$\mathsf{abs}\left(\frac{q'-q}{r'-r}\right) \geq \mathsf{abs}\left(\frac{\partial q}{\partial r}\Big|_{q'}\right) \qquad \text{if} \quad q' > q \quad \& \quad \partial q(r)/\partial r < 0. \tag{46}$$

Thus, we have shown that no privately optimal redevelopment is distorted. □

A.4 Proof of Proposition 2

Binding zoning restrictions, by reducing quantities at a given plot, increase rents at that plot. The rest of Proposition 2 will follow as long as plots, as competing products, are strategic complements in pricing decisions.

Definition A.1. Strategic Complements: If the cross derivative of a given player's own payoff function with respect to her action and that a rival's action is positive, then the actions are strategic complements.

Here, we switch to indexing buildings using j and k rather than the building quality, a. Recall that $D_j = \frac{\mathsf{e}^{F(a_j, r(a_j))}}{\sum_{k \in \mathcal{A}} \{\mathsf{e}^{F(a_k, r(a_k))}\}}$ from the main text using logit demand. To make notation easier, define $\alpha = \partial F(a,r)/\partial r < 0$ be the (negative) marginal utility of consumption. In addition, denote $C(q)$ as the composite cost function and likewise $c(q)$ for marginal cost.[58]

In our Bertrand oligopoly setting, rents are strategic complements if

$$\frac{\partial^2 \pi_j}{\partial r_j \partial r_k} = \frac{\partial \left[\partial D_j / \partial r_j\right]}{\partial r_k} \cdot (r_j - c_j) + \frac{\partial D_j}{\partial r_j} \cdot \left(-\frac{\partial c_j}{\partial q}\frac{\partial D_j}{\partial r_k}\right) + \frac{\partial D_j}{\partial r_k} \geq 0. \tag{47}$$

When we apply Logit demand functions, this becomes:

$$\frac{\partial^2 \pi_j}{\partial r_j \partial r_k} = -\alpha^2 D_j D_k (1 - 2D_j)(r_j - C_j) - c_j \alpha D_j (1 - D_j) - \alpha D_j D_k \tag{48}$$

$$= \underbrace{-\alpha D_j D_k}_{>0} \left[\underbrace{\frac{D_j}{(1 - D_j)}}_{>0} + \underbrace{(-c_j \alpha D_j (1 - D_j))}_{>0 \text{ only if } c_j > 0} \right]. \tag{49}$$

A sufficient condition for strategic complements in the logit case is that $c_j \geq 0 \forall j$. This is true with constant marginal costs or diseconomies of scale for the building. With decreasing marginal costs, the strategic complementary of pricing decisions is ambiguous and may vary between pairs of buildings.

If marginal cost is constant, then the rent increase could only be due to an increase in monopoly markups. With variable marginal cost, the rent changes are a mix of markup and marginal cost increases. Decreasing marginal costs would push the landlord to expand quantity supplied and travel further down the demand curve, which may lead to a smaller markup per unit but greater profit (and lower rent). On the other hand, increasing marginal costs attenuate the landlord's desire to expand keeping the landlord in a steeper part of the demand curve but with greater marginal costs eating into the markup.

If marginal cost is 'locally constant' in equilibrium (i.e., its change is 'small enough'), then we can say buildings are strategic complements in the logit case. Given strategic complements of price strategies, an increase in zoning constrained building k's rent will increase demand for unzoned building j, and increases the price at j accordingly. □

[58] Alternatively, assume all redevelopment decisions are fixed, and landlords are only competing on occupancy and considering their landlord service costs.

A.5 Proof of Proposition 3

We prove that when an landlord's parcel ownership concentration increases, the landlord increases the prices at all properties. Recall, that consider only the joint developer-landlord problem and relax the assumption that each landlord owns only one parcel. We apply the framework of Nocke and Schutz (2018a,b) to calculate the price effect by utilizing the 'ι-markup of the landlord' from the authors' papers. While those authors use a nested-logit model with constant marginal cost, we remove the nesting structure and allow variable marginal cost.

To prove the proposition, we wish to show that, in the logit case with non-decreasing marginal cost, rent is increasing in market-share of the landlord: $\frac{\partial r_j}{\partial s_f} > 0, \ \forall \ j \in f$. Below, we show this in the two product case for intuition and then in the general case with an arbitrary number of buildings. As in the proof above, we use a composite cost function $C(q)$ and its marginal cost $c(q)$.

Oligopolist Pricing Equation First, we show that landlord f chooses a common markup (Nocke and Schutz, 2018a,b). Let each landlord solves the following joint-profit equation:

$$\max_{\{r_j\}_{j\in f}} \sum_{j\in f} r_j D_j(r_j) - C_j(D_j(r_j)). \tag{50}$$

Following the insight from Nocke and Schutz (2018b), the first order for each property satisfies:

$$(r_j - c_j) = \frac{-1}{\alpha} + \pi_f = \frac{-1}{\alpha(1-s_f)} \implies r_j = c_j - \frac{1}{\alpha(1-s_f)} > 0, \tag{51}$$

where $\alpha < 0$ the (negative) marginal utility of consumption. We assume that $c_j > 0$ and its derivative is positive: $\tilde{c}_j := \frac{\partial c_j}{\partial q} \geq 0, \ \forall j \in J$.[59]

Two Product Case Recall again that under logit demand:

$$\frac{\partial D_j}{\partial r_j} = \alpha D_j(1 - D_j) < 0 \tag{52}$$

$$\frac{\partial D_k}{\partial r_j} = -\alpha D_j D_k > 0 \tag{53}$$

[59] A micro-foundation is that the residential space production function is concave in inputs which implies that the cost function in convex in quantity; hence, marginal cost is non-decreasing in quantity.

Now, we differentiate with respect to the landlord's total market share:

$$r_j = \frac{-1}{\alpha(1-s_f)} + c_j \tag{54}$$

$$\implies \frac{\partial r_j}{\partial s_f} = \frac{-1}{\alpha(1-s_f)^2} + \frac{\partial c_j}{\partial q}\left(\frac{\partial D_j}{\partial r_j}\frac{\partial r_j}{\partial s_f} + \frac{\partial D_j}{\partial r_j}\frac{\partial r_k}{\partial s_f}\right) \tag{55}$$

and by symmetry:

$$\frac{\partial r_j}{\partial s_f} = \frac{\frac{-1}{\alpha(1-s_f)^2} + \frac{\partial c_j}{\partial q}\frac{\partial D_j}{\partial r_k}\left[\frac{\frac{-1}{\alpha(1-s_f)^2} + \frac{\partial c_k}{\partial q}\frac{\partial D_k}{\partial r_j}\frac{\partial r_j}{\partial s_f}}{\left(1-\frac{\partial c_k}{\partial q}\frac{\partial D_k}{\partial r_k}\right)}\right]}{\left(1-\frac{\partial c_j}{\partial q}\frac{\partial D_j}{\partial r_j}\right)} \tag{56}$$

$$= \frac{-1}{\alpha(1-s_f)^2}\left[\frac{1-\frac{\partial c_k}{\partial q}\frac{\partial D_k}{\partial r_k} + \frac{\partial c_j}{\partial q}\frac{\partial D_j}{\partial r_k}}{\left(1-\frac{\partial c_k}{\partial q}\frac{\partial D_k}{\partial r_k}\right)\left(1-\frac{\partial c_j}{\partial q}\frac{\partial D_j}{\partial r_j}\right) - \left(\frac{\partial c_j}{\partial q}\frac{\partial D_j}{\partial r_k}\right)\left(\frac{\partial c_k}{\partial q}\frac{\partial D_k}{\partial r_j}\right)}\right]. \tag{57}$$

Finally, we impose the logit model to get:

$$\frac{-1}{\alpha(1-s_f)^2}\left[\frac{1-\frac{\partial c_k}{\partial q}\frac{\partial D_k}{\partial r_k} + \frac{\partial c_j}{\partial q}\frac{\partial D_j}{\partial r_k}}{1-\frac{\partial c_k}{\partial q}\frac{\partial D_k}{\partial r_k} - \frac{\partial c_j}{\partial q}\frac{\partial D_j}{\partial r_j} - \frac{\partial c_j}{\partial q}\frac{\partial c_k}{\partial q}\frac{\partial D_k}{\partial r_j}\alpha(1-s_f)}\right] > 0. \tag{58}$$

A.6 General Product Case

Note that we have the following:

$$[r_i] = [\Gamma(s_f)\cdot 1_f] + [c_i(D_i)] \tag{59}$$

$$\mathsf{D}_{s_f} r = [\Gamma'(s_f)\cdot 1_f] + \mathsf{D}_q c\cdot \mathsf{D}_r D\cdot \mathsf{D}_{s_f} r \tag{60}$$

$$\implies \mathsf{D}_{s_f} r\cdot[\mathbb{I} - \mathsf{D}_q c\cdot \mathsf{D}_r D] = [\Gamma'(s_f)\cdot 1_f] \tag{61}$$

$$\implies \mathsf{D}_{s_f} r = [\mathbb{I} - \mathsf{D}_q c\cdot \mathsf{D}_r D]^{-1}\cdot[\Gamma'(s_f)\cdot 1_f] \tag{62}$$

A.6.1 Definitions and Lemmas

Definition A.2. Strictly (Row) Diagonally Dominant : for every row, i, the element along the diagonal, a_{ii}, is greater in magnitude than the sum of the magnitudes of each non-diagonal element in the row $a_{i,j},\ j \neq i$. That is, $|a_{i,i}| > \sum_{j\neq i}|a_{i,j}|$.

Definition A.3. Z-matrix : a matrix whose off-diagonal entries are less than or equal to zero.

Definition A.4. $\mathtt{M}$-matrix : a $\mathtt{Z}$-matrix where every real eigenvalue of A is positive.

Lemma 5. *If A is a $\mathtt{Z}$-matrix that is strictly diagonally dominant, then A is an $\mathtt{M}$-matrix by* Gershgorin Circle Theorem.

Lemma 6. *If A is an $\mathtt{M}$-matrix with positive diagonals and negative off diagonals, then $B = A^{-1}$ is monotone positive; i.e., $b_{ij} > 0,\ \forall\ i, j$; proof in Fan 1958.*

A.6.2 General Case Proof

We need to show that the lemma holds and that the vector $B \cdot \Gamma'(s)$ is a monotone positive vector. Let $[\mathbb{I} - \mathsf{D}_q c \cdot \mathsf{D}_r D] = A$.
First, see that A is (a) a $\mathtt{Z}$-matrix that is (b) Strictly (Row) Diagonally Dominant :

(a) for each row, using logit demand, we have

$$a_{i,i} = 1 - \tilde{c}_i \alpha D_i (1 - D_i) > 0 \tag{63}$$

$$a_{i,j} = \tilde{c}_i \alpha D_i D_j < 0 \tag{64}$$

(b) plug into definition of (row) diagonally dominant

$$\implies 1 + \tilde{c}_i |\alpha| D_i (1 - D_i) > \sum_{j \in f \setminus i} \tilde{c}_i |\alpha| D_i D_j = \tilde{c}_i |\alpha| D_i \sum_{j \in f \setminus i} D_j \tag{65}$$

$$\implies 1 + \tilde{c}_i |\alpha| D_i > \tilde{c}_i |\alpha| D_i \cdot s_f. \tag{66}$$

Thus A satisfies lemma 6, so B is a monotone positive matrix.
Second, $\Gamma'(s_f) = \frac{\mathsf{d}}{\mathsf{d}s_f} \frac{-1}{\alpha(1-s_f)} = \frac{-1}{\alpha(1-s_f)^2} > 0$.
Thus as $B \cdot \Gamma'(s_f)$ is a series of multiplication and addition of positive numbers, so $\mathsf{D}_{s_f} r$ must be a monotone positive vector. $\square$

A.7 Alternative Models

In this section, we explore how alternative frameworks affect theoretical results. We first explore a competitive model as an instructive benchmark relative to the model in the main text. We then explore several extensions of our model.

