Local Causes and Aggregate Implications of Land Use Regulation*

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Abstract

I study why some cities have strict land use regulation, how regulation affects the U.S. economy, and how policymakers can mitigate its negative consequences. I develop a quantitative spatial equilibrium model where local regulation is determined endogenously, by voting. Landowners in productive cities with attractive amenities vote for strict regulation. The model accounts for 40% of the observed differences in regulation across cities. Quantitative experiments show that excessive local regulation reduces aggregate productivity, but not necessarily welfare because, unlike renters, landowners benefit from regulation. I propose federal policies that raise productivity and welfare by weakening incentives to regulate land use.

Key Words: land use regulation, spatial equilibrium, productivity, housing
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1 Introduction

Land use is highly regulated in large productive metropolitan areas in the United States, such as New York, San Francisco, and Los Angeles. This is important because land use constraints such as zoning laws, project approval procedures, and public opposition to new construction all add significantly to housing costs. As a result, many people may have to live and work not where they are most productive but where they can afford housing. The restrictions on housing supply in the most productive U.S. metro areas have attracted a lot of attention from the media, policymakers, and academics in recent years, and have been blamed for the housing affordability crisis and for slowing down economic growth.

This paper studies the causes and consequences of land use regulation in the U.S. and makes three contributions. First, it builds a spatial equilibrium model in which regulation in every location is determined endogenously by voting, and shows that the model accounts for about 40% of the observed variation in land use regulation across metro areas. Second, it quantitatively evaluates how regulation affects aggregate productivity and welfare, city size distribution, as well as wage and house price dispersion across cities, extending the predictions of previous studies. Third, it proposes and studies federal policies that reduce incentives of local governments to regulate, and shows that these policies could raise aggregate productivity and welfare.

The theoretical model features owners and renters of housing, living in one of the many cities. The number of owners in each city is fixed. In contrast, renters choose where to live, and their choice depends on wages, housing costs, local amenities, and idiosyncratic location preferences. Rents depend on housing demand and supply, whereas the supply depends on the abundance of land as well as land use regulation. All land in each city is owned by local homeowners. Regulation affects housing supply and rents in two ways. First, it reduces the productivity of developers. Second, it increases the share of land in the production function for housing.

I endogenize land use regulation by using a model of voting with lobbying. Before renters choose a location, incumbent owners vote in local elections, where candidates each run with a proposed level of regulation. Owners have three main considerations when choosing regulation: urban congestion, productive agglomeration externalities, and land rents. In equilibrium, stricter regulation increases rents and land prices, and reduces local employment. Incumbents benefit from lower congestion, but they also lose from lower wages, since the productive externalities depend on city size. At the same time, because homeowners own all land in the city, they benefit from higher land prices. To induce a candidate to promise to implement a high level of regulation, owners must engage in costly lobbying. In equilibrium, owners in cities with high productivity and attractive amenities prefer stricter regulation and, therefore, are willing to pay a high lobbying cost.

Next, I build a quantitative version of the model that comprises 201 metropolitan areas. Its parameters are disciplined by a set of moments that describe local labor and housing markets in the U.S. in 2005–2007, as well as local land use regulation measured using the Wharton Residential Land Use Regulatory Index (Gyourko, Saiz, and Summers, 2008). I show that the model accounts for about 40% of the observed differences in the Wharton Index. In addition, it successfully replicates empirical relationships between regulation and several variables of interest, such as wages, rents, and land prices.

Then I perform several counterfactual experiments and show that lowering regulation makes the economy more productive. Particularly large positive effects arise from deregulating the "superstar" cities, which are large metro areas with high wages and rents, as well as strict land use regulation. I also demonstrate that distinguishing between owners and renters is crucial for understanding the welfare effects of regulation. I find much smaller welfare gains than previous studies, most of which only feature renters. This is because, when land use regulation is relaxed, renters benefit from lower rents but owners are worse off as land loses value.

One reason why existing regulation has a negative effect on aggregate productivity and welfare is that local governments choose regulation independently from each other and thus disregard the implications of their decisions on the rest of the economy. As a result, by making the most productive cities highly regulated, local political decisions lead to misallocation of labor across cities. An important benefit of having a plausible model of endogenous land use regulation is that it allows studying national-level policies that discourage local incentives to regulate land use, instead of relying on counterfactual experiments that reduce regulation to an ad-hoc lower level.

I study two such policies: federal infrastructure subsidies conditional on the level of regulation and a land value tax. Under the first policy, "superstar" cities choose to vote for lower regulation in order to obtain federal funds. Under the second policy, owners in "superstar" cities are less interested in high levels of regulation since their land rents are taxed. In both cases, "superstar" cities become more affordable and more workers relocate there. These policies produce significant productivity gains and, unlike the ad-hoc experiments where regulation is arbitrarily relaxed, also lead to sizable welfare gains. However, by reallocating labor into more productive metropolitan areas they also lead to a rise in wage inequality across locations.

This paper joins recent literature on local and aggregate effects of land use regulation; see Gyourko and Molloy (2015) for an excellent review of the literature. Like Herkenhoff, Ohanian, and Prescott (2018) and Hsieh and Moretti (2019), it also studies aggregate implications of reducing regulation. However, in those papers regulation is exogenous. The model of endogenous regulation in this paper allows studying *why* some cities are more regulated and evaluating policy interventions that reduce *incentives* of cities to regulate, as compared to only studying counterfactual experiments in which regulation is reduced to an arbitrarily lower level. Hsieh and Moretti (2019) find that lowering regulation in New York, San Francisco, and San Jose would raise output by 3.7%–8.9%. Herkenhoff, Ohanian, and Prescott (2018) find that reducing regulation everywhere to half the level of Texas would raise U.S. productivity by as much as 12.4–19.5%. In comparison, I find that lowering regulation in a set of ten large and productive "superstar" cities would increase productivity by 3.6%. I also replicate the counterfactual experiments in these two studies using my model and find smaller productivity gains and no welfare gains. These differences arise because my model features local congestion externalities and individual location preferences, but most importantly because it distinguishes between renters and owners.

Two other closely related papers are Bunten (2017) and Duranton and Puga (2022). Bunten (2017) proposes a model of endogenous regulation in which current residents limit housing supply as a defense against congestion inflicted by newcomers. As a result, attractive cities undersupply housing, relative to the social optimum. A quantitative exercise shows that implementation of the optimum yields a 2.1% higher output. In Duranton and Puga (2022) local housing supply depends on permitting costs which are decided by incumbent residents and are increasing in local population and natural geographic constraints. In a counterfactual experiment which exogenously lowers permitting costs in seven large cities, aggregate output goes up by nearly 8%.

In the above-mentioned studies, deregulation of land use leads to welfare gains because local decisions on land use policies in highly productive cities do not internalize their negative effects on the aggregate economy. This echoes the findings of Albouy, Behrens, Robert-Nicoud, and Seegert (2019), among others, where they show how the decentralization of city size restrictions creates externalities that distort the allocation of population across sites with different fundamentals. Other studies that highlight negative local or aggregate effects of local land use regulations or population constraints include Turner, Haughwout, and van der Klaauw (2014); Ganong and Shoag (2017); Howard and Liebersohn (2021); Anagol, Ferreira, and Rexer (2021); Song (2021); Acosta (2022); and Yu (2022).

The political economy model of this paper builds upon an extensive, largely theoretical, literature on the political economy of regulation and optimal zoning. The three most closely related papers are Brueckner (1995), which develops a model in which landowners choose urban growth controls in order to maximize land rents, Hilber and Robert-Nicoud (2013), which studies a lobbying game where landowners compete with developers on the level of regulation, and Ortalo-Magné and Prat (2014), which models political competition between renters and owners in a median-voter framework. Other work on the political economy of regulation includes Brueckner and Lai (1996), Helsley and Strange (1995), Rossi-Hansberg (2004), Calabrese, Epple, and Romano (2007), Solé-Ollé and Viladecans-Marsal (2012), and Ouasbaa, Solé-Ollé, and Viladecans-Marsal (2023).

In addition, this paper joins the literature on the recent rise in house price dispersion across locations and argues that differences in land use regulation contribute to the dispersion (Glaeser, Gyourko, and Saks, 2005b; Van Nieuwerburgh and Weill, 2010; Gyourko, Mayer, and Sinai, 2013; Desmet and Rossi-Hansberg, 2014; Albouy and Ehrlich, 2018; Cun and Pesaran, 2018; Yao, 2021; Howard and Liebersohn, 2022). It also contributes to a large body of work on the causes of the escalation in income inequality in recent decades, and shows how regulation affects wage inequality across cities (Moretti, 2013; Baum-Snow and Pavan, 2013; Diamond, 2016; Giannone, 2022). More broadly, this paper relates to the literature which studies how various local and national policies result in spatial misallocation across and within cities (Albouy, 2009; Eeckhout and Guner, 2017; Fajgelbaum, Morales, Suárez Serrato, and Zidar, 2019; Furth, 2019; Fajgelbaum and Gaubert, 2020; Parkhomenko, 2022).

The rest of the paper is organized as follows. Section 2 describes the theoretical framework. Section 3 discusses the data, estimation and calibration of model parameters, and the quantitative model. Section 4 studies counterfactual and policy experiments. Section 5 concludes.

2 Environment

This section introduces a Rosen-Roback spatial equilibrium model (Rosen, 1979; Roback, 1982) in which land use regulation is an endogenous outcome of a political economy mechanism. I first present the model without political economy, and then explain how regulation is determined.

2.1 Individuals and Cities

The economy is populated by workers who live for one period. It consists of J cities, which are indexed by j and belong to $\mathcal{J} \equiv \{1, ..., J\}$. Each individual lives and works in one of the cities. Local employment is equal to N_j and the aggregate labor supply is $N = \sum_{j \in \mathcal{J}} N_j$.

Preferences. Workers consume a numeraire consumption good (c) and housing (h). In addition, they derive utility from local amenities and disamenities (X) that are a non-rival public good. The utility function is logarithmic and depends on a Cobb–Douglas composite of the numeraire and housing,

$$u(c, h, X) = \ln\left(c^{1-\gamma} h^{\gamma}\right) + \ln X, \tag{1}$$

where $\gamma > 0$ measures the importance of housing in utility.

Owners and renters. In each city, there are incumbent workers who were born in the city, as well as newcomers who were born elsewhere. The number of incumbents is $\bar{N}_j$ and the number of newcomers is $\tilde{N}_j$, with $\bar{N}_j + \tilde{N}_j = N_j$. The share of newcomers is denoted by $\hat{n}_j \equiv \tilde{N}_j / N_j$. I assume that incumbents own their houses, while newcomers rent. There is no tenure choice: incumbents were born homeowners and houses occupied by newcomers are owned by developers and cannot be sold to tenants.

The number of owners in location j is exogenous, the assumption that I will relax in the counterfactual analysis in Section 4, whereas the number of renters is endogenous and determined by optimal location choices. Owners do not incur the cost of housing services. While in practice costs such as maintenance, mortgage interest expenses, or property taxes are large, in Appendix Section A.1 I show that including such costs would not change any theoretical results because they would not affect the incentives of incumbents to vote for land use regulation. Owners in city j consume an exogenous amount of housing, $\bar{h}_j$, assumed to be large enough so that owners would never prefer to switch to renting. They also own all land in the city.

The static nature of this model means that many determinants why households buy houses (wealth accumulation, insurance against risk, etc.) are absent and therefore I abstain from modeling tenure choice. One way to interpret the setting of the model is that owners made location and tenure choices, as well as chose the size of the house in the previous period, while in the current period high moving and transaction costs prevent owners from changing their location and tenure status or moving to a different house.[1]

[1]While it would be possible to endogenize location and tenure choices even in a static model (Parkhomenko, 2022), their interaction with political economy that determines land use regulation would make the model intractable.

Optimal choices. Since there are no homeownership costs, owners spend all their disposable income on the consumption of the numeraire. Renters must solve for the optimal amounts of the numeraire and housing. Besides earning labor income, owners also earn land rents in the form of the lump-sum transfer T_j. The owners' budget constraint is $c_j \leq w_j + T_j$, while the renters' budget constraint is $c_j + r_j h_j \leq w_j$, where r_j is equilibrium rent in city j. Therefore, the indirect utility of owners is given by

$$\bar{v}\left(w_j + T_j, \bar{h}_j, X_j\right) = (1-\gamma)\ln\left(w_j + T_j\right) + \gamma \ln \bar{h}_j + \ln X_j, \tag{2}$$

and the indirect utility of renters is

$$\tilde{v}\left(w_j, r_j, X_j\right) = \ln\left(\gamma^{\gamma}(1-\gamma)^{1-\gamma}\right) + \ln w_j - \gamma \ln r_j + \ln X_j. \tag{3}$$

At the beginning of the period, before choosing location, every renter i experiences a preference shock ε_{ij} for each city j in the economy. Then she chooses to reside in location j^*, which provides the best combination of local wages, rents, amenities, and the preference shock:

$$j^* = \underset{j \in \mathcal{J}}{\operatorname{argmax}} \left\{\tilde{v}\left(w_j, r_j, X_j\right) + \sigma \varepsilon_{ij}\right\}. \tag{4}$$

The preference shocks follow the Extreme Value Type I distribution (McFadden, 1973). Parameter $\sigma > 0$ determines the importance of individual preferences relative to common features of a location, i.e., wages, rents, and amenities. Higher σ implies lower elasticity of local labor supply with respect to the fundamentals. The probability that a renter chooses to reside in location j is

$$\tilde{\pi}_j = \frac{\exp\left(\tilde{v}\left(w_j, r_j, X_j\right)\right)^{1/\sigma}}{\sum_{j' \in \mathcal{J}} \exp\left(\tilde{v}\left(w_{j'}, r_{j'}, X_{j'}\right)\right)^{1/\sigma}} = \frac{\left(w_j r_j^{-\gamma} X_j\right)^{1/\sigma}}{\sum_{j' \in \mathcal{J}} \left(w_{j'} r_{j'}^{-\gamma} X_{j'}\right)^{1/\sigma}}, \tag{5}$$

and the equilibrium supply of renters in location j is given by

$$\tilde{N}_j = \tilde{\pi}_j \tilde{N}, \tag{6}$$

where $\tilde{N}$ is the exogenous number of all renters in the economy. Since the number of owners in each city is fixed, equation (6) also characterizes the equilibrium city size, N_j. Since owners are immobile and renters' preference shocks are drawn from a distribution with unbounded support, all locations have positive numbers of both renters and owners.

2.2 Amenities

A worker in city j has access to the amenity level X_j, defined as

$$X_j = \alpha_j m_j(N_j), \tag{7}$$

where α_j is an exogenous component of amenities and

$$m_j(N_j) = \xi_j N_j^{-\theta} \tag{8}$$

represents the amount of leisure time that a worker can spend on amenities α_j. When $\theta > 0$, leisure time is decreasing in city size, possibly due to longer commutes.[2] Parameter ξ_j measures city-specific factors, other than city size, that affect local leisure time, e.g., quality of transportation infrastructure and availability of public transit.

2.3 Local Labor Markets

In every city, there is a large number of perfectly competitive firms that use labor to produce the numeraire consumption good. The numeraire is traded across cities at zero cost. Each worker supplies one unit of labor inelastically. The production technology is

$$Y_j = A_j N_j, \tag{9}$$

where A_j is local labor productivity and N_j is local labor supply. Labor productivity is determined as

$$A_j = \bar{A}_j N_j^{\rho}. \tag{10}$$

Parameter $\bar{A}_j$ is the exogenous component of the productivity, while $\rho > 0$ represents agglomeration externalities that capture the returns to city size (Duranton and Puga, 2004; Combes and Gobillon, 2015). The equilibrium wage in city j is equal to the marginal product of labor and is given by

$$w_j = \bar{A}_j N_j^{\rho}. \tag{11}$$

2.4 Local Housing Markets

The housing stock owned by homeowners is exogenously given. Housing consumed by renters must be built. In each city, there are many perfectly competitive developers who

[2]This paper focuses on two important urban congestion forces, housing and commuting costs, though larger city size may result in other disamenitites, e.g., pollution, as well as amenities, e.g., cultural attractions.

use land (L) and non-land inputs (K) to build housing. This housing is rented out at price r_j and fully depreciates at the end of the period.[3] The construction technology is

$$H_j = e^{\chi_j} L_j^{\eta_j} K_j^{1-\eta_j}, \tag{12}$$

where e^{χ_j} is the productivity of developers and η_j is the share of land in construction.[4] The non-land inputs are produced using the numeraire at no cost, and hence their price is equal to one in all locations.

The total land supply in a city is exogenous and given by Λ_j. Land available for construction is $\tilde{\Lambda}_j < \Lambda_j$. The remaining land, $\Lambda_j - \tilde{\Lambda}_j$, is used by owner-occupied houses. Since the amount of owners and the size of their houses are exogenous, $\tilde{\Lambda}_j$ is exogenous too. Land is fully owned by incumbent homeowners who do not face any costs of releasing the land to developers. Therefore, they are willing to sell land to developers at any positive price which implies that in equilibrium no land remains unused, i.e., $L_j = \tilde{\Lambda}_j$.

Profit maximization on the part of developers, combined with optimal housing consumption on the part of renters, yields the following equilibrium land price

$$l_j = \frac{\gamma \eta_j w_j \tilde{N}_j}{\tilde{\Lambda}_j}, \tag{13}$$

and equilibrium rent

$$r_j = \frac{l_j^{\eta_j}}{e^{\chi_j} \eta_j^{\eta_j} (1-\eta_j)^{1-\eta_j}}. \tag{14}$$

The transfer from land ownership earned by incumbent owners is equal to the proceeds from land sales per owner,

$$T_j = \frac{l_j \tilde{\Lambda}_j}{\bar{N}_j}. \tag{15}$$

Finally, the equilibrium rental housing supply in city j is equal to

$$H_j = (e^{\chi_j})^{\frac{1}{\eta_j}} \left((1-\eta_j) r_j\right)^{\frac{1-\eta_j}{\eta_j}} \tilde{\Lambda}_j. \tag{16}$$

[3]Perfect competition and full depreciation of housing render irrelevant who owns the housing stock consumed by renters. Developers spend all their revenue on paying for land and the numeraire. Land payments go to local incumbent owners, and numeraire payments go to goods-producing firms and ultimately to workers.

[4]Perfect competition is a common assumption and most empirical studies, as summarized in Glaeser, Gyourko, and Saks (2005c), support it. Nonetheless, more recent evidence documented by Quintero (2022) suggests that market concentration in the homebuilding industry has increased since 2005. Combes, Duranton, and Gobillon (2021) provide empirical support for the Cobb–Douglas production function.

2.5 Land Use Regulation

Land use regulation is a set of policies that determine how restricted the use of land for residential development is in a given city. These policies are summarized by variable z_j and can represent regulations, such as zoning laws or building permit procedures, as well as other non-regulatory constraints, such as local residents' opposition to development, known as the "Not In My Back Yard" (NIMBY) movement.