A.7.1 Competitive Urban Model

Here, we develop an urban model where rents are differentiated based on local amenities but landlords still have no pricing power. The primary assumptions are that landlords view themselves as atomistic and that renters' preferences are uniform.

Consider a city with fixed population of renters $i \in N$ and a set of locations $j \in J$. Each location has a local amenity x_j and rent r_j, and is owned by a unique, atomistic landlord who is a price-taker providing housing with a marginal cost of $mc_j(q)$ for q residents. Each atomistic renter must choose one unit of housing and has preferences over amenities and consumption, and we can describe their utility using the value function $u_{i,j} = x_j - r_j$. In the competitive spatial equilibrium, (1) all renters are housed in their utility maximizing location, (2) utility is equal everywhere, and (3) and zero profits. This conditions imply that (1) $\sum_j q_j = N$, (2) $u_{i,j} = \bar{u}$, and (3) $mc_j(q_j) = r_j$.

To find a solution, we note that (2) implies that $r_j = x_j - \bar{u}$, that (3) implies $q_j = mc_j^{-1}(r_j)$, and together with (1) we have $\sum_j \left(mc_j^{-1}(x_j - \bar{u})\right) = N$. These equations form a system of $J+1$ unknowns ($\{\vec{r}, \bar{u}\}$), $J+1$ parameters ($\{\vec{x}, N\}$), and $J+1$ equations:

$$\sum_j \left(mc_j^{-1}(x_j - \bar{u})\right) = N$$
$$r_j = x_j - \bar{u}.$$

In Section 5.1, we show that idiosyncratic cost shocks are passed through to building rents. The above equations make clear that changes in marginal cost at j do not impact rents r_j. Furthermore, were the outside option $\bar{u}$ to be endogenously determined through N, say through idiosyncratic tastes for the outside option, the impact of a cost shock at j on rent r_j would operate only through the outside option $\bar{u}$, i.e. insofar as marginal costs at j contribute to a market-level cost shock. Thus, if landlords are atomistic, then an idiosyncratic cost shock will not affect $\bar{u}$ nor rent.

A.7.2 Markups in the Monocentric City Model

In this section, we adapt the monocentric city model to include individual heterogeneity in location preferences for a finite set of locations that induces downward sloping residual demand for locations. This heterogeneity implies that markups exist and that profits are increasing with proximity to the city center. In addition, prices in denser areas are higher and the quantity of housing lower than if the supply were competitive (price set to marginal cost). Pricing power results in a city that is flatter, demonstrating how pricing power acts as a dispersive force.

We begin with the model from Appendix A.7.1, which immediately precedes this section, noting that x_j can denote location j's distance to the city center on a line segment, with differences between any two locations j and $j+1$'s distances x_j and x_{j+1} being constant and nonzero for all js (such that there are a large but finite set of locations J), starting with the CBD itself at $j=0$ with distance $x_0=0$, until an endogenously determined periphery point,j^{b} with distance to CBD $x_{j^{\mathsf{b}}}$.[60] In addition we assume a mass N of renters and for simplicity we assume that the city is closed. The assumption of a discrete number of locations follows Berliant and Fujita (1992) and is a departure from standard monocentric city models, where space is continuous for tractability reasons, but similar to Alonso's original model.

We now adjust the above model by positing that indirect utility of each individual i at location j is a combination of location j's rent, r_j, and distance to the CBD, x_j, as well as an idiosyncratic valuation parameter, ϵ_i, drawn from some distribution $G(\epsilon)$ where $\epsilon \geq 0$ and $\mathsf{E}[\epsilon] \in \mathcal{R}_+$:

$$v_i(j) = (1 - x_j)\epsilon_i - r_j. \tag{67}$$

Note that this is isomorphic to heterogeneous transportation costs.[61]

Downward-sloping demand for each location is derived from renter heterogeneity and the assertion that for each distance x_j there is only 1 plot of that distance (with differences $x_j - x_{j+1} > 0$ and constant). An alternative approach that would sustain markups in the presence of multiple plots with identical values x_j would be to assume renter-location specific heterogeneity $\epsilon_{i,j}$ as in the main text discrete choice model. In such a setting, markups can converge to a positive constant even as the number of choices goes to infinity.

In the present setting, willingness to pay for each location will be different for each individual. This generates a downward sloping residual demand curve for each location j that brings about markups. As in the previous model, willingness to pay is also determined by prices at other locations:

$$WTP_i(j) = \min_{j'}\{(1 - x_j)\epsilon_i - (1 - x_{j'})\epsilon_i - r_{j'}\}. \tag{68}$$

Note that for any given option j', the difference between i's valuations of j and j' is increasing in ϵ_i. This super-modularity guarantees a sorting equilibrium: each location j will be populated by a set of types $[\underline{\epsilon}_j, \bar{\epsilon}_j]$, with higher locations having higher cutoffs (Mirrlees, 1971). Locally, the only relevant alternatives for individuals at plot j are at plots $j-1$ and $j+1$. Specifically, at each plot j there is a threshold, $\tilde{\epsilon}_j$, below which the relevant

[60] Note, defining x_J as the furthest point from the CBD that is feasible given the landscape (possibly due to natural features), we allow for $x_{j^{\mathsf{b}}} \leq x_J$.

[61] In addition, we assume that all units are the constrained to be equal sized.

alternative is $j+1$, and above which the relevant alternative is $j-1$: the highest types in each plot will be deciding between j and moving one space closer to the city center while the lower types will be deciding between j and moving space further.

Locally, conditional on $\epsilon_i > \tilde{\epsilon}_j$, willingness to pay for j is therefore:

$$WTP_i(j) = (x_{j-1} - x_j)\epsilon_i - r_{j-1}, \tag{69}$$

while below $\tilde{\epsilon}_j$, willingness to pay for j is:

$$WTP_i(j) = (x_{j+1} - x_j)\epsilon_i - r_{j+1}. \tag{70}$$

Total demand for j given a price r_j is therefore

$$q_j(r_j) = P\left(\epsilon > \tilde{\epsilon}_j\right) \cdot P\left(\epsilon < \frac{r_{j-1} - r_j}{x_j - x_{j-1}}\right) + P\left(\epsilon \leq \tilde{\epsilon}_j\right) \cdot P\left(\epsilon > \frac{r_j - r_{j+1}}{x_{j+1} - x_j}\right) \tag{71}$$

or

$$q_j(r_j) = \left[1 - G\left(\tilde{\epsilon}_j\right)\right] \cdot G\left(\frac{r_{j-1} - r_j}{x_j - x_{j-1}}\right) + G\left(\tilde{\epsilon}_j\right) \cdot \left[1 - G\left(\frac{r_j - r_{j+1}}{x_{j+1} - x_j}\right)\right]. \tag{72}$$

It's clear from the above that quantity demanded is declining in price on two margins: as r_j increases, those at the top margin near $\bar{\epsilon}_j$ leave for $j-1$ and those at the bottom margin $\underline{\epsilon}_j$ leave for $j+1$. Marginal revenue is therefore also declining. As in the main text, profits are given by:

$$\pi = \max_{\mathbb{1}_{redev}, q_j} \begin{cases} r_j(q_j) \cdot q_j - C^{\mathsf{d}}(q_j) - C^{\mathsf{f}}(q_j) & \text{if } \mathbb{1}_{redev} = 1 \\ 0 & \text{if } \mathbb{1}_{redev} = 0, \end{cases} \tag{73}$$

where here we assume for simplicity no structure currently exists at any location j, no transfers, and costs are symmetric. We also now assert a fixed cost of development $C^{\mathsf{d}}(0) > 0$.

At each location, taking prices at all other plots $r_{j'}$ as given, landlords set quantities to maximize profits and will do so where falling marginal revenues are equal to marginal cost. Because prices must be decreasing with distance x_j in the sorting equilibrium described above, r_{j+1} and r_{j-1} are also falling with x_j. All else equal, demand at any price is falling in x_j. It follows that plots closer to the city will have higher quantities and profits. It further follows that the city will be filled in: if a location j is developed, all locations $j' < j$ will also be developed.

To close the model, the peripheral location, $j^{\mathbf{b}}$ at distance $x_{j^{\mathbf{b}}}$, must be found after which no development occurs. Note that quantity demanded at $j^{\mathbf{b}}$ is given by:

$$q^D_{j^{\mathbf{b}}}(r_{j^{\mathbf{b}}}) = G\left(\frac{r_{j^{\mathbf{b}}-1} - r_{j^{\mathbf{b}}}}{x_{j^{\mathbf{b}}} - x_{j^{\mathbf{b}}-1}}\right). \tag{74}$$

A slight complication to note is that, as is present in the above demand expression, at this location (as well as at the most central location) there is only a single margin from which to draw additional individuals, or to which marginal individuals leave.

Because space is discrete, we have an approximation of a zero profit condition in Eq 75. The peripheral location, $j^{\mathbf{b}}$, is defined as the furthest plot from the city center such that its profit is weakly positive (and almost zero) but at the next undeveloped plot, $(j^{\mathbf{b}} + 1)$, profit upon entry is strictly negative:

$$0 > r_{(j^{\mathbf{b}}+1)}(q_{(j^{\mathbf{b}}+1)}) \cdot q_{(j^{\mathbf{b}}+1)} - C^{\mathsf{d}}(q_{(j^{\mathbf{b}}+1)}) - C^{\mathsf{f}}(q_{(j^{\mathbf{b}}+1)}). \tag{75}$$

Despite (near) zero profits, the landlord at $j^{\mathbf{b}}$ still sets rent with a markup over marginal cost. Rather, the fixed cost $C^{\mathsf{d}}(0)$ almost exactly offsets variable profit from the optimally chosen quantity at the periphery (and profits are increasing towards the city center).

Finally, the total quantity of housing provided must equal the total quantity demanded:

$$\mathsf{N} = \sum_{0}^{j^{\mathbf{b}}} q^*_j(r^*_j), \tag{76}$$

where q^*_j and r^*_j are equilibrium, profit-maximizing quantities and prices at plot j.