The stringency of land use regulation z_j affects housing markets through two channels, both of which impact the housing production function.[5] First, it can lower χ_j, the productivity of developers. For example, land use regulation may result in lengthy and numerous project reviews, costly exactions, and impact payments, all of which reduce the efficiency of residential development. Second, it can increase η_j, the share of land in construction. For example, if zoning laws impose limits on building heights or specify maximum floor-to-area ratios, then a land parcel can contain only a limited amount of housing and developers face a relatively high land share. The effect of land use regulation on productivity is modeled as

$$\chi_j(z_j) = \bar{\chi}_j + \hat{\chi} z_j, \tag{17}$$

while the effect on the land share is given by

$$\eta(z_j) = \bar{\eta} + \hat{\eta} z_j. \tag{18}$$

Thus, the productivity of developers in city j, $\chi_j(z_j)$, depends on an exogenous city-specific component $\bar{\chi}_j$ and the level of regulation z_j. The land share, $\eta(z_j)$, depends on an exogenous common term, $\bar{\eta}$, and local regulation. In the remainder of this section, I assume that the elasticity of the construction productivity with respect to land use regulation is non-positive, that is, $\hat{\chi} \leq 0$, while the elasticity of the land share is non-negative, that is, $\hat{\eta} \geq 0$.[6] These assumptions are confirmed by empirical findings described in Section 3.

Definition 1 describes a spatial equilibrium in an economy where land use regulation is exogenously given.

Definition 1. A *spatial equilibrium with exogenous regulation* consists of local labor supply N_j, housing supply H_j, wages w_j, rents r_j, land prices l_j, transfers T_j, and amenities X_j, such that equations (6), (7), (11), (13), (14), (15), and (16) are satisfied.

How does land use regulation affect equilibrium employment, rents, and land prices?

[5] My approach for modeling the effect of land use regulation on the housing production function is based on Albouy and Ehrlich (2018).

[6] When $\bar{\eta} < 0$, as it is in the quantitative model described in Section 3 below, the land share $\eta(z_j)$ may be negative. However, z_j is always large enough such that this does not occur for any city.

It depends on how strong location preferences (σ) are relative to the benefits and costs of city size (ρ and θ), as well as housing and land costs (γ and η). In particular, if

$$\sigma > \Big((1 - \gamma\eta(z_j))\rho - \theta\Big)\,\hat{n}_j - \gamma\eta(z_j), \tag{19}$$

then, as Proposition 1 demonstrates, higher regulation lowers local employment. Furthermore, under a slightly stricter condition on the inverse variance of shocks,

$$\sigma > (\rho - \theta)\,\hat{n}_j - \frac{\gamma\eta(z_j)}{2}\Big(\rho\hat{n}_j + 1\Big), \tag{20}$$

more stringent regulation also increases rents. Intuitively, when location preferences are strong labor supply is relatively inelastic, and higher rents do not result in large out-migration.[7] Similarly, when the elasticity of the land share with respect to land use regulation is high relative to the elasticity of labor supply with the respect to regulation,

$$\frac{\eta'(z_j)}{\eta(z_j)} > -(1 + \rho\hat{n}_j)\frac{1}{\tilde{N}_j}\frac{d\tilde{N}_j}{dz_j}, \tag{21}$$

stricter regulation increases land prices.[8] Conditions (19), (20), and (21) indeed hold in all cities in the quantitative version of the model that is described below in Section 3.

Proposition 1. Let the condition (19) hold. Then:

(a) $d\tilde{N}_j/dz_j < 0$, i.e., local employment is decreasing in the level of land use regulation;

(b) $dr_j/dz_j > 0$, i.e., rents are increasing in the level of land use regulation, if, in addition, condition (20) holds;

(c) $dl_j/dz_j > 0$, i.e., land prices are increasing in the level of land use regulation, if, in addition, condition (21) holds.

Proof. See Appendix Section B.1 □

Corollary 1 below builds on the results from Proposition 1 and describes how regulation affects other equilibrium variables. It shows that, when two out of three conditions for Proposition 1 hold, regulation also lowers housing supply and wages, and increases amenities.

[7] Alternatively, when labor supply is highly elastic increasing regulation may lead to large outflows of renters and even reduce rents, as in Chatterjee and Eyigungor (2017).

[8] The results of Proposition 1 are consistent with an extensive literature that finds that stricter regulation causes higher land and house prices, as well as lower housing supply (Mayer and Somerville, 2000; Quigley and Rosenthal, 2005; Ihlanfeldt, 2007; Paciorek, 2013; Emrath, 2016; Severen and Plantinga, 2018; Song, 2021; Kulka, Sood, and Chiumenti, 2022).

Corollary 1. Let the conditions (19) and (20) hold. Then:

(a) $dH_j/dz_j < 0$, i.e., housing supply is decreasing in the level of land use regulation;

(b) $dw_j/dz_j < 0$, i.e., wages are decreasing in the level of land use regulation;

(c) $dX_j/dz_j > 0$, i.e., amenities are increasing in the level of land use regulation;

Proof. See Appendix Section B.2 □

2.6 Political Economy

Next, I augment the model by introducing a voting mechanism that determines the level of regulation in each city.

Before renters choose a location, incumbent owners in each city decide how strictly to regulate land use, that is, choose the level of z_j. Their collective decision is modeled as in a standard voting model with lobbying (Persson and Tabellini, 2002). Local elections are contended by any number of candidates greater than two. Each candidate i promises to set regulation at level z_{ji}. If elected, the candidate must commit to the promise. However, candidates are indifferent to the level of z and their only goal is to be elected. The level of regulation promised by a candidate can be affected by voters through lobbying. In particular, in order to ensure that the elected candidate runs with the promised level of z_{ji}, owners must incur a lobbying cost $\kappa(z_{ji})$, assumed to be increasing in z.[9] The lobbying cost may be interpreted as time and effort required to understand local land use regulation issues and to vote appropriately. In a unique political equilibrium, all candidates run with the same level z_j and this level ends up being implemented.

Note that the indirect utility of owners (equation 2) can also be written as a function of regulation, $\bar{v}_j(z_j)$, since regulation affects the equilibrium levels of w_j, T_j, and X_j. Owners prefer the level of regulation z_j, which maximizes $\bar{v}_j(z_j) - \kappa(z_j)$ and which, in equilibrium, is the political platform chosen by all candidates. As a result, the outcome of voting is

$$z_j^* = \underset{z \in \mathbb{R}^+}{\operatorname{argmax}} \left\{ \bar{v}_j(z) - \kappa(z) \right\}. \tag{22}$$

Note that the value of z_j^* coincides with a solution of a planner's problem where the planner maximizes the weighted utilitarian welfare of local owners subject to the lobbying cost. The equilibrium regulation chosen by voting can also be characterized by the first-order

[9] This approach is close in spirit to Glaeser, Gyourko, and Saks (2005a), where homeowners spend time to affect the decisions of the zoning authority, and to Hilber and Robert-Nicoud (2013), where regulation is a function of monetary contributions from landowners and developers to the planning board.

condition,

$$\frac{1-\gamma}{w_j + T_j}\left(\frac{dw_j}{dz_j} + \frac{dT_j}{dz_j}\right) + \frac{1}{X_j}\frac{dX_j}{dz_j} = \kappa'(z_j), \tag{23}$$

which states that, in equilibrium, the marginal private benefit of regulation to the owners must be equal to the marginal private cost.

Equation (23) highlights three main considerations that owners have when choosing regulation–productive agglomeration externalities, land rents, and urban amenities–all of which are affected by the level of z_j. Given that regulation lowers local employment (part (a) of Proposition 1), it leads to lower wages and greater amenities (parts (b) and (c) of Corollary 1).[10] Higher regulation also increases land rents (part (c) of Proposition 1). The choice of regulation depends on the relative magnitudes of these three effects.

Definition 2 generalizes the notion of equilibrium described in Section 2.5 by incorporating endogenously determined land use regulation.

Definition 2. A *spatial equilibrium with endogenous regulation* consists of local labor supply N_j, housing supply H_j, wages w_j, rents r_j, land prices l_j, transfers T_j, amenities X_j, and levels of regulation z_j, such that equations (6), (11), (7), (13), (14), (15), (16), and (23) are satisfied.

Proposition 2 describes when cities with higher exogenous productivity and amenities vote for higher regulation. Suppose that location preferences are sufficiently strong (condition 20), and that the land share is sufficiently elastic with respect to land use regulation (condition 21). Then, if the lobbying cost is convex and the congestion externalities θ are large enough compared to agglomeration externalities ρ, as described by inequality (24), cities with high productivity and amenities will choose higher regulation. If the congestion externalities are small, then highly productive cities with attractive amenities can still vote for strict regulation, but under the additional condition that (1) the elasticity of local labor supply with respect to productivity and amenities is high and (2) the elasticity of local labor supply with respect to regulation is not too sensitive to productivity and amenities, as summarized in inequality (25). Intuitively, places with high amenities and productivity attract a lot of renters. When the conditions of the proposition hold, local incumbents can vote for high regulation knowing that most local renters will not leave the city thanks to their strong location preferences.

[10] In this model, land use regulation affects amenities only indirectly, by lowering local population. It is also possible that certain types of regulation, such as protection of open spaces, directly affect local amenities.

Proposition 2. Let the conditions (20) and (21) hold, let the lobbying cost be convex, i.e., $\kappa''(z) > 0$, and assume that

$$\theta \geq (1-\gamma\eta(z_j))\rho + \frac{(1-\gamma)\gamma\eta(z_j)}{1-(1-\gamma\eta(z_j))\hat{n}_j} \tag{24}$$

Then, equilibrium regulation z_j is

(a) increasing in exogenous local productivity $\bar{A}_j$,

(b) increasing in the exogenous amenity term α_j.