To see monopoly power act as a dispersion force, note that at the city center, $j = 0$, demand is given by:

$$q^D_0(r_0) = 1 - G\left(\frac{r_0 - r_1}{x_1}\right). \tag{77}$$

Quantity at this location is lower than in a competitive model due to both landlord at $j = 0$ setting rent above marginal cost *and*, through general equilibrium forces: rent at $j = 1$ is also set its marginal cost. However, not every location will experience reduced density: the equilibrium effects of reduced density at the center push demand out to the periphery, and, at some point, these effects may dominate the pricing power effect and locations further away may be more built up than in under marginal cost pricing. Furthermore, the increased profitability at $j^{\mathbf{b}}$ and the general equilibrium effects increasing demand at $j^{\mathbf{b}}$

imply that the peripherally developed plot is *futher* away from the CBD under monopolistic pricing. Taken together, these facts imply the density of the monopolistically priced city first-order stochastically dominates that of the city built to marginal cost pricing (although we do not formally show this).

We reiterate that the markup in this setting is a feature of two items: heterogeneity of individual taste in the form of the (variance of the) distribution $G(\epsilon)$, and amenity differences $x_j - x_{j-1}$. As either go to zero, markups are eliminated. This is **not** the case if instead heterogeneity took the form of individual-by-location draws, $\epsilon_{i,j}$, as in the model in the main text. Under this regime with specific assumptions on the distribution of $G(\epsilon)$, markups will converge to a constant as the distance between spaces converges to zero or, as on a disk, multiple buildings with the same value of x coexist.

A.7.3 Entry and Exit to Other Real Markets

Our baseline model takes the number of parcels available for rent as constant. An alternative, and more realistic, assumption is that landlords can choose which of several housing markets to enter. For example, a landlord with an *ex ante* rental building could sell it as condominiums or a commercial building could be converted to residential space.

In such a setup, the city overall is still comprised of an exogenous set of parcels, $\mathcal{A} = \{a_0, a_1, a_2, \ldots, a_J\}$, but each housing market, m, consists of an endogenously selected and mutually exclusive subset of parcels, $\bigcup_m \mathcal{A}_m = \mathcal{A}$, for all real estate markets m. Once these sets are determined equations (1)-(9) remain the same as in the main text. To close the model and determine these sets, we add an addition equilibrium constraint. Facing different demand (and potentially costs) in each market, each landlord chooses which housing market to enter, such that the chosen market is the profit-maximizing market for that parcel:

$$m_a^* = \underset{m}{\operatorname{argmax}}\{\pi_a^m\} \tag{78}$$

Exit and entry change the plots's profitability in their incumbent markets. In the case of symmetric costs and demand for all buildings in each market, this yields profit equalization condition across markets.

Because of the real costs of these kinds of switches and policy-determined constraints, we observe relatively few buildings switching between markets over the course of our sample. Still such a setup might be more descriptive of a very long-run land-use equilibrium.

A.7.4 Generalized Free Entry

Another alternative assumption is that there is a fringe of parcels with the capacity to freely enter the market. That is, undeveloped land that could be turned into apartment buildings. This arrangement is difficult to fathom in a built urban core, such as our empirical setting in New York, but could be appropriate for locations proximate to large undeveloped terrain.

In this case, again, the set of parcels available for renters is endogenous in the model, and—again—conditional on this decision, equations (1)-(9) remain unchanged. An easy structure to close such a model is to assume a fixed entry cost ξ_e (e.g., a permitting cost), before a draw of the location amenity a. Although we do not specify profitability as a function of a, the equilibrium condition determining the set $\mathcal{A}$ is that profits are zero in expectation:

$$\mathsf{E}[\pi_a] = \xi_e \tag{79}$$

In this case, expected profits are zero, but realized profits may be heterogeneous. Ex-post of entry, landlords still charge markups. While profits are zero, in general, efficiency of this market structure depends on more restrictive assumptions on preferences (Bilbiie, Ghironi, and Melitz, 2008).

It should also be noted that under this market structure, typical analyses of urban policies are highly non-regular. For example, the welfare impact of zoning can become ambiguous, as parcel-level deviations from efficiency could be ameliorated by the policy's (potential) effect of induced entry. For this reason, and because the assumption of free entry is unrealistic in the urban core, we do not favor this analysis.

A.7.5 Uncertainty

We consider uncertainty in the form of uncertain (future) building-specific demand, so that the joint developer-landlord expected profit function is:

$$\mathsf{E}[\pi_a] = \max_{\mathbb{1}_{redev}, q_a} \begin{cases} \mathsf{E}\left[\mu \cdot r_a(q_a) \cdot q_a - C^{\mathsf{d}}_a(q_a) - C^{\mathsf{f}}_a(q_a) + \mathsf{S}_a\right] & \text{if } \mathbb{1}_{redev} = 1 \\ \mathsf{E}\left[\mu \cdot r_a(q_a) \cdot q_a - C^{\mathsf{f}}_a(q_a)\right] & \text{if } \mathbb{1}_{redev} = 0 \end{cases} \tag{80}$$

where μ is an exogenous, stochastic parameter capturing the uncertainty of future demand with distribution $G(\mu)$ that is non-negative and has finite mean and variance. In this case, the developer-landlord's optimal choice of q (conditional on the redevelopment) and the redevelopment decision only depend on $E(\mu)$, rather than the realized value. Because the demand system is stochastic, the social surplus is also stochastic, and a social planner optimizes over the same expected value, $E(\mu)$. Redevelopment failure occurs, if it occurs, for the non-stochastic demand system $E[\mu] \cdot r_a(q_a)$, and Proposition 1 remains unchanged.

This approach differs from Titman (1985) in that our redevelopment decision must be decided upon before the realized state of the world. We also differ from Capozza and Li (1994), who model uncertainty in a continuous time framework with Brownian motion. The latter framework is fitting for a separate research question: *what dictates the timing of redevelopment decisions?* Though beyond the scope of this paper to analyse, we note that as is standard in the investment literature, demand variance generates option value and postpones investment. As in He and Kondor (2016), sub-optimal redevelopment may occur.

A.7.6 Endogenous Quality Selection

Here we consider a model extension where developers are allowed the additional choice of adjusting building quality when considering redevelopment.

Buildings, indexed by j, can be in one of a set of discrete, hierarchical quality categories $a \in A = \{a_1, a_2, ...a_Q\}$, where we say $a_{j,0}$ is the initial quality.[62] In addition, each building has some initial capacity, $q_{j,0}$. We let the as-is sale price of the building vary across buildings, even conditional on initial quality and size, due to various factors such as different capital vintages and depreciation. Developer d, who owns a parcel containing a building with attributes $(a_{j,0}, q_{j,0})$, chooses whether to sell the building as-is or to redevelop, and, conditional on redeveloping, chooses a quality, a, from the discrete set of potential quality types and a new quantity, q, conditional on long-run zoning regulations.

Thus, the developer's new maximization problem is:

$$\pi^{\mathsf{d}} = \max_{\{\mathbb{1}_{redev}, a, q\}} \begin{cases} s_j(a_{j,0}, q_{j,0}) & \text{if } \mathbb{1}_{redev} = 0 \\ [s(a,q) - C(q,a)] \cdot \xi_a^{\mathsf{d}} & \text{if } \mathbb{1}_{redev} = 1 \end{cases} \tag{81}$$
$$\text{s.t. } q \le q_{j,z},$$

where we now assume the cost function and sale prices are quality but not developer specific, and the value of redevelopment to a specific quality a has an idiosyncratic component ξ_a^{d}, which is developer and quality specific, drawn from a Fréchet distribution with

[62]Note, we no longer index buildings by a, as in the main text, since this is now a choice variable.

shape parameter θ: $F(\xi) = \mathrm{e}^{\xi^{-\theta}}$.

Solving the developer problem in reverse may be instructive. Because all buildings of a specific quality face same cost function and residual demand, all developers choosing to redevelop to a given quality will also choose to redevelop to the same quantity, which we refer to as q_a.[63] Embedding the quantity choice into the quality choice, the problem now becomes a standard discrete choice problem with Fréchet draws. In particular, *conditional on redevelopment*, the probability of choosing quality a is:

$$\Pr\left(a \mid \mathbb{1}_{redev} = 1\right) = \frac{(s(a, q_a) - C(a, q_a))^{\theta}}{\sum_{a' \in A}(s(a', q_{a'}) - C(a', q_{a'}))^{\theta}}. \tag{82}$$

Furthermore, conditional on a non-redeveloped building sale price of $\tilde{s}_0$, which maps to a set of initial building qualities and sizes, the share of buildings being redeveloped to quality level (a, q_a) is:

$$\int_{\tilde{s}_0} \Pr(\pi_a > \tilde{s}_0) = \int_{\tilde{s}_0} \mathrm{e}^{-(s(a,q_a)-C(a,q_a))^{-\theta}} \mathrm{d}G(\tilde{s}), \tag{83}$$

where $G(\cdot)$ is the distribution on sales prices conditional on non-development.

Therefore, the number of redeveloped parcels in each period and to each quality level can be found by summing the above expression over the distribution of building valuations across the city.

A number of interesting new dynamics build off of the results of the model in our main text. For example, through markups, exogenous changes in demand for luxury housing may lead to switches from low income to luxury redevelopment and increase the pricing power of lower income housing landlords.

A.8 Pass-through Theory in Graphs

In Section 5.1, we claim that under pure competition idiosyncratic cost shocks cannot be passed through to rent (Claim 1) and that overshifting is a further test for the presence of

[63] For a given developer conditional on a choice of a, choosing q over $q' \neq q$ implies that $s(a, q) - C(a, q) > s(a, q') - C(a, q')$. Thus, as long as there is a unique optimal quantity conditional on the quality choice, then all developers choosing a given a, will choose the same q.

market power (Claim 2).[64] That is, under pure competition:

$$C_1 : \Delta r / \Delta mc(q) = 0 \tag{84}$$

$$C_2 : \Delta r / \Delta mc(q) \leq 1. \tag{85}$$

Here, we present simple graphs to illustrate these two points.

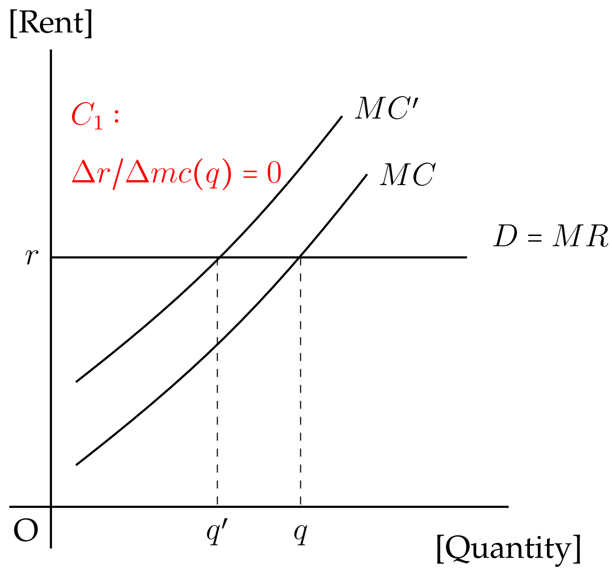
Appendix A.7.1 provides a perfectly competitive model that micro-founds C_1 above. Figure A.1 demonstrates how the residual demand facing a building in that model is flat, and how, in that setting, any shifts in cost cannot result in changes in observed rents. This is our primary test.

Secondly, we find pass-through rates that are on average above 1. As we argue in the text, this is inconsistent with most competitive settings. We reiterate that a competitive framework, building *residual demand* is always flat as in Figure A.1.[65] However, pass-through can still happen at an aggregate level (e.g., from aggregate cost shocks). In Figure A.2, we illustrate that when markets are competitive, the pass-through of aggregated supply shocks cannot exceed a rate of 1. Our estimate of a pass-through elasticity greater than one—implies that such an environment is inconsistent with the data.