If instead (24) is not satisfied, then results (a) and (b) will hold when, in addition,

$$\frac{\Psi^3(\hat{n}_j, z_j)}{\Psi^2(\hat{n}_j, z_j)}\mathcal{E}(\tilde{N}_j, x_j) > -\frac{\partial\mathcal{E}(\tilde{N}_j, z_j)}{\partial x_j}. \tag{25}$$

In this expression, $\mathcal{E}(y, x) \equiv \frac{1}{y}\frac{dy}{dx}$ is the semi-elasticity of a variable of interest y with respect to $x \in \{\bar{A}_j, \alpha_j\}$, while Ψ^2_j and Ψ^3_j are positive variables that depend on local share of renters and regulation and are defined in Appendix Section B.3.

Proof. See Appendix Section B.3 □

2.6.1 Discussion of the Lobbying Cost Function

Since rents are increasing in regulation (Proposition 1), the voting model implies that owners in pricier cities are willing to pay a higher lobbying cost. Hall and Yoder (2022) provide empirical evidence for this result. Using rich administrative panel data that links voters and their properties, they show that homeowners who buy more expensive properties are more likely to participate in local elections than buyers of cheaper homes. This finding also supports the "homevoter hypothesis" proposed by Fischel (2001), who argues that homeowners favor stricter regulation when their houses are worth more, since regulation acts as a protection against a possible devaluation of the house.

While there is no systematic data on resources spent on campaigning for or against residential development, anecdotal evidence suggests that such actions involve substantial resources.[11] Note that if there were no lobbying cost, i.e., $\kappa(z) = 0$, nothing would prevent owners from setting regulation as high as they want, and the voting model would not be able to predict local levels of regulation observed in the data. Similarly, if the lobbying cost did not depend on the level of regulation, i.e., $\kappa'(z) = 0$, the incentives of owners

[11] The Los Angeles Times estimate that over $13 million were spent on campaigning before the 2017 vote on Measure S, which would impose a two-year moratorium on all development in Los Angeles that requires a change in zoning. See http://www.latimes.com/local/lanow/la-me-ln-measure-s-20170307-story.html.

to regulate would not depend on the two fundamental features of a city described in Proposition 2. Then the model would also be unable to predict the observed regulation.

2.6.2 Political Participation of Renters and Developers

In the model renters do not vote. While this is not exactly true, previous research has shown that turnout in local elections is much higher for homeowners than for renters (DiPascuale and Glaeser, 1999; Manturuk, Lindblad, and Quercia, 2009). Looking specifically at local votes on issues regarding land zoning, Hall and Yoder (2022) find that the homeowners' turnout rate is twice as large as the renters' turnout rate. Additionally, strong history-dependence and persistence of land use regulation suggest that recent residents of a metropolitan area or a neighborhood within the area had lower impact on the current levels of regulation, and renters tend to be recent residents more often than owners.[12]

Developers are also excluded from the political process. While in practice developers do affect local government's decisions regarding land use and housing supply, in the model their interests are aligned with those of renters who also want to increase housing supply.[13]

3 Quantitative Model

This section describes the data, discusses identification of model parameters, and assesses the fit of the quantitative model relative to the data.

3.1 Data

Information on individual characteristics, wages, rents, local labor supply, and commuting come from the American Community Survey (ACS) in 2005–2007.[14] The quantitative

[12]Based on the 2005–2010 data from the U.S. Census and the Current Population Survey, while 78% of homeowners lived in the same residence five years ago, only 34% of renters did. See https://www.census.gov/prod/2012pubs/p20-567.pdf.

[13]See Hilber and Robert-Nicoud (2013) for a political economy model with landowners and developers.

[14]This time interval corresponds to the peak of the housing boom, and so may not be ideal for this study. The choice of this interval is motivated by the following considerations. The data on regulation is available for years 2004–2006 and 2018, and hence other data must be close to one of these years. The MSA-level data on land prices is available for 2005–2010 but using years right after 2007 is undesirable, since they would correspond to the Great Recession. Finally, the data on regulation for 2018 (Gyourko, Hartley, and Krimmel, 2021) has not been widely used in the literature yet and using the 2006 allows for the direct comparison of my findings with those of other scholars. As a result, I focus on the period of 2005–2007.

model has 201 locations, which correspond to metropolitan areas in the data.[15] The number of incumbent residents in each location, $\bar{N}_j$, is set to the observed number of homeowners in each metro area in the data.

I use the Wharton Residential Land Use Regulation Index from Gyourko, Saiz, and Summers (2008) as a measure of land use regulation z_j. The index was constructed at the municipal level using survey data from 2004–2006. First, I aggregate the index to the MSA level using population weights. Then, following Saiz (2010), I convert it to units suitable for the housing supply specification in this paper by taking the log of the index and adding a constant, so that regulation is positive in all cities and its average is equal to one. Appendix C provides more details on the data and reports summary statistics.

3.2 Estimated Parameters

Taking log of equation (11), we obtain the following empirical labor demand relationship,

$$\ln w_j = \beta^w + \rho \ln N_j + \epsilon_j^w, \tag{26}$$

where w_j are mean hourly wages in city j in 2005–2007, previously controlled for race, age, gender, industry, occupation, and college attainment. N_j is the average local labor supply in metro area j in 2005–2007. The local exogenous productivity parameter is constructed from the sum of the constant and the residual, $\bar{A}_j = \exp(\beta^w + \epsilon_j^w)$.

Taking log of equation (8) gives the following estimating expression for local congestion,

$$\ln m_j = \beta^m - \theta \ln N_j + \epsilon_j^m. \tag{27}$$

Leisure time m_j is equal to the time spent on leisure relative to the combined time spent on leisure and commuting. The round-trip commuting time is calculated as the average number of hours spent on commuting from home to work in each metro area times 2. Leisure time is the average number of hours spent on leisure and sports activities by full-time employed individuals on weekdays in 2006 from the American Time Use Survey.[16] The average commuting time is 0.82 hours a day and the average leisure time is 3.36 hours a day; hence the average m_j is equal to $3.36/(3.36 + 0.82) = 0.80$. Parameter ξ_j can be recovered from the sum of the constant and the residual, $\xi_j = \exp(\beta^m + \epsilon_j^m)$.

[15]The ACS data were downloaded from the IPUMS (Ruggles et al., 2015) where it allows to identify more than 300 MSAs. However, some MSAs, typically small ones, had to be excluded due to the unavailability of data on land use regulation or land prices.

[16]See https://www.bls.gov/news.release/archives/atus_06032008.htm

From equations (14), (17), and (18), the log rent relationship can be estimated as

$$\ln r_j = \bar{\chi} - \hat{\chi} z_j + (\bar{\eta} + \hat{\eta} z_j) \ln l_j - (\bar{\eta} + \hat{\eta} z_j) \ln(\bar{\eta} + \hat{\eta} z_j) - (1 - \bar{\eta} - \hat{\eta} z_j) \ln(1 - \bar{\eta} - \hat{\eta} z_j) + \epsilon_j^r, \quad (28)$$

where rents r_j are the estimated hedonic rent indices for each metropolitan area. To obtain the rent indices, I adjust self-reported rents for differences in the number of rooms, the year of construction, and the number of housing units in the structure where the unit is located. Land prices l_j correspond to the average land price per acre for the period 2005–2007 in metro area j, as estimated in Albouy, Ehrlich, and Shin (2018) using data on individual land transactions. The city-specific construction productivity term can be reconstructed from the sum of the constant and the residual as $\bar{\chi}_j = -(\bar{\chi} + \epsilon_j^r)$.

3.2.1 Instrumental Variables

The right-hand side variables in equations (26), (27), and (28) and are likely to be correlated with error terms due to the endogeneity between left-hand and right-hand side variables. Therefore, I need to use instruments for the right-hand side variables. In particular, equations (26) and (27) require instruments for local employment N_j, whereas equation (28) requires instruments for regulation z_j and land prices l_j.

To instrument for employment N_j, I use the population of each metropolitan area in 1920.[17] Historical population levels have been widely used as instruments for local labor supply (Ciccone and Hall, 1996; Combes and Gobillon, 2015). The identifying assumption is that population levels in 1920 affect local labor supply in 2005–2007 due to historical persistence, yet do not directly affect wages or commuting costs in 2005–2007, presumably because the industrial structure and labor force composition of each city as well as transportation technology have changed substantially since 1920. Panel A of Appendix Table E.1 confirms that 1920 population has a strong positive and significant effect on labor supply in 2005-2007.

In instrumenting for regulation z_j and land prices l_j, I follow the approach by Albouy and Ehrlich (2018). In particular, I use two instruments for regulation: (1) the share of non-traditional Christians among the MSA population in 1971 and (2) the share of protective inspections in local government revenues, according to the 1982 Census of Governments.[18] I also use two instruments for land prices: (1) the log of the distance from the nearest saltwater coast and (2) the USDA Natural Amenities Scale.[19]

[17]County-level population data was obtained from Eckert, Gvirtz, and Peters (2018). I find that metro area population levels prior to 1920 are not statistically significant determinants of employment in 2005–2007.

[18]These two instruments were used earlier in Saiz (2010).