[64]We are not the first to make these claims. There is a growing literature on how pass-through can provide information of market structure; see Weyl and Fabinger (2013); Pless and van Benthem (2019); Ritz (2019) for other applications and theoretical results.

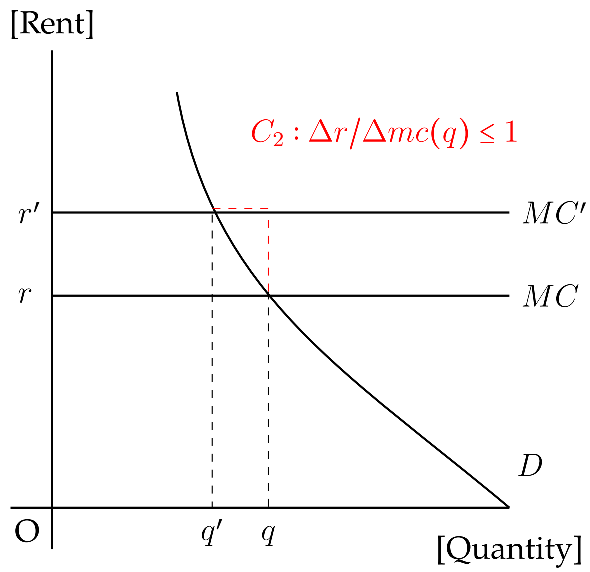
[65]We cannot think of a model that would feature (1) profit maximizing monopolists, (2) downward sloping residual demand, and (3) rent equal to marginal cost.

Figure A.1: Pass-through with Perfectly Elastic Demand



Note: The figure demonstrates that under perfectly elastic demand an idiosyncratic cost shift cannot be passed onto rents. The only possible margin would be a decrease in quantity, either at intensive margin or extensive margin.

Figure A.2: Pass-through with Downward Sloping Demand



Note: The figure demonstrates that under downward sloping demand where (somehow) rent equals marginal cost an idiosyncratic cost shift increases rents by no more than the shift in marginal cost. This is by assumption since we force rent to equal marginal cost.

B Detailed Sourcing of Average Building Rent

Recovering building average unit rents is a key feature of this analysis that relies on three facts. By law, the NYC DOF assesses rental buildings based on their income generation. This is called income-based assessment. For single-use, residential rental buildings, this corresponds to the rent paid to landlords. For mixed-use rental buildings, we cannot separate the source of income between commercial and residential tenants. This leads us to restrict our sample to single-use residential buildings in all regressions. For all such buildings, NYC DOF income information comes from income and expenses reported on Real Property Income and Expense (RPIE) statements filed by owners with DOF. All income generating property owners are required to file these annually and face financial penalties for not doing so. NYC DOF uses these forms to generate tax assessments and reports these values to building owners in mailings called Notices of Property Values (NPVs), sent annually and also posted publicly online. NPVs confirm NYC DOF have received income and or expense information from owners and the amounts for each. We download these statements where they are publicly available for all buildings in our sample.

If an owner does not file, the DOF has the right to assign a market value based on its best judgement. NPVs note whether actual information was provided and we only record income and expenses derived from RPIE statements. The DOF also adjusts extreme outliers. Without access to the RPIE statements, it is not possible to determine which properties have been adjusted. However, owners have a financial stake in ensuring the information is correct.

C Detailed Construction of Samples

Here, we discuss the sample construction in the following subsections:

- Source Data
- Table 2: Pass Through Results
- Table 3: Rent-HHI Results
- Table 4: Demand Estimation Results

C.1 Source Data

The underlying source data for New York city (NYC) buildings comes from combining multiple public administrative data sets from the NYC government. We combine the Primary Land Use Tax Lot Output (PLUTO), the Department of Finance Final Assessment Roll (FAR), the Multiple Dwellings Registration and Contacts (MDRC) datasets (with prior years graciously provided to us by the NYU Furman Center), and communications between the DOF and building owners, scraped off the Property Tax Public Access web portal, which we call the Notice of Property Value (NPV) dataset.

The PLUTO and FAR provide location, zoning, market value, and other building characteristics, and the MDRC reveals common ownership across buildings. The NPV includes information mailed to building owners including gross revenue and cost estimates and the number of rent stabilized units.

We collect all available datasets from 2001 to 2019. We only collect data that excludes parcels for 1-3 family buildings (specifically, NYC Tax Class 1 buildings) due to the fact that these buildings are assessed using a comparable sales model that it not usable for our analysis. In addition, we exclude Staten Island parcels as there are very few large rental buildings in this borough.

The initial dataset features about 860,000 parcels per year, which includes all commercial buildings (specifically, NYC Tax Classes 2-4). We keep parcels with buildings that have a NYC Building Class C1-C9, D0-D9, S3-S5, or S9 at some point in their tenure in the dataset. We also drop years prior to 2007 due to lack of financial data, as well as other missing variables. This returns a dataset of rental buildings with about 87,000 parcels per year.

Many of these buildings are "Mixed Use," by which we mean contain residential and commercial tenants, and so we cannot separately identify the two sources of building income. While we use all buildings for construction HHI's or BLP instruments, we only

Table A1: NYC Building Data Full

	Bronx	Brooklyn	Manhattan	Queens	NYC
	All Tax Class 2-4 Buildings				
All Years	1,168,353	3,611,174	562,969	4,217,852	11,170,414
	All Rental Buildings				
All Years	137,540	491,667	293,794	205,567	1,128,568
	Single Use Residential Rental Buildings				
2007	7,946	28,320	12,169	12,093	60,528
2008	7,983	28,608	12,258	12,147	60,996
2009	8,019	28,872	12,257	12,277	61,425
2010	8,028	28,627	12,197	12,253	61,105
2011	8,060	28,578	12,124	12,248	61,010
2012	8,061	28,616	12,031	12,350	61,058
2013	8,111	28,590	11,972	12,345	61,018
2014	8,134	28,652	11,893	12,295	60,974
2015	8,158	28,678	11,832	12,299	60,967
2016	8,176	28,838	11,759	12,330	61,103
2017	8,214	29,006	11,709	12,343	61,272
2018	8,273	29,332	11,668	12,357	61,630
2019	8,304	29,589	11,645	12,374	61,912
All Years	105,467	374,306	155,514	159,711	794,998

use “Single Use” residential buildings in our regressions. See Table A1 for our main sample sizes for our complete data.

C.2 Table 2: Pass Through Sample

For our pass through results, we subset the data using only the years 2011 to 2019. We do this because our financial data is most complete for these years and because from 2007 to 2010 there was a systemic change in property tax procedures.We also drop buildings where the average building rent is in the extreme tails of the distribution (0.1% and 99.9%). We then use data from 2011 as a baseline for creating our tax based instruments and omit this year from the regressions – see Appendix F for more details on construction of IVs.

C.3 Table 3: HHI Sample

For our HHI results in Table 3, we start with the single use residential sample and filter to only the years 2009 and 2019. This yields a 'long-run' association of concentration changes on rents. As in Table 2, we also drop buildings where the average building rent is in the extreme tails of the distribution (0.1% and 99.9%).

C.4 Table 4: Demand Sample

For our pass through results, we subset the data using only the years 2011 to 2019. Again, we do this because our financial data is most complete for these years due to the NYC online portal deleting communications from 2010 and back. We also drop buildings where the average building rent is in the extreme tails of the distribution (0.1% and 99.9%). We then use data from 2011 as a baseline for creating our tax based instruments and omit this year from the regressions – see Appendix F for more details on construction of IVs.

D The NYC Housing Policy Environment

Here we briefly describe the major policy constraints in NYC—zoning restrictions on quantity and rent stabilization on prices, their prevalence in the data, and our approach to their interaction with our empirical specifications.

D.1 Zoning

> *Zoning is a law that organizes how land may be used. It establishes an orderly pattern of development across neighborhoods and the city by identifying what may be built on a piece of property.*[66]

In 1916, New York was the first major city in the United States to adopt citywide zoning, and the zoning ordinance has been amended many times since. The city has four zoning district types: Residential, Commercial, Manufacturing, and Special Purpose. The Special Purpose districts modify an area within a district. Some residential districts (or areas within) may have a commercial overlay that allows for commercial space in a ground floor (and possibly a second floor) with residential units above.

The zoning law establishes the classes of use and the physical dimensions of a building on a given parcel of land. The zoning law often changes and new construction is subject to the current zoning regulations. This can imply that within a given block buildings can vary in several dimensions based on construction time.

D.1.1 Zoning Concepts

There are numerous concepts involved in establishing the physical shape and dimensions of a building, and a full discussion is far beyond the scope for this appendix. However, some useful concepts for the physical dimension rules are: setbacks, building envelope, floor area ratio, open space ratio, and density factor.[67]

Setbacks are regulations about how far *back* a building must be *set* from some reference point. Street setbacks dictate how close the street-facing wall of a building must be from the street; building setbacks dictate how far back a portion of a building must be from its edge as height increases. The building envelope is the three dimensional shape that

[66] "What is Zoning?" (`https://www1.nyc.gov/site/planning/zoning/about-zoning.page`).

[67] See the NYC Zoning Glossary for more terms (`https://www1.nyc.gov/site/planning/zoning/glossary.page`).

represents the maximum regulatory dimensions of a building; i.e., the true building must fit within the building envelope.

The floor area ratio (FAR) is the factor by which a parcel's lot area permits building area. For example, suppose a lot has area $L_{area} = L_{width} \cdot L_{depth}$ and a FAR of f, then the allowable floor area of the building is $B_{area} = f \cdot L_{area}$. The open space ratio (OSR) is the percent of a lot that must have open space; i.e., that cannot be covered by the building. For example, given $\{B_{area}, L_{area}\}$ and OSR of o, then the footprint of the building must be contained within $L_{area} - o \cdot B_{area}$. One use of these two tools is 'height factor buildings' where the zoning regulations can promote tall, skinny buildings. Specifically, to maximize floor area available, the number of stories of the building must be $f/(1 - o \cdot f)$. If $f = (5/2)$ and $o = (1/3)$, then this results in a $(5/2)/(1/6) = 15$ story building.

Density factors are "approximations of average unit size plus allowances for any common areas (NYC Zoning Glossary)," and when combined with floor area ratios result in the maximum number of dwelling units in a building. For example, if d is the density factor, then B_{area}/d is the maximum number of units allowed in the building.[68]

D.1.2 Zoning Facts in NYC

We consider a building to zoning constrained if the building, given its current building area and zoning policy, cannot add an additional minimum sized unit to the building. If any of the following conditions are met, then we consider a building to be zoning constrained:

1. Average Unit Area is greater than the maximum possible residential area of the building divided by current units plus one: $(B_{area}/U) > (\mathsf{Max}(\text{Res}_{area})/(U+1))$,

2. The denisty factor is greater than the maximum possible residential area of the building divided by current units plus one: $d > (\mathsf{Max}(\text{Res}_{area})/(U+1))$, or

3. Building Area plus 300 sqft is greater than the maximum possible residential area of the building: $B_{area} + 300 > \mathsf{Max}(\text{Res}_{area})$.

In Table A2 we show that zoning constraints affect about 60% of NYC with variation in levels across boroughs but little variation over time. Interestingly, Manhattan has the least zoning constrained buildings while Queens has the most. Pooling all years together, we map the locations of zoning constraints in Figure A.3.

[68]Values are rounded up only if the fractional remainder is greater than $(3/4)$.

Table A2: Zoning Constraints Across Boroughs

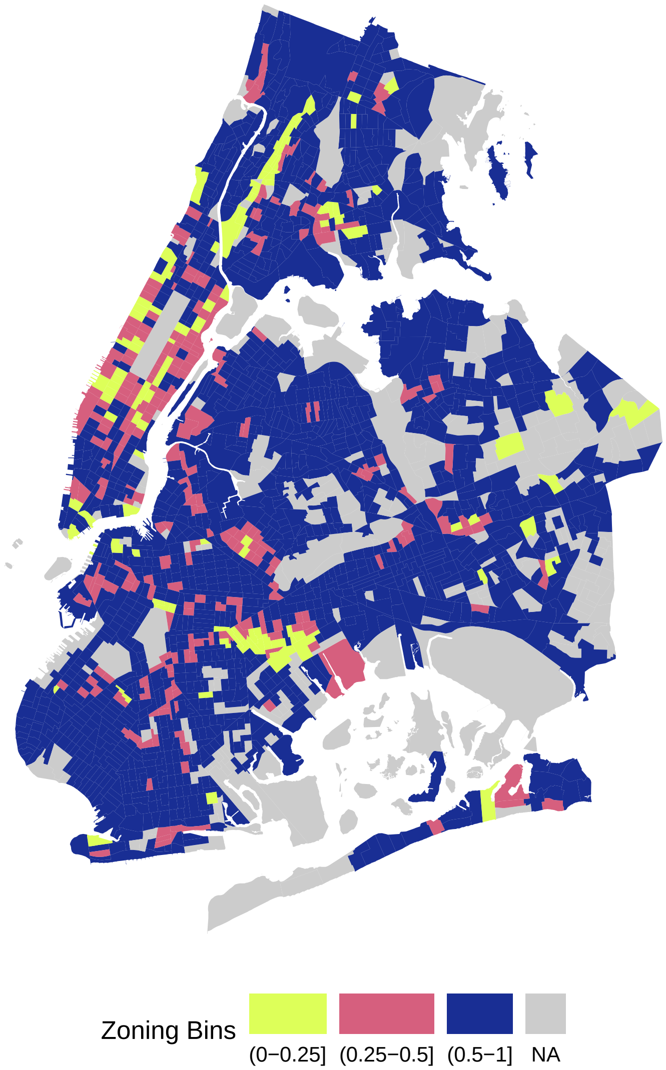
	BX	BK	MN	QN	NYC
2007	0.64	0.63	0.54	0.78	0.64
2008	0.64	0.63	0.53	0.79	0.64
2009	0.63	0.63	0.54	0.78	0.63
2010	0.63	0.63	0.53	0.78	0.63
2011	0.63	0.63	0.53	0.78	0.63
2012	0.63	0.62	0.51	0.78	0.62
2013	0.63	0.62	0.51	0.79	0.62
2014	0.64	0.64	0.52	0.80	0.64
2015	0.64	0.63	0.52	0.80	0.64
2016	0.64	0.64	0.52	0.80	0.64
2017	0.64	0.64	0.52	0.80	0.64
2018	0.64	0.65	0.52	0.81	0.65
2019	0.64	0.65	0.52	0.81	0.65
Total	0.64	0.63	0.53	0.79	0.64

Note: 2007-2019 NYC residential buildings with 4+ units. Data from DOF and PLUTO files. Unweighted average across buildings.

D.1.3 Impact on Empirical Specifications

We model zoning constraints directly as hard caps on building size which enter into the redevelopment decision. Some buildings' redevelopment will be to the corner imposed by the zoning limit. This is born out in the data, as a majority of newly developed structures are limited in size by at least one of the above zoning constraints at the time of their construction. This is of particular interest in our quantitative exercise: we show that the markup can only be calculated for the subset of these buildings which were unconstrained at the time of their construction. However, note that the estimation parameters are not effected by these quantity constraints. So long as the market for each building clears, unbiased estimates of the structural parameters can be recovered from constrained and unconstrained buildings alike.

Figure A.3: Distribution of Zoning Constraints



Note: The figure maps the percent of buildings that are zoning constrained, pooling across years. As described in text, we define a building as zoning constrained if under the current building area and zoning policy the building cannot add an additional unit.

D.2 Price Controls

A full history of NYC's rent regulation is available from the city as "History of the [NYC Rent Guidelines] Board and Rent Regulation."[69] Rent regulations came to NYC from a 1920 state law allowing rent controls due scarcity in housing induced by the war-effort for World War One. Because the problem was of housing scarcity, the law (1) exempted

[69] Accessible online at
rentguidelinesboard.cityofnewyork.us/wp-content/uploads/2020/01/historyoftheboard.pdf

all properties building after September 1920 from the law and (2) exempted all buildings built between 1920-1924 from property tax until 1932. The 1920 law expired at the end of 1929. Rent control returned in 1943 due to World War Two price controls. Rent control legislation was controlled at various times by the state and federal government, with the state assuming control after in 1951.

While rent control still exists for long-time incumbent renters, rent stabilization was introduced in 1969 and is the dominant form of rent regulation today. Both rent control and rent stabilization create the legal right to renew a lease, but the difference between the two is that rent control regulates the level of rents while rent stabilization regulates the growth in rents. Rent control applied to buildings built before 1947 while rent stabilization applied to buildings built between 1947-1974 (with six or more units), formerly rent controlled units, and units that accept J-51, 421-a, or 421-g tax benefits.[70]

While we speak of rent regulated buildings, regulations actually apply to specific units in buildings. That is, a building may have only zero, one, or many regulated units. Individuals can contact the Rent Guidelines Board to inquire about specific units; however, the best method to observe regulated units at the building level is through parsing tax communications with the Department of Finance, which we have done.

Rent stabilization in NYC is managed by the Rent Guidelines Board. The board oversees these issues and establishes rent rate increases. Broadly, the rate increase per year is the minimum of (1) 7.5% or (2) the average rent increase of the last five years. Individual landlords may request exemptions or special consideration based on hardships, agreements with the tenant, or major renovations.

Until 2019, units in rent stabilized buildings could become unregulated ("destabilized") if upon being vacated the landlord could rent the unit above a certain amount. One method of doing this was a renovation that allowed the landlord pass some cost of renovation to the rent by an amount enough to push the rent above a predetermined threshold. The 2019 law ended this possibility. Currently, the only way to exit regulated status would be either a condo/coop-conversion (although this does not evict a current rent stabilized tenant who does not want to buy) or a rebuild of a new building that does not take NYC tax benefits for new construction.

However, the landlord was also allowed to charge a "preferential rent" that could be less than the contract rent. It's not possible in our data to ascertain the percentage of units in each building which are charged preferential rent. These units are officially regulated,

[70]These benefits are for new building construction, conversions, and/or renovations.

but regulations do not bind. In discussions, former Department of Housing Preservation and Development officials indicated that preferential rents were more common in outer boroughs and northern Manhattan.

D.2.1 Rent Stabilization in NYC

Here we document some findings about rent regulation in NYC. We parse communications from the NYC Department of Finance to building owners that lists the number of regulated units in a building. In Table A3 we list the portion of buildings that have any rent stabilized units and in Table A4 we list the portion of buildings that have over 50% of units rent stabilized. Interestingly, Manhattan actually has relatively fewer rent stabilized units relative to the other boroughs.

Table A3: Portion of Buildings with Any Stabilized Units

	BX	BK	MN	QN	NYC
2007	0.58	0.41	0.67	0.47	0.51
2008	0.58	0.40	0.67	0.46	0.50
2009	0.55	0.36	0.63	0.43	0.47
2010	0.55	0.36	0.63	0.43	0.46
2011	0.57	0.37	0.64	0.44	0.47
2012	0.58	0.38	0.65	0.45	0.48
2013	0.58	0.38	0.65	0.45	0.48
2014	0.57	0.37	0.63	0.44	0.47
2015	0.56	0.36	0.62	0.43	0.46
2016	0.55	0.36	0.62	0.43	0.46
2017	0.55	0.35	0.61	0.42	0.45
2018	0.54	0.34	0.61	0.42	0.45
2019	0.53	0.34	0.61	0.42	0.44
Total	0.56	0.37	0.63	0.44	0.47

Note: 2007-2019 NYC residential buildings with 4+ units. Data from DOF and PLUTO files. Unweighted average across buildings.

Next, we plot two graphs. First, in Figure X we show the portion of buildings of rent stabilization based on age. As expected, buildings built after 1974 are much less likely to have rent stabilized units. New buildings have rent stabilized units because they are likely taking advantage of tax benefit programs. Second, in Figure A.5 we show the distribution of rent stabilization around the city.

Table A4: Portion of Buildings with Over 50% of Units Stabilized

	BX	BK	MN	QN	NYC
2007	0.57	0.38	0.47	0.45	0.44
2008	0.57	0.38	0.46	0.45	0.44
2009	0.54	0.34	0.41	0.42	0.40
2010	0.54	0.33	0.39	0.41	0.39
2011	0.56	0.34	0.38	0.41	0.39
2012	0.57	0.35	0.37	0.42	0.40
2013	0.57	0.35	0.36	0.42	0.39
2014	0.56	0.33	0.35	0.41	0.38
2015	0.55	0.32	0.33	0.40	0.37
2016	0.55	0.32	0.33	0.40	0.37
2017	0.54	0.31	0.32	0.39	0.36
2018	0.53	0.31	0.32	0.39	0.35
2019	0.53	0.30	0.32	0.39	0.35
Total	0.55	0.34	0.37	0.41	0.39

Note: 2007-2019 NYC residential buildings with 4+ units. Data from DOF and PLUTO files. Unweighted average across buildings.