[19]The distance to coast is the great-circle distance of the population centroid of an MSA from the nearest

The two regulation instruments have been widely used in the literature, following Saiz (2010). Higher share of non-traditional Christians may indicate lower taste for any kind of regulation, while higher share of protective inspections suggest that local governments have more restrictive regulations that require more costly oversight. In panel B of Appendix Table E.1, I confirm that higher non-traditional Christian share predicts lower regulation and higher inspections share predicts higher regulation, with the joint R^2 of 0.18. Besides being relevant, the two instruments must also be excludable. While it is unlikely that protective inspections affect housing rents via any other channel besides land use regulation, Davidoff (2016) showed that the non-traditional Christian share is correlated with housing demand growth. However, the regression includes a direct measure of land prices and the extra housing demand is likely to be capitalized in land values.

The two land price instruments represent geographic determinants of land prices. Areas adjacent to the coast may have larger amenity value as well as more irregular topography, both of which raise land prices. The Natural Amenities Index measures the amenity value directly and therefore should also result in higher land prices. In panel C of Appendix Table E.1, I show that shorter distance to coast and greater amenities predicts higher land prices, with the joint R^2 of 0.42. The exclusion restriction is likely to be satisfied since both instrument determine the attractiveness of a particular location and should not affect rents through any other channel except land prices.

3.2.2 Parameter Estimates

I first estimate equations (26), (27), and (28) without instruments. Equations (26) and (27) are estimated using OLS. Since equation (28) is nonlinear, it is estimated using nonlinear least squares (NLS). Then I estimate these equations using instruments. Equations (26) and (27) are estimated using two-stage least squares (2SLS), while (28) is estimated using the generalized method of moments (GMM). When estimating equation (28), I use the two regulation instruments, the two land price instruments, and interactions between them.

Panel A of Table 1 presents the estimates of productivity externalities. The OLS estimate of parameter ρ is 0.047, while the 2SLS estimate is somewhat lower at 0.04. These estimates are within the range of estimates obtained by previous studies (Combes and Gobillon, 2015). Panel B shows the estimates of the congestion externality parameter θ. The OLS and 2SLS estimates indicate an elasticity of travel time with respect to city size

coast (excluding the coasts of internal water bodies, such as the Great Lakes). It was computed using the data from the Pacific Islands Ocean Observing System. The USDA Natural Amenities Scale consists of six components: mean January temperature, mean January sunlight hours, mean July temperature, mean relative July humidity, a measure of land topography, and the percent of land area covered by water.

Table 1: Parameter Estimates

Panel A: Agglomeration externalities

	(1)	(2)
ρ	0.0473	0.0401
	(0.0051)	(0.0079)
Model	OLS	2SLS
R^2	0.300	0.293
1-st stage F-stat		96.61

Panel B: Congestion externalities

	(1)	(2)
θ	0.0233	0.0208
	(0.0010)	(0.0017)
Model	OLS	2SLS
R^2	0.744	0.736
1-st stage F-stat		96.61

Panel C: Land use regulation

	(1)	(2)
$\bar{\chi}$	0.7339	0.8386
	(0.0461)	(0.1329)
$\hat{\chi}$	-0.2172	-0.3234
	(0.0439)	(0.1317)
$\bar{\eta}$	-0.0204	-0.0391
	(0.0491)	(0.1209)
$\hat{\eta}$	0.2245	0.2481
	(0.0465)	(0.1281)
Model	NLS	GMM
R^2	0.696	
Hansen's J, p-value		0.06

Notes: Panels A and B report estimates of equations (26) and (27), respectively. In both panels, column (1) reports OLS estimates and column (2) shows 2SLS estimates. Panel C reports estimates of equation (28). Column (1) shows NLS estimates, while column (2) shows GMM estimates. The number of observations in each regression is 201 MSAs. Robust standard errors are reported in parentheses.

of about 0.02. This is lower than the estimates in the literature; however, most available estimates include housing costs or focus on disamenities other than commuting time. Combes, Duranton, and Gobillon (2019) find that the elasticity of urban costs with respect to city size is between 0.03 and 0.08.

Panel C demonstrates estimates of the parameters that determine the relationship between construction productivity, land share, and land use regulations. Note that the GMM estimates have slightly larger magnitude but are also noisier than the NLS estimates. Given large standard errors of the GMM estimates, the NLS estimates are well within the 95% confidence interval of the GMM estimates. Based on the results of the Hansen (1982) test for overidentifying restrictions, I am unable to reject the null hypothesis that the exclusion restrictions are jointly true, albeit with a relatively low p-value of 0.06.

The estimated value of the parameter $\hat{\chi}$ suggests that construction costs are increasing in regulation. At the same, the values of the land share parameters, $\bar{\eta}$ and $\hat{\eta}$, suggest that land share is increasing in regulation. Given that the average value of the regulation index is 1, the values of $\bar{\eta}$ and $\hat{\eta}$ imply an average land share of around 0.21, similar to the estimates obtained in the literature. Albouy and Ehrlich (2018) find that the land share is about 1/3 for the U.S., while Combes, Duranton, and Gobillon (2021) estimate a value of around 0.2 for France.

The 2SLS estimates of ρ and θ, and the GMM estimates of $\bar{\eta}$, $\hat{\eta}$, $\bar{\chi}$, and $\hat{\chi}$ are used in the quantitative model.

3.3 Calibrated Parameters

The vector of exogenous amenity terms α_j is calibrated to the observed distribution of employment across MSAs. Since the number of owners is exogenous and taken from the data, calibrated values of α_j ensure that the number of renters in the model $\tilde{N}_j$ corresponds to that in the data. Parameter σ is calibrated to the 20-year elasticity of employment with respect to a TFP shock, estimated at 4.16 in Hornbeck and Moretti (2022).[20] The calibrated value of σ is 0.164. The relative preference for housing is equal to $\gamma = 0.24$ and represents the housing expenditure share of renters, following Davis and Ortalo-Magné (2011).

Land use for rental housing $\tilde{\Lambda}_j$ is obtained as follows. Housing consumption of owners is equal to $\bar{h}_j = \zeta\tilde{h}_j$, where $\tilde{h}_j$ is the optimal housing consumption of a renter and

[20]Since this paper focuses on stationary equilibria, the period to which the elasticity applies must be long enough to allow for a transition between equilibria. Beaudry, Green, and Sand (2014) compare various local elasticities at 10- and 20-year spans and find sizable differences between them. Hornbeck and Moretti (2022) compare labor and housing market elasticities to TFP shocks at 10, 20, and 30 years, and find differences between the 10- and 20-year estimates but not between the 20- and 30-year estimates. These findings suggest that 20 years is a reasonable amount of time required to attain a spatial equilibrium.

Table 2: Parameters of the quantitative model

Parameter	Value	Source or Target	Moment Model	Moment Data
Internally and externally calibrated parameters				
Exogenous amenities	α_j: multiple values	Labor force by MSA	dist<0.0001%	
Labor supply elasticity	$\sigma = 0.164$	20-year labor supply elasticity	4.16	4.16
Housing consumption share	$\gamma = 0.24$	Davis and Ortalo-Magné (2011)		
Estimated parameters				
Exogenous labor productivity	$\bar{A}_j$: multiple values			
Agglomeration externality	$\rho = 0.0401$			
Construction productivity term	$\bar{\chi}_j$: multiple values			
Elasticity of χ_j wrt regulation	$\hat{\chi} = -0.3234$			
Land share, common term	$\bar{\eta} = -0.0391$			
Elasticity of η_j wrt regulation	$\hat{\eta} = 0.2481$			
City-specific congestion term	ξ_j: multiple values			
Congestion elasticity	$\theta = -0.0208$			

Note: The table summarizes parameters used in the quantitative model.

$\zeta = 1.502$ is the ratio of the national median square footage per person in owner-occupied properties to the square footage in rental properties.[21] I assume that a unit of owner-occupied housing uses the same amount of land as a unit of rental housing.[22] Therefore, the land area occupied by rental units is $\tilde{\Lambda}_j = \vartheta_j \Lambda_j$, where $\vartheta_j \equiv \tilde{N}_j/(\tilde{N}_j + \zeta\bar{N}_j)$ is the fraction of land devoted to owner-occupied properties. Finally, land supply Λ_j is the total amount of urban land in each metropolitan area, as estimated in Albouy, Ehrlich, and Shin (2018).[23]

Table 2 lists parameters of the quantitative model and their sources or targets. The model reproduces exactly the targeted moments, and the distribution of population is matched exactly to the one observed in the data. Note that the distribution of local wages is also matched exactly, since N_j is the same as in the data and $\bar{A}_j$ subsumes all possible causes of wage variation across cities except the size of employment.

[21] In 2007, the median square feet per person was 805 in owner-occupied units and 536 in rental units. See the 2007 American Housing Survey, National Tables, Table 2-3.

[22] Nonetheless, since owners live in larger houses, their houses occupy more land than those of renters, consistent with empirical evidence in Yao (2021).

[23] It is important to distinguish between *total* land area and *urban* land area. Because MSAs are defined based on county borders, total land area often includes rural land and therefore overestimates the land area that can be feasibly used for expanding the MSA in the near future. Albouy, Ehrlich, and Shin (2018) do not directly report urban land area; however, one can calculate it by dividing the total value of urban land in a city by the estimated land price per acre.

Table 3: Parameters of the lobbying cost function

Parameter	Value	Target	Moment	
			Model	Data
κ_1	5.945×10^{-3}	Normalized Wharton Index, mean	1.000	1.000
κ_2	1.240×10^{-3}	Normalized Wharton Index, s.d.	0.266	0.266

Note: This table reports the calibrated lobbying cost function parameters.