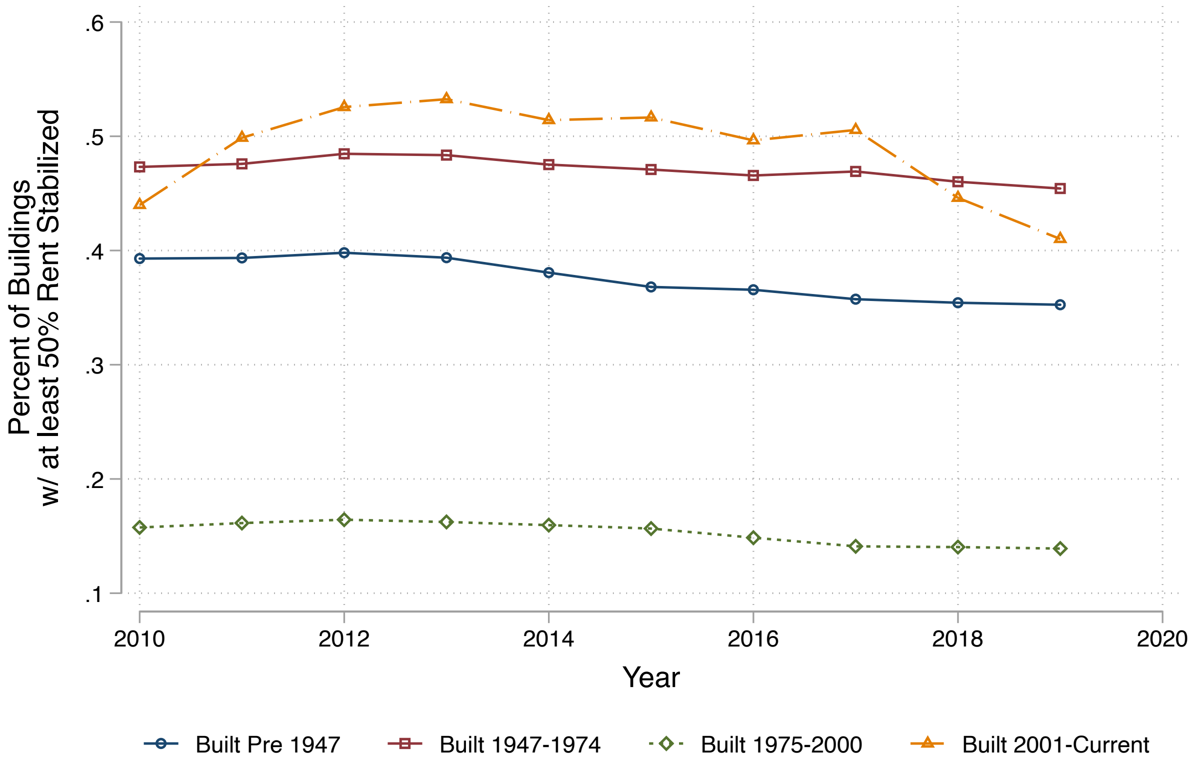
Chen, Jiang, and Quintero (2022) note that rent stabilized units are more likely to be cheaper, and that the longer a unit remains rent-stabilized the cheaper it will be. These facts are consistent with selection out of stabilization using the above characteristics, as well as with a dynamic pricing model where stabilized units experience less dynamic price increases but larger jumps at vacancies. A separate possibility is that rent-stabilization selects on or causes declines in unobservable unit amenities, which is a prediction of the large literature on price controls.

D.2.2 Impact on Empirical Specifications

Despite not being akin to a true price control, rent stabilization can manifest as a bias in our empirical estimates. Our main reduced form specifications consider within-building changes in rents over time. To the extent to which some units are both regulated and regulations bind on those units over the long time period we study, we expect stabilized units to show lower price responses. We expect this to bias our estimates downward.

To deal with this, an important robustness check we perform is to exclude buildings with many rent-stabilized units from the analysis. These robustness checks can be found in Appendix G. Overall, we don't find results consistent with the hypothesis that regulations

Figure A.4: Distribution of Rent Stabilization



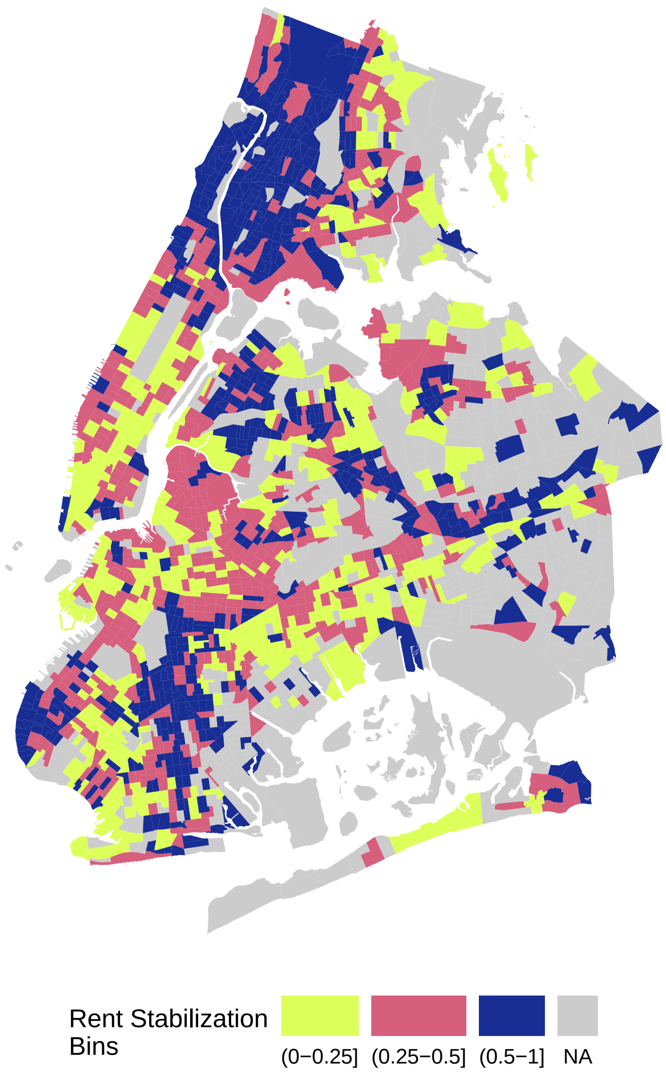
Note: The figure plots the percent of buildings that have more than 50% of units rent stabilized over 2010 to 2019 by building age groups. Buildings built after 1974 are not *de facto* rent stabilized. Buildings that take advantage of tax benefits for new construction, renovation, or conversion are rent stabilized for a fixed amount of time.

reduce elasticities. However, we refrain from interpreting these results in part because the sample of regulated units can be different on a number of dimensions.

In particular, regulated units may be different on unobservable dimensions. One possibility is that regulation itself effects landlord willingness to provide amenities. This could also impact our demand estimation, as a source of unobserved building amenity value. These and other building unobservables in part explain the negative effect of instruments on our estimation.

Rent stabilization can enter into our demand estimation in a number of other ways as well. Most perniciously, to the extent they are *not* compensated for with changes to unobserved amenities, binding rent stabilization in conjunction with quantity constraints could bias our coefficients upwards. Because we include rent stabilization as a control, this bias is attenuated to the extent that it acts as a percentage shift in rents. Separately, we perform a robustness exercise excluding buildings with large numbers of rent stabilized

Figure A.5: Distribution of Rent Stabilization



Note: The figure maps the percent of buildings that have more than 50% of units rent stabilized, pooling across years, at the tract level.

units from our estimation. These results can also be found in Section G. Here again the results are largely inconsistent with the hypothesis that rent stabilization upwardly biases estimates of price elasticities.

Overall, despite the possibility that rent stabilization biases our estimates, we don't find evidence that removing highly regulated buildings from our analysis moves estimates in the predicted direction. One possible explanation for this is that our sample of regulated buildings may be dominated by buildings for which regulations are nonbinding. As noted above, stabilization became substantially more dynamically binding the year after the last year of data in our sample.

One drawback of our data is that we are unable to determine whether price-regulated units are actually constrained by regulation. In conversations with former Department of Housing Preservation and Development officials, we have been informed preferential rent is uncommon in the densest parts of the Manhattan but pervasive in outer boroughs and northern NTAs of Manhattan. To the extent that preferential rents are more common, we expect rent stabilization to not bind and therefore not impact our estimates. To the extent that rent stabilization does not bind, its impact on our empirical results would be attenuated, potentially explaining the results we find.

E HHI and Ownership Matching

Here we describe how we match buildings to owner groups. This procedure is necessary because a large portion of reported rental building owners are corporate entities.[71] Thus the reported ownership structure underestimates the degree of common ownership. The NYC Department of Housing Preservation and Development (HPD) requires that building owners register each building with multiple dwellings (or that is inhabited primarily by non-family members) and compiles this registration list to create the Multiple Dwelling Registry and Contacts (MDRC). Importantly, the MDRC assigns a unique ID to each building-owner pair and for each owner lists the names of the main 'shareholders' of the corporate owner. Building owners must re-register annually. Thus, we have a list of buildings with their corporate owner names and a list of shareholder names linked to corporate owners.

However, we face two data challenges in matching buildings to owners using the MDRC.[72] First, we only have MDRC lists for scattered years: 2012, 2014, 2015, 2017, 2018, 2020, and 2022. The MDRC lists are updated quarterly by the HPD; however, vintage files are not stored publicly. Thus, we have collected these files based on archived web-pages and, for 2012 and 2015, through the generosity of the NYU Furman Center. Second, the MDRC does not link buildings by common owners and is not built to do this; rather, the files are designed only to identify a single building's owner. Thus, there is no identifier that links owners across buildings other than their names. We deal with each in turn.

To create a building owner panel, we append the MDRC annual files together and 'back-fill' the ownership from MDRC information for missing years. That is, if we observe a building-owner pair for year 2020, then we assume the owner is the same from 2020, 2019, 2018, and so on, until we have another observation. When constructing the MDRC, we arrange the shareholder names based on frequency.[73]

We then merge this with our DOF/PLUTO building year panel of rental buildings. Table A5 reports the match rate for the main four boroughs by year used in the rent sample.

Finally, we use a text matching procedure to ensure that the reported building corporate

[71] We use the term 'corporate entity' loosely; some building owners are truly corporations while others are limited liability companies, sole proprietorships, partnerships, or cooperatives.

[72] Technically, the MDRC are two different files: the Multiple Dwelling List (MDL) and the Registration Contacts (RD) list. We merge the two together by a common building identifier.

[73] For example, if name A is associated with 5 buildings and name B with 4 buildings, then for any set of buildings with both names $\{A, B\}$ we designate name A as the primary name.

Table A5: Match Rate Across Boroughs

	BX	BK	MN	QN
2007	0.94	0.93	0.96	0.89
2008	0.94	0.92	0.96	0.89
2009	0.94	0.92	0.95	0.88
2010	0.94	0.92	0.96	0.89
2011	0.94	0.92	0.96	0.89
2012	0.94	0.92	0.96	0.88
2013	0.94	0.92	0.96	0.88
2014	0.94	0.92	0.96	0.88
2015	0.94	0.92	0.96	0.88
2016	0.94	0.92	0.96	0.88
2017	0.94	0.92	0.96	0.88
2018	0.94	0.92	0.96	0.88
2019	0.93	0.91	0.96	0.88

Note: 2007-2019 NYC residential buildings with 4+ units. Data from DOF, PLUTO, MDRC files. Match rate between from PLUTO-FAR and MDRC lists.

owner matches the MDRC corporate owner name. We find that, even though we match over 90% of our buildings to the MDRC, we only match the reported owners about 60% of the time. We can treat these buildings two different ways. First, we could ignore the difference in owners between the two datasets, which could exaggerate concentration. Second, we could treat these non-matches as unique owners, which could attenuate concentration. We pursue the latter in the interest of providing the most conservative results.

To find all buildings that have common shareholders, we again perform a text matching procedure across buildings within a Census tract-year pair. We perform this procedure for each tract-year pair in the four main boroughs of NYC.[74] Our procedure calculates multiple five scores: one for the amount of matching whole words ('tokens') and then four for sequences of characters ('n-grams').[75] We assign multiple threshold value rules to these scores to determine whether there is a match. For example, if two owners have over 70% of the same 4-grams in the same order, then we call this a match. For another

[74] As a robustness test, we also use the NYC geography Neighborhood Tabulation Areas (NTAs) that are collections of Census tracts within Public Use Micro Areas (PUMAs). We hesitate to expand beyond these areas as our matching procedure uses only first and last names; e.g., there could be many owners named Joe Smith across the city but the chance is lower within a local geography.

[75] We calculate 3-grams, 4-grams, 8-grams, and 10-grams.

example, if two owners have over 5% of 10-grams and at least four matching tokens, then this is a match. We tested simpler threshold rules (e.g., 'if over 50% of 3-grams match, then match'), but we were not satisfied when manually auditing the results. For any building that does not match to the MDRC, we use the reported ownername (usually a corporate entity) and require an exact string match within the tract-year.

F Instrument Construction

We use three sets of instruments for our various empirical results. Intuitively we can think of market rent having two parts:

$$\text{Rent} = \text{Marginal Cost} + \text{Markup}. \tag{86}$$

Our first set uses variation in competition from similar buildings to shift the markup, parameterized using 'BLP instruments' (Berry, Levinsohn, and Pakes, 1995). Our other two sets use variation in the landlord's cost to provide space. Each of these three approaches use different identifying variation, reinforcing their corroborating results.

F.1 BLP Instruments

We combine two approaches for this approach. First, we use the 'differentiation' based instruments advocated in Gandhi and Houde (2018); Conlon and Gortmaker (2020), with a spatial radius, as in Bayer, McMillan, and Rueben (2004); Bayer, Ferreira, and McMillan (2007). These instruments are meant to be *an* approximation to the optimal instruments in the sense of Amemiya (1977) and Chamberlain (1987).[76]

The 'true' optimal instruments are based on the partial derivative of the structural error term:

$$Z^{\text{opt}} = \text{Var}(\delta_j)^{-1} \cdot \text{E}\left[\frac{\partial \delta_j}{\partial \beta} \quad \frac{\partial \delta_j}{\partial \alpha} \middle| Z \right]. \tag{87}$$

This has exactly as many moments as parameters, so is exactly identified. To calculate this object, one must take a stand on the conditional distribution of the structural error, solve the Bertrand pricing problem, back out model-implied structural errors, and then calculate the derivatives. Because we do not accurately observe prices for mixed-use buildings, which is roughly half of the choice set, we cannot credibly solve the Bertrand pricing problem.[77]

Still faced with the issue of many possibly weak instruments, we follow the approach in Bayer, McMillan, and Rueben (2004); Bayer, Ferreira, and McMillan (2007); Davis et al. (2021) in reducing the dimension of instruments. Our approach is the natural application of these authors in the context of Berry (1994) (i.e., no random coefficients). We simply

[76]More formally, they are a finite-order basis-function approximation to the optimal instruments.

[77]In addition, with rent control and zoning constraints, we would need to solve a constrained Bertrand pricing problem, which is considerably more difficult.

regress log rent on the BLP IVs, attain the fitted value, exponentiate it (to go from log to level and ensure positive rent values), and then divide by the average borough income.

F.2 Cost Instruments

We have information on two sources of cost information: assessment procedures & property tax and historic costs.

F.2.1 Assessment Procedures

We use NYC DOF assessment guidelines to isolate the effect of both structural and year-to-year changes in assessment procedures on property tax rates; i.e., we create a simulated tax instrument holding landlord behavior constant. This synthetic tax instrument is constructed using the base characteristics of a building and the varying assessment procedures over the sample period. That is, we residualize using building and Census tract-year fixed effects (along with other time-varying controls). This uses variation in assessment procedures by the NYC Department of Finance specific to an individual building but purges the variation of the landlord's response to the tax changes or other demand factors.[78]

We first gather the relevant building variables for the assessment procedures: and indicator for 10 or fewer units, gross income (GI), and expenses per square foot. For these we use the earliest value of these variables from before 2010. Second, we gather the Effect Tax Rates (ETR) targeted by the NYC DOF. The third step uses the time-varying assessment function that maps income to the property tax-base that is different for small verses large buildings.

For large buildings, we use the building base values and the assessment function that maps gross income per square foot (GIPSF) to 'capitalization rates' (CAP):

$$\mathrm{CAP}_{j,0,t} = \beta_t^0 + \mathrm{GIPSF}_{j0}^{\beta_t^1} + \beta_t^2 \cdot \ln[\mathrm{GIPSF}_{j0}]. \tag{88}$$

The time-varying parameters $\{\beta_t^0, \beta_t^1, \beta_t^2\}_{t \in T}$ can be found in annual "Additional Statistical Distributions and Capitalization Rate Methodology" reports on the NYC DOF website.[79] This gives us a counterfactual $\hat{\mathrm{CAP}}_t$ for each year if the building had the same characteristics. We then use the base net-income (NI), base building area, $\widehat{\mathrm{CAP}}_{jt}$, and the ETR_t to

[78]See replication files for specific tax function parameters that we use to calculate our instrument.

[79]For the years, 2011-2013, we have to back-out these parameters using non-linear least squares using observed CAP and GIPSF. Using our formula, we obtain capitalization rates which predict the observed rates with an R-squared of 0.8 or higher in each year.

calculate the (log) counterfactual property tax:

$$\ln\left[\widehat{\mathsf{Tax}}_{jt}^{\text{Large}}\right] = \ln\left[(\text{NI}_{j0}/(\widehat{\text{CAP}}_{jt} + \text{ETR}_t)) \cdot \text{ETR}_t)\right]. \tag{89}$$

For small buildings, gross income is mapped to property taxes using a Gross Income Multiplier (GIM). The GIM is assigned to buildings based on the economic characteristics of an area; e.g., two small buildings in the same block would have the same GIM.[80] Thus, we calculate the small building (log) counterfactual property tax:

$$\ln\left[\widehat{\mathsf{Tax}}_{jt}^{\text{Small}}\right] = \ln\left[\text{GI}_{j0} \cdot \text{GIM}_{g(j),t} \cdot \text{ETR}_t\right], \tag{90}$$

where $g(j)$ is the Census tract of a given building. Note that are results are robust to excluding these buildings.

F.2.2 Historic Borrowing Costs

Finally, we use historic building and leasing costs in buildings' year of construction that may have impacted buildings' long-run size. We use cost indices for unskilled wages and materials costs as well as the tax rate on rental buildings in NYC from Barr (2016). We extend these cost indices using US Bureau of Labor Statistics price indices as well as information on effective tax rates for Class 2 structures for recent years posted on the NYC DOF website. These three variables are the instruments.

The intuition for these instruments is that in the year of construction, these costs are both the prevailing construction costs faced by developers and the real estate tax rate influences landlords' predicted long-run predicted leasing costs. Higher values of either act as a cost shift at the time of buildings' construction and will influence quantities.

An obvious concern is that these costs would be negatively correlated with unobservable amenities: developers faced with higher costs may reduce investments, and the lower quantity investment appears as lower amenity values. If this were true, the coefficient on the structural parameter α would be negatively biased. While we believe this pathway is credible, the source and predicted direction of bias is distinct from that of the BLP instruments, and that gives us added confidence that our BLP estimates are correct.

[80] Because some buildings that we observe in administrative files were not able to be scraped and GIMs are assigned based on geography, we use the Census tract-year average of observed GIM to fill in the missing values.

G Additional Estimation Results

G.1 Additional Pass Through Estimation Results

Here we present additional empirical results from Section 5.1. First, we present a 'balancing test' of our Tax instrument, and then we discuss robustness of our main results.

G.1.1 Balancing Test

In order to interpret our positive pass-through results as indicative of a downward sloping residual demand curve, we want to make sure we are tracing out the curvature of demand using cost shifters, rather than picking up demand shifts. To do so, we need to exclude the possibility that our instrument is positively correlated with shifts in a building's residual demand curve. In the two-stage least squares framework, this is an exclusion restriction.

Such residual demand curve shifts could be a product of market-level changes in demand. For example, in both our model in Section 2 and the competitive benchmark in Appendix A.7, building j's demand is a function of not only its own rent but also the rents of competitor buildings j:

$$r_j = R_j(r_k, q_j). \tag{91}$$

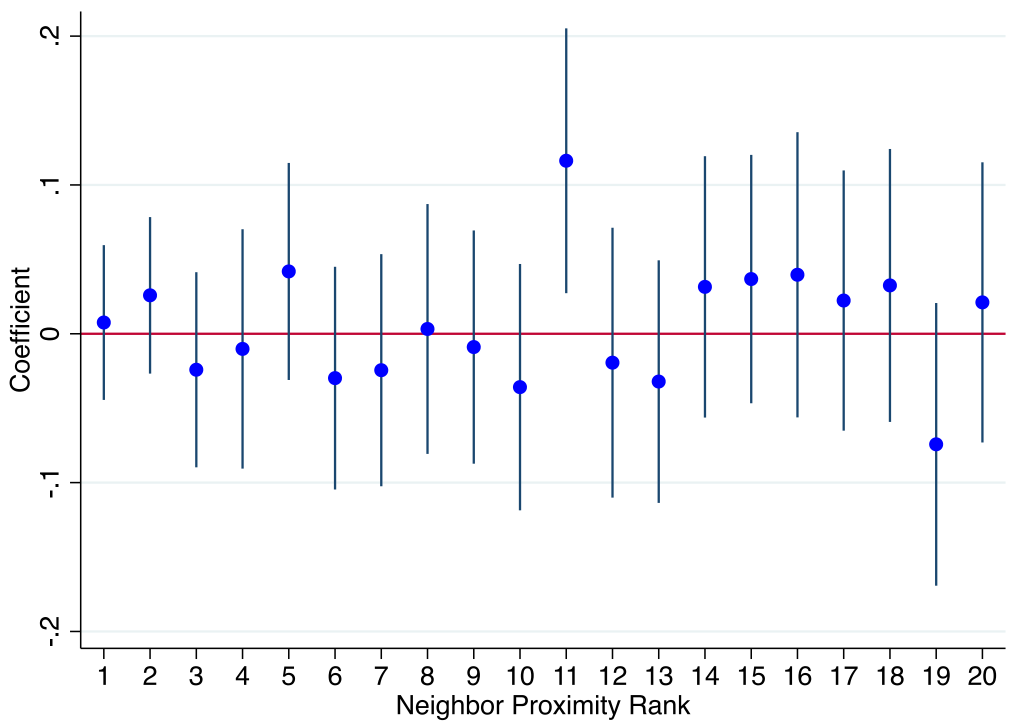
A positive shift in a building's competitors' rents would positively shift the building's own residual demand curve. If our instrument z_j is correlated with those others' rent shifts, then we will observe a positive result even if residual demand curves were flat.

To the extent possible, we wish to test whether our instrument is positively correlated with market-level demand shifters, thereby violating our exclusion restriction. We assess this channel by regressing our instrument on realized market-level rent shifts—i.e. rent changes at each buildings' competitors—conditioning on the controls we use. However, we do not know the appropriate demarcation of the market (and thus, for each building, the relevant set of competitor buildings). In what follows, we attempt to exclude the possibility of positive correlation between our instrument and market-level rent shifts using various definitions of a building's market.