3.4 Endogenous Regulation

Next, I take the calibrated model and endogenize land use regulation. The lobbying cost function is parameterized as the following quadratic function of the level of regulation: $\kappa(z) = \kappa_0 + \kappa_1 z + \frac{\kappa_2}{2} z^2$. Quadratic cost functions for voting and lobbying have been widely used in political science models (Esteban and Ray, 2001; Lalley and Weyl, 2018). Thus the the marginal private cost of regulation is equal to

$$\kappa'(z) = \kappa_1 + \kappa_2 z. \tag{29}$$

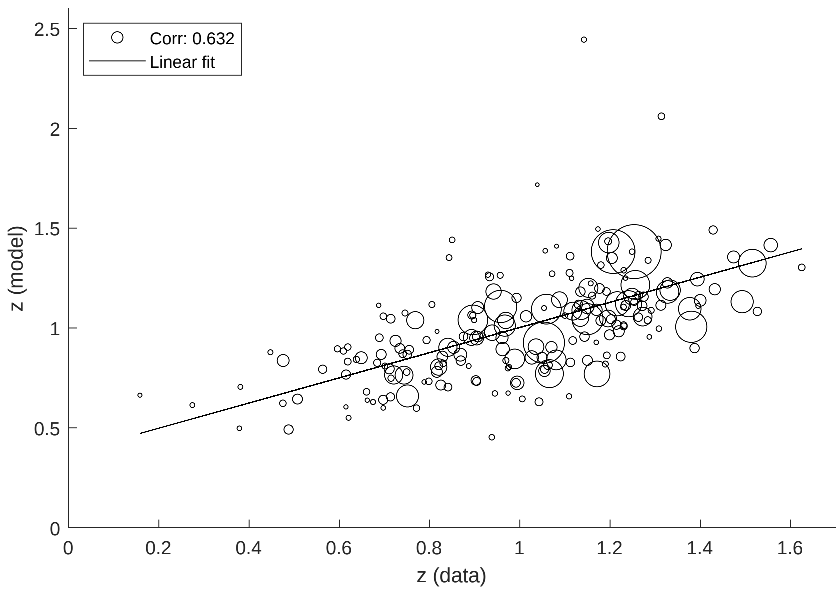
Parameters κ_1 and κ_2 are calibrated so that the mean and the standard deviation of z_j produced by the model are equal to the mean and the standard deviation of the normalized Wharton Index. Table 3 shows the calibrated values. Because only the marginal cost affects voting, the value of κ_0 is irrelevant for the quantitative model. Given that the value of κ_2 is positive, the marginal cost of regulation is convex, as required by Proposition 2.

3.5 Model Fit

Note that I only target the mean and the standard deviation of the distribution of the Wharton Index by setting the two parameters of the lobbying function, and let the voting model determine the level of regulation for each city.[24] The model produces a fairly accurate prediction of the level of regulation in each location. Figure 1 shows that the population-weighted correlation between the Wharton index and the regulation predicted by the model is 0.632 (the unweighted correlation is 0.585). That is, the model accounts for about 40% of the observed differences in the Wharton index, even though there are many other important reasons why regulation differs across locations and which are beyond the

[24]By targeting the mean and the standard deviation, I am disciplining the numerical values of regulation that the voting model produces; however, I do not target the level of regulation in any particular city and let the model determine the level of z_j.

Figure 1: Regulation: model vs data



Note: The plot shows the normalized Wharton Index on the horizontal axis and the level of land use regulation predicted by the voting model on the vertical axis. Marker sizes are proportional to local employment in the data. The correlation is weighted by local employment.

scope of the model.[25]

The success of the model in predicting the observed regulation relies on the fact that the fundamental determinants of regulation in the model, i.e., productivity and amenities, are also important correlates of regulation in the data. As Table 4 shows, the correlations between each of these two variables and the level of regulation itself are similar both in the model and in the data. In addition, the model produces correlations between regulation and a few other variables of interest comparable to those in the data. Yet, the quantitative model fails to produce the negative relationship between regulation and the per-worker land supply (inverse density), and produces a weak relationship between regulation and city size. This is because the incentives of owners to regulate land use in the model do not directly depend on city size and density.

Local land prices and rents are not targeted, but Appendix Figure E.1 shows that they are highly correlated with the values observed in the data. Furthermore, Appendix Table E.2 demonstrates that the model correctly predicts correlations of many, though not all,

[25]The square of the correlation between the model and the data is equal to the R^2 in the regression of the model-predicted regulation on the Wharton index. Hence, the model accounts for $0.632^2 \approx 0.4$ of the observed variation in the Wharton index. Other reasons for regulation include historical land use patterns (Glaeser and Ward, 2009), political ideology of local voters (Kahn, 2011), and many others. See Gyourko and Molloy (2015) for a survey.

Table 4: Correlations of regulation with other variables

Correlation of regulation (z_j) with	**Model**	**Data**
log exogenous productivity ($\ln \bar{A}_j$)	0.33	0.46
log exogenous amenity level ($\ln \alpha_j$)	0.28	0.35
log wages ($\ln w_j$)	0.31	0.50
log land prices ($\ln l_j$)	0.37	0.47
log land supply per worker ($\ln(\Lambda_j/N_j)$)	0.11	-0.28
log rents ($\ln r_j$)	0.74	0.59
log city size ($\ln N_j$)	0.07	0.25
log number of incumbents ($\ln \bar{N}_j$)	0.03	0.23

Note: The table reports unweighted correlations between regulation and several variables of interest, both in the model and the data.

observed indicators of amenities, e.g., spending on education, college-employment ratio, air quality, spending on parks and patents, as measured in Diamond (2016).

4 Counterfactual Experiments

Next, I describe a counterfactual economy where land use regulation differs from the benchmark economy described above. I run a series of counterfactual experiments to understand how land use regulation affects the allocation of labor across space, local outcomes, and welfare. I also study hypothetical policies that discourage local owners from excessively regulating land use.

4.1 A Counterfactual Economy

Owners and land use in a counterfactual economy. In the model, the number of owners in each city is exogenous. However, in the long run, counterfactual changes will reallocate not only renters, but also owners. Thus, I assume that in a counterfactual economy owners also experience location preference shocks ε_{ij} with the same variance parameter σ as renters, and can move across locations as the economy transitions to a counterfactual equilibrium. An owner who relocates loses the house and becomes a renter in the destination of choice.[26] The house sold by the homeowner who moves fully depreciates. However, the owner can sell the land he owned in the previous city to the

[26] I ignore the possibility that the owner could benefit from selling her house. Yet, this assumption makes relocation less desirable for owners and results in more conservative effects of counterfactual experiments.

owners who stay. Since a counterfactual economy may contain a different local mix of owners and renters, land use also changes. As a result, the transfer earned by an owner who lived in city k in the benchmark economy and lives in city j in the counterfactual economy changes whether the individual moves or stays and is given by

$$T_{kj} = \begin{cases} \frac{l_k}{\bar{N}_k}\left(\tilde{\Lambda}_k - \left(1 - \frac{\bar{N}_k}{\bar{N}_k^0}\right)\Lambda_k\right) & \text{if } j = k, \\ \frac{l_k \Lambda_k}{\bar{N}_k^0} & \text{if } j \neq k, \end{cases} \tag{30}$$

where the superscript 0 denotes variables in the benchmark economy.

When an owner i in city k decides whether to move to city j, she compares the value of remaining an owner in city k, $\bar{v}(w_k + T_{kk}, \bar{h}_k, X_k) + \sigma\varepsilon_{ik}$, with the value of moving and becoming a renter in city j, $\tilde{v}(w_j + T_{kj}, r_j, X_j) + \sigma\varepsilon_{ij}$. Thus, the probability that an owner from location $k \neq j$ will decide to move to location j in the counterfactual economy is equal to

$$\bar{\pi}_{kj} = \frac{\exp\left(\tilde{v}(w_j + T_{kj}, r_j, X_j)\right)^{1/\sigma}}{\exp\left(\bar{v}(w_k + T_{kk}, \bar{h}_k, X_k)\right)^{1/\sigma} + \sum_{j' \neq k} \exp\left(\tilde{v}(w_{j'} + T_{kj'}, r_{j'}, X_{j'})\right)^{1/\sigma}}. \tag{31}$$

The total number of owners in location j in the counterfactual economy is

$$\bar{N}_j = \left(1 - \sum_{k \neq j} \bar{\pi}_{jk}\right)\bar{N}_j^0 + \sum_{k \neq j} \bar{\pi}_{kj}\bar{N}_k^0. \tag{32}$$

Measuring productivity and welfare effects. The main variables of interest in counterfactual experiments are aggregate labor productivity and aggregate welfare. Aggregate labor productivity is measured as

$$A = \frac{1}{N}\sum_{j \in \mathcal{J}} \bar{A}_j N_j^{1+\rho}. \tag{33}$$

This expression illustrates that aggregate labor productivity only depends on the distribution of workers across cities and is higher when more workers choose to locate in places with high exogenous productivity, $\bar{A}_j$. Also, since wages are equal to $w_j = \bar{A}_j N_j^{\rho}$, a change in local labor productivity coincides with the change in local wages. In addition, because aggregate labor supply is fixed, changes in aggregate productivity are identical to changes in aggregate output.