One natural way to define a buildings' relevant market is geographically. Markets are likely to be geographically defined if, for instance, renters search for units in restricted geographic areas as opposed to in the city at large. If the instrument is correlated with rents of geographically close competitors, we would be concerned that the exclusion restriction is violated. This is the motivation behind including tract-year fixed effects in our main specification. If the appropriate geographic definition of a building's market is at or above (larger than) the level of tract, these tract-year fixed effects absorb all changes in price due to market-level shifts. However, if buildings' relevant competitors are at (and therefore shifts to their demand come from rent shifts at) finer geographies, our fixed effects would be insufficient to capture all market-level price shifts, and our exclusion restriction could be violated if those unaccounted for sub-tract price shifts are positively correlated with our instrument.

To test for this possibility, we correlate buildings' instrument values with rents of the buildings' n-th nearest neighbor, including the tract-year fixed effects and all other controls in our specification. Figure A.6 reports the correlation coefficients for the first 20 neighbors. Reassuringly, we find no correlation between our instrument and neighbor's prices, using the controls in our specification. This is robust to a multitude of alternative specifications, including grouping all the top 10 or top 20 neighbors, and drawing various sized (50+ meter) circles around buildings and including all the neighbors therein.

Figure A.6: Correlation Between Instrument and the n-th Nearest Neighbor's Rent



An outstanding concern is that there could be other relevant market definitions for buildings that are not geographic in nature. For example, renters' searches—and therefore markets—could be split by building size, luxury status (observable as rent or rent per square foot), unit size, or building age. If that were true, market-wide shifts in prices along those dimensions could be correlated with our instrument, leading to an exclusion restriction violation.

To address this, we divide buildings in the first year of our sample in to percentiles based on these building observable characteristics and similarly regress mean price of each percentile group against our instrument. While we don't include these results, similar to our geographic results, using those market definitions we can exclude the possibility that prices movements at the market level under those alternative definitions of markets are positively correlated with our instrument, conditional on our specification controls.

Ultimately, of course, we cannot eliminate the possibility that our instrument is contaminated with market-level price shifts in markets that are defined by other, unobservable characteristics. Still, we conclude that there is no evidence to suggest our exclusion restriction is violated.

G.1.2 Robustness Results

Next, we probe robustness to our results in Table 2 using two alternative samples. We use a sample of buildings with less than 50% of units rent stabilized. Then, we use a sample of buildings with more than 10 residential units, which face a different tax regime thank buildings with 10 or more units. Table A6 report our results for both subsamples, which largely similar to our main specification with one exception: for unconstrained buildings, 'reduced-form' pass through is positive but insignificant, while instrumented pass through rates are positive but less than unity. We hesitate to over-interpret this particular empirical result, which are likely driven by sample selection.

G.2 Additional HHI Estimation Results

In this section, we probe robustness to our results in Section 5.2 in two ways. First, we use the unconstrained and the large building subsamples, as above. Second, we use the aggregate HHI for the tract-year, $\mathsf{HHI}_{g,t}$, rather than the landlord-level leave-out HHI measure, $\mathsf{HHI}_{f(j),g,t}$.

Results are largely similar to our main specification, although the point estimates are slightly attenuated. There is a notable drop in sample size for Table A7 Panel A when using building fixed effects; however, the point estimate remains the same as in Panel B

Table A6: Additional Pass Through Estimation Results
Subsamples

Dependent Variable: Log Rental Income				
	Reduced Form		2SLS	
Sample	Unconstrained (1)	Large (2)	Unconstrained (3)	Large (4)
Log Cf Tax	0.01	0.03		
	(0.01)	(0.00)		
Log Total Cost			0.87	1.24
			(0.14)	(0.11)
Robust F Stat			21.67	52.96
Robust AR Stat			21.89	104.61
One-Side Test			0.84	0.01
Time-varying controls	N	Y	N	Y
Tract-year FEs	Y	Y	Y	Y
Building FEs	Y	Y	Y	Y
Observations	76,345	112,954	33,497	112,914

Note: The table displays robustness results for Table 2 using two subsamples. Columns (1) and (3) use buildings with less than 50% of units that are rent stabilized; columns (2) and (4) use buildings with more than 10 units. We estimate the (1,2) the reduced form regressions of the Tax IV on log rental income and (3,4) a 2SLS regression where we instrument log total building costs using the Tax IV. All models include Census tract-year fixed effects, along with controls for log distance to nearest subway station, log age, log years since renovation, log average unit square-feet, and an indicator for having an elevator. Standard errors are clustered by Census tract and the first stage F statistics and the Anderson-Rubin F statistic for the estimated coefficients are cluster robust as well.

for the same specification and for the same specification in Table A8.

Table A7: Additional HHI Estimation Results
Subsamples

Dependent Variable: Log Average Monthly Rent						
	Panel A: Unconstrained Sample					
	(1)	(2)	(3)	(4)	(5)	(6)
Log Leave-Out Tract HHI	-0.02	0.05	0.04	-0.02	0.06	0.04
	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
Log Owner Share in Tract				-0.01	0.01	0.02
				(0.00)	(0.00)	(0.01)
Time-varying controls	Y	Y	Y	Y	Y	Y
Borough FEs	Y	N	N	Y	N	N
Tract FEs	N	Y	N	N	Y	N
Building FEs	N	N	Y	N	N	Y
Observations	27,612	27,464	10,772	27,612	27,464	10,772
	Panel B: Large Sample					
	(1)	(2)	(3)	(4)	(5)	(6)
Log Leave-Out Tract HHI	-0.03	0.02	0.04	-0.01	0.02	0.04
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Log Owner Share in Tract				-0.04	-0.00	0.01
				(0.01)	(0.00)	(0.01)
Time-varying controls	Y	Y	Y	Y	Y	Y
Borough FEs	Y	N	N	Y	N	N
Tract FEs	N	Y	N	N	Y	N
Building FEs	N	N	Y	N	N	Y
Observations	35,218	35,168	31,210	35,218	35,168	31,210

Note: The table displays robustness results for Table 3 using two subsamples. Panel A uses buildings with less than 50% of units that are rent stabilized; Panel B uses buildings with more than 10 units. Columns (1-6) use the log of the landlord specific leave-out Census tract-year HHI; columns (4-6) include the log of the landlord's share in the tract-year. Specifications vary by location fixed effects: borough, Census tract, or building level. All models include year fixed effects, along with time varying controls for log age, log years since renovation, log average unit square-feet, and an indicator for having an elevator. Standard errors are clustered by Census tract.

G.3 Additional Demand Estimation Results

Table A9 presents direct estimates of "reduced-form, across-building" OPEs. We find that the instruments from 6 lead to OPEs between $[-6.3, -2.7]$. We note two things about these

Table A8: Additional HHI Estimation Results
Aggregate HHI

Dependent Variable: Log Average Monthly Rent						
	(1)	(2)	(3)	(4)	(5)	(6)
Log Tract HHI	-0.02	0.06	0.04	-0.00	0.06	0.04
	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
Log Owner Share in Tract				-0.03	-0.01	0.01
				(0.00)	(0.00)	(0.01)
Time-varying controls	Y	Y	Y	Y	Y	Y
Borough FEs	Y	N	N	Y	N	N
Tract FEs	N	Y	N	N	Y	N
Building FEs	N	N	Y	N	N	Y
Observations	63,232	63,146	41,922	63,232	63,146	41,922

Note: The table displays robustness results for Table 3 using the aggregate Census tract-year HHI measure, $\mathsf{HHI}_{g,t}$, rather than the landlord specific leave-out HHI, $\mathsf{HHI}_{f(j),g,t}$. The sample is the residential building sample as in Table 3. Columns (1-6) use the log of the aggregate Census tract-year HHI; columns (4-6) include the log of the landlord's share in the tract-year. Specifications vary by location fixed effects: borough, Census tract, or building level. All models include year fixed effects, along with time varying controls for log age, log years since renovation, log average unit square-feet, and an indicator for having an elevator. Standard errors are clustered by Census tract.

estimates. First, they are similar in magnitude from our main estimates, which we find reassuring.

Second, unlike the model based estimates, these pool across buildings for the OPE estimate. Our theoretical discussion makes clear that this elasticity *cannot* be used to measure monopoly power in the city and many buildings are likely price or quantity constrained. However, the estimates do provide evidence that building level OPEs are negative and elastic in the city. This highlights the conceptual difference between our work and those of prior housing demand studies (Gyourko and Voith, 2000; Albouy, Ehrlich, and Liu, 2016).

Table A10 presents robustness results for our demand model estimation in Table 4. In this sample, we exclude buildings with any rent stabilized units as well as buildings with ten or fewer units. Thus, this estimates the model using large rental buildings where the owner has maximal control over the pricing of units. We find similar results that are noisier than our main results due to the substantial loss of the sample size: from over 350 thousand in Table 4 to 22 thousand below. Nevertheless, we take this as reassuring that our results are not driven by any major rent regulation.

Table A9: Additional Demand Estimation Results

	OLS (1)	IV: BLP (2)	IV: TAX (3)	IV: Historic (4)
ε	0.27	-4.41	-6.25	-2.73
	(0.03)	(1.17)	(0.47)	(0.56)
Robust F Stat	-	25.34	243.98	23.46
Robust AR Stat for Rent	-	56.81	1,468.04	101.59
Observations	354,435	354,435	183,210	336,139

Note: The table displays parameter estimates from log-log demand models. We estimate the (1) OLS regression and three 2SLS regressions using (2) BLP IVs, (3) the counterfactual tax IV, and (4) historic building costs. All models include Census tract-year fixed effects, along with controls for log distance to nearest subway station, log age, log years since renovation, log average unit square-feet, and an indicator for having an elevator. Standard errors are clustered by Census tract and the first stage F statistics and the Anderson-Rubin F statistic for the estimated coefficients are cluster robust as well.

Table A10: Additional Demand Estimation Results

	OLS (1)	IV: BLP (2)	IV: TAX (3)	IV: Historic (4)
	No Rent Stabilized Sample			
α	-1.04	-11.27	-4.59	-14.52
	(0.20)	(4.06)	(1.05)	(4.64)
Robust F Stat	-	8.54	91.58	5.87
Robust AR Stat for Rent	-	11.42	23.39	65.62
Observations	22,403	22,403	19,312	21,586
$\mathsf{Med}(\varepsilon_{jbt})$	-0.18	-1.97	-0.80	-2.54
$\mathsf{Med}(\varepsilon_{jbt} \mid \text{Unconst., New})$	-0.25	-2.72	-1.11	-3.51
Pct Elastic	0.00%	99%	62%	100%
$\mathsf{Med}(\mathsf{L}_{jbt} \mid \text{Unconst., New})$	0.94	0.37	0.77	0.28

Note: The table displays parameter estimates from logit demand models using only the subsample of buildings that have more than 10 units and do not have any rent stabilized units. We estimate the (1) OLS regression and three 2SLS regressions using (2) BLP IVs, (3) the counterfactual tax IV, and (4) historic building costs. All models include Census tract-year fixed effects, along with controls for log distance to nearest subway station, log age, log years since renovation, log average unit square-feet, and an indicator for having an elevator. Standard errors are clustered by Census tract and the first stage F statistics and the Anderson-Rubin F statistic for the estimated coefficients are cluster robust as well.