Welfare comparisons between the benchmark and the counterfactual economies are made using the consumption equivalence approach. Since owners do not experience preference shocks in the benchmark economy, I cannot compare ex-ante welfare of owners and therefore use their indirect utility, net of preference shocks. Also, since owners cannot move in the benchmark economy, it is desirable to isolate welfare effects due to changes in consumption and amenities from those due to relocation. Thus, I focus on the part of welfare gains that arise from changes in local consumption and amenities. Under this approach, the percentage change in the consumption-equivalent welfare $\bar{\Delta}$ solves

$$\sum_{j \in \mathcal{J}} \bar{N}_j^0 \left[\bar{v}\left(\bar{c}_j, X_j\right) - \bar{v}\left((1+\bar{\Delta})\, \bar{c}_j^0, X_j^0\right)\right] = 0, \tag{34}$$

where $\bar{c}_j \equiv \left(w_j + T_{jj}\right)^{1-\gamma} \bar{h}_j^{\gamma}$ is the composite consumption of owners.

To make welfare changes of renters comparable to those of owners, I also use indirect utility, net of preference shocks. Under this measure, the percentage change in the consumption-equivalent welfare of renters $\tilde{\Delta}$ solves

$$\sum_{j \in \mathcal{J}} \tilde{N}_j \tilde{v}\left(\tilde{c}_j, X_j\right) - \sum_{j \in \mathcal{J}} \tilde{N}_j^0 \tilde{v}\left(\left(1+\tilde{\Delta}\right) \tilde{c}_j^0, X_j^0\right) = 0, \tag{35}$$

where $\tilde{c}_j \equiv \gamma^{\gamma}(1-\gamma)^{1-\gamma} w_j r_j^{-\gamma}$ is the composite consumption of renters.

Therefore, the change in aggregate welfare is the weighted average of welfare changes for renters and owners:

$$\Delta = \frac{1}{N} \sum_{j \in \mathcal{J}} \left(\tilde{\Delta}\tilde{N}_j^0 + \bar{\Delta}\bar{N}_j^0\right). \tag{36}$$

4.2 Effects of Deregulation

To study aggregate effects of land use regulation, I use the counterfactual economy described above and perform several counterfactual experiments in which land use constraints are relaxed.

In the first experiment, I eliminate all differences in regulation across cities by fixing it at the average level everywhere, that is, $z_j = 1$ for all j.[27] The results are shown in column (1) of Table 5. Because highly regulated cities tend to be more productive, lowering z_j in those places attracts some workers there and increases aggregate output by 2.8%. Average rents and land prices fall. As a result, owners experience welfare losses of over 2%, while renters enjoy welfare gains of nearly 7%. However, since around 70% of the population are owners, aggregate improvement in welfare is a mere 0.5%. Since large cities tend to

[27] Here the effect of regulation is symmetric for positive and negative changes in housing demand. Alternatively, regulation could be binding only when the demand rises, as in Glaeser and Gyourko (2005).

Table 5: Effects of Deregulation

	Benchmark	(1) $z_j = z_{\text{mean}}$ in all cities	(2) $z_j \leq 0.896$ in all cities	(3) $z_j \leq 0.896$ in superstars
Output, % chg		2.8	2.9	3.6
Rents, % chg		-17.3	-26.1	-19.1
Welfare, % chg		0.5	1.5	1.2
owners		-2.1	-2.0	-2.2
renters		6.9	10.0	9.5
Var of log city size	1.18	1.56	1.51	1.45
Var of log wages ×100	0.88	1.04	1.02	0.97
Var of log rents ×100	8.50	3.68	4.24	6.99

Note: The table compares several variables in the benchmark and three counterfactual economies. Column (1) contains results of the experiment in which land use regulation is fixed at the national average in all cities. Column (2) contains results of the experiment in which land use regulation is capped at the level of Houston in all cities. Column (3) contains results of the experiment in which land use regulation is capped at the level of Houston in ten "superstar" cities.

be more regulated, equalizing regulation means that large cities become larger and small cities shrink, and so the variance of the city size distribution goes up. The dispersion of wages across cities increases too. This happens because deregulation reallocates more workers into highly productive areas thereby increasing wage inequality across cities. At the same time, deregulation lowers average rents as well as their dispersion across cities.

The second experiment takes Houston, TX as an example of a large city with lax regulation, and limits the level of regulation in all cities to the level of Houston.[28] The normalized Wharton index in Houston is 0.896. Therefore, in this experiment if city j has $z_j \leq 0.896$, then z_j remains at the observed level. Otherwise, z_j is lowered to 0.896. The results of this experiment are in column (2) of Table 5. The effects on output, wages, rents, and city size distribution are similar to the first experiment; however, since Houston's regulation is below average, rents fall more and renters' welfare gain is greater.

The previous two counterfactuals adjust regulation in all cities in the economy. However, most cities, especially small and medium ones, have affordable housing. To make deregulation more targeted, I define a set of "superstar" cities as follows.[29] I take the 50 largest metropolitan areas and rank them by (1) the level of regulation, (2) wages, and (3) rents, and then select the top 10 areas in the combined ranking. The "superstar" cities are Boston, San Francisco, New York, San Jose, Seattle, Baltimore, Philadelphia, San Diego, Washington, and Los Angeles. All of these cities, with the possible exception of Baltimore

[28]Houston is the only large U.S. city without a zoning code. However, land use in Houston is not completely unregulated, as deed restrictions and other ad-hoc regulations place limits on land use.

[29]The term "superstar city" was coined by Gyourko, Mayer, and Sinai (2013).

Table 6: City-level Effects of Deregulating "Superstar" Cities to the Level of Houston

MSA	Exog. prod.	Exog. amen.	Reg., BM	Reg., CF	Emp., % chg	Wages, % chg	Rents, % chg	Land price, % chg	$\hat{Y}_j$, p.p.
Baltimore, MD	1.08	1.29	1.493	0.896	46	1.5	-43	-40	0.6
Boston, MA-NH	1.12	1.45	1.515	0.896	66	2.1	-42	-31	1.6
Los Angeles, CA	1.01	1.83	1.207	0.896	81	2.4	-25	5	5.3
New York, NY-NJ	1.09	1.84	1.253	0.896	84	2.5	-29	3	9.0
Philadelphia, PA	1.05	1.43	1.380	0.896	14	0.5	-40	-49	0.4
San Diego, CA	1.09	1.39	1.197	0.896	49	1.6	-24	-17	0.7
San Francisco, CA	1.21	1.34	1.256	0.896	59	1.9	-31	-16	1.7
San Jose, CA	1.32	1.07	1.117	0.896	27	1.0	-24	-24	0.3
Seattle, WA	1.09	1.26	1.327	0.896	43	1.4	-35	-32	0.6
Washington, DC	1.15	1.42	1.150	0.896	8	0.3	-27	-40	0.2
Other cities	0.99	1.22	1.023	1.037	-24	-0.9	-10	-39	-16.9

Note: This table shows counterfactual results for each of the ten "superstar" cities as well as all non-"superstar" cities combined in the experiment where land use regulation is capped at the level of Houston, TX in "superstar" cities. The columns show the exogenous productivity $\bar{A}_j$, exogenous amenities α_j, benchmark level of regulation (the normalized Wharton index), counterfactual level of regulation (the Houston's level in "superstar" cities), counterfactual changes in employment, wages, rents, land prices, as well as contribution to counterfactual output growth in percentage points.

and Philadelphia, are frequently characterized as highly productive and innovative but unaffordable. Appendix Table E.3 shows the ranking of the "superstars."

In the third experiment, I repeat the exercise of capping regulation at the Houston's level, but only in "superstar" cities. Column (3) of Table 5 shows that adjusting regulation in just ten "superstar" cities produces a larger output gain than applying the same kind of deregulation everywhere. This is because in this experiment other, non-"superstar," cities do not become more attractive due to deregulation and this induces even more workers to flock into the "superstars." On the other hand, welfare gains are smaller than in the previous experiment as owners in the "superstars" lose land rents due to deregulation and owners in other cities lose land rents due to the outflow of workers. The variance of the city size distribution and wage inequality do not increase as much as in the previous two experiments, and the dispersion of rents across cities does not fall as much.

City-level results. Table 6 shows the results of the third counterfactual for each of the "superstar" cities. Not surprisingly, deregulation raises employment in all "superstars"; however, magnitudes vary by city. While labor supply goes up by more than 80% in Los Angeles and New York and by about 60% in San Francisco and Boston, it only increases by 27% in San Jose and by less than 10% in Washington, DC. These disparities arise for the following reasons. First, the Wharton index is smaller in San Jose and Washington than in Los Angeles, New York, San Francisco, and Boston. Hence, a deregulation to the level of Houston results in a smaller change in z_j in San Jose and Washington. Second, exogenous amenities are larger in New York and Los Angeles than elsewhere. While amenities in San Jose are relatively low, its employment growth is still sizable thanks to high exogenous productivity. Employment growth in Washington, DC is weak due to the combination of low initial regulation, average productivity and average amenities.

As a result of the deregulation, real incomes in the "superstars" go up. First, the increase in labor supply leads to higher wages due to the agglomeration externalities. Second, lower regulation significantly reduces the land share, which in turn lowers rents even despite the larger housing demand. Rents fall even in Los Angeles and New York, despite the fact that land prices in these cities go up due to the increase in housing demand.

How does each of the "superstar" cities contribute to the growth of aggregate output? The contribution of city j is measured as

$$\hat{Y}_j \equiv \frac{Y_j^1 - Y_j^0}{\sum_{k \in \mathcal{J}} Y_k^0}. \tag{37}$$

As Table 6 shows, most of the aggregate productivity gains from deregulation in the "superstars" come from New York and Los Angeles, followed by Boston and San Francisco. New York alone contributes 9 percentage points to aggregate increase in output of 3.6%.[30] The contributions of other "superstars" are much smaller, while the contributions of non-"superstar" cities are negative, as workers leave them.

Comparison to previous studies. Several previous papers, including Hsieh and Moretti (2019) and Herkenhoff, Ohanian, and Prescott (2018), have also studied how lowering land use restrictions would affect the economy. In Appendix Section D, I use my model to repeat the counterfactual experiments conducted in those two papers and show that my model delivers smaller productivity gains. The difference is largely explained by strong location preferences and congestion externalities in my model. I also show that, while those two papers found sizable welfare gains from deregulation, my model produces no welfare gains. This is because my model distinguishes between renters and owners, and owners experience welfare losses when land use is deregulated.[31]

[30]Since other cities shrink in this counterfactual, their contribution to the increase in aggregate output is negative, while the combined contribution of the "superstars" exceeds 3.6 percentage points.

[31]Another paper that shows that distinguishing between renters and owners is important for understanding welfare effects of land use regulation is Greaney (2023).

4.3 Policy Interventions

Land use regulation in the U.S. is decided by municipal governments. The federal and state governments are rarely involved in local land use issues.[32] In the model of this paper, local governments likewise choose regulation independently, considering only local welfare and disregarding the possible nationwide effects of their decisions. However, as counterfactual experiments of Section 4.2 illustrate, the freedom of cities to choose their preferred level of regulation results in aggregate productivity losses. This suggests that some cities may impose negative externalities on the entire economy and therefore there may be room for a national policy that discourages regulation in productive cities.

While the counterfactual experiments in this paper, as well as those in other studies, entail substantial aggregate benefits of deregulation, it is not clear which concrete policies could achieve such deregulation. The benefit of having a model that explains how cities determine land use regulation is that one can study how changing local motives to regulate land use could affect local regulation, as well as other variables of interest, such as employment, productivity, rents, etc. This is useful because, even though, due to legal and political constraints, the federal government may not be able to force cities to reduce regulation, it can introduce policies that lower the incentives of local governments to regulate.

In the rest of the section, I study two hypothetical federal policies that discourage local land use regulation: infrastructure subsidies conditional on deregulation and a land value tax in "superstar" cities. Unlike in previous counterfactuals, in these two policy experiments regulation will change endogenously. Therefore, to evaluate the effects of the policies, I will use the benchmark economy in which regulation is endogenously determined by the voting mechanism described in Section 2.6 and compare it with counterfactual economies where equilibrium variables change as described in Section 4.1.

4.3.1 Infrastructure Subsidies

The federal government provides sizable transfers to municipal governments.[33] One of the common uses of the transfers is to build or improve infrastructure. Recall that in the

[32] According to Gyourko and Molloy (2015), "the U.S. Constitution did not grant the federal government authority to regulate land, and the states have generally left this power with local governments. The fact that land use is controlled by local governments has contributed to the heterogeneity of regulations."

[33] The National League of Cities estimates that about 5% of municipal revenues are transfers from the federal government and 20%–25% are transfers from state governments. However, according to the Tax Policy Center, 30% of state revenues come from federal transfers, and hence the transfers from states to municipalities may also include federal funds. See https://www.nlc.org/revenue-from-intergovernmental-transfers and http://www.taxpolicycenter.org/briefing-book/what-are-sources-revenue-state-governments.

model the amenity value of a city depends on the number of residents and a fixed location-specific factor ξ_j (equation 8). One interpretation of ξ_j is that it measures the quality of local infrastructure that reduces commuting times for a given number of residents. I propose a policy in which a national planner can affect city-specific commuting efficiency. In particular, the planner can adjust the level of ξ_j via a system of taxes and subsidies so that the effective level of commuting efficiency available to the residents of city j is $(1-\tau_j)\xi_j$. When $\tau_j > 0$, the planner reduces transfers to the city and local transportation infrastructure deteriorates, resulting in longer commutes and hence a lower amenity level X_j. When $\tau_j < 0$, the planner provides additional transfers to the city, which leads to an improvement in the infrastructure and shortens commutes.

One way to ensure that the policy discourages regulation is to condition τ_j on the level of z_j, that is, make infrastructure funding to cities dependent on the level of land use regulation. I specify τ_j as follows:

$$\tau(z_j) = \begin{cases} -\tau^0 & \text{if } j \notin \mathcal{J}^* \\ -\tau^0 + \tau^1 z_j & \text{if } j \in \mathcal{J}^*, \end{cases} \tag{38}$$

where $\mathcal{J}^*$ is the set of ten "superstar" cities (see Section 4.2). Under this policy, all cities receive an infrastructure subsidy from the federal government in the amount of $\tau^0\xi_j$. However, in addition to receiving the subsidy, the "superstars" must pay a tax that depends on their level of regulation. As a result, the effective amount of infrastructure in non-"superstar" cities is $(1+\tau^0)\xi_j$ and in "superstar" cities it is equal to $(1+\tau^0-\tau^1 z_j)\xi_j$. The underlying assumption is that in the long run infrastructure quality will adjust to a level proportional to the level of a tax or subsidy from the federal government. The policy is revenue-neutral at the aggregate level, i.e.,

$$\sum_{j\in\mathcal{J}} \tau(z_j)\xi_j N_j = 0. \tag{39}$$

This policy is akin to a Pigouvian tax on cities with high regulation, the proceeds from which are used to provide transfers to cities with low regulation.

The way the federal policy changes incentives of local governments to regulate land use is illustrated by the first-order condition for equilibrium regulation,

$$\frac{1-\gamma}{w_j+T_j}\left(\frac{dw_j}{dz_j}+\frac{dT_j}{dz_j}\right)+\frac{1}{X_j}\frac{dX_j}{dz_j} = \kappa'(z_j) + \frac{\tau'(z_j)}{1-\tau'(z_j)}, \tag{40}$$

which, except for the additional term $\tau'(z_j)/(1-\tau'(z_j))$, is identical to the condition for

Table 7: Effects of Infrastructure Subsidies

	Benchmark	(1) Optimal regulation tax	(2) Same gains as $z_j \leq 0.896$ in superstars
τ^0	0	0.0029	0.0022
τ^1	0	0.0503	0.0094
mean z	1.000	0.453	0.803
s.d. of z	0.266	0.256	0.260
Output, % chg		7.9	3.6
Rents, % chg		-60.0	-31.4
Welfare, % chg		10.9	2.9
owners		-2.0	-1.2
renters		42.3	12.7
Var of log city size	1.18	1.80	1.53
Var of log wages ×100	0.88	1.10	1.01
Var of log rents ×100	8.50	5.52	6.76

Note: The table compares several variables in the benchmark and two counterfactual economies. Column (1) contains results of the experiment in which the tax on regulation is welfare-maximizing. Column (2) contains results of the experiment in which the tax on regulation is such that productivity gains are identical to the gains in the experiment where land use regulation is capped at the level of Houston in ten "superstar" cities.

equilibrium regulation (23), although the functional forms of dw_j/dz_j, dT_j/dz_j, and dX_j/dz_j also change. The second term on the right-hand side is positive in "superstar" cities. For a given value of the marginal benefit of regulation, these cities now vote for a lower equilibrium value of z_j. In other cities, $\tau'(z_j)/(1-\tau'(z_j)) = 0$. However, as a result of policy-induced deregulation in the "superstars," other cities become smaller. This lowers the marginal benefit of regulation, which means that non-"superstar" cities also vote for a lower z_j.

The planner chooses τ^0 and τ^1 in order to maximize aggregate welfare subject to the constraint (39). The welfare-maximizing policy sets $\tau^0 = 0.0029$ and $\tau^1 = 0.0503$. Any $\tau^1 > 0.0503$ would be sufficient to make each of the ten "superstar" cities choose minimal regulation.[34] As column (1) of Table 7 shows, this kind of deregulation would boost output by as much as 7.9% and welfare by 10.9%, but also make large cities larger and lead to greater wage inequality across cities. The effects are so large because minimal regulation implies a zero land share. Rents fall by as much as 60%, although welfare losses for owners are comparable to those in deregulation exercises in Section 4.2. This is because the increase in output, and therefore wages, is much higher and compensates for the loss

[34]Since the land share $\eta(z_j)$ cannot be negative, z_j must satisfy $\bar{\eta} + \hat{\eta} z_j \geq 0$ or $z_j \geq -\bar{\eta}/\hat{\eta}$. Under the estimated values of $\bar{\eta}$ and $\hat{\eta}$, this implies that the minimal level of regulation is 0.1575.

of land rents.

Since a zero land share may be unrealistic, I also study the aggregate effects of setting τ^1 such that the productivity gain due to the policy is identical to the productivity gain in a the experiment where regulation in the "superstars" is lowered to the level of Houston (see Table 5). This also allows me to compare the ad-hoc deregulation to the level of Houston with a deregulation incentivized by the federal government. The results of this experiment are demonstrated in column (2) of Table 7. Under this policy, welfare goes up by 2.9%, compared to a 1.2% gain in the ad-hoc deregulation.

Panel A of Appendix Table E.4 shows how the policy described in column (2) of Table 7 affects each of the "superstar" cities. As a result of the policy, all "superstars" vote for lower regulation and grow in size. However, compared to the ad-hoc deregulation, aggregate productivity does not increase only because of New York, Los Angeles, Boston, and San Francisco. Other cities' contributions are substantially higher. This is because owners in cities with the most expensive land, such as the four abovementioned ones, are not so eager to abandon regulation as the share of land transfers in their disposable incomes is larger than that of owners in other cities. This suggests that policies that discourage local regulation may be less successful in places where real estate ownership is a particularly important source of income and wealth.

4.3.2 Land Value Tax

Next, I study the implications of introducing a tax on land rents earned by owners in "superstar" cities. A tax on land values was first proposed and popularized by George (1879). Under this policy, net transfer earnings of owners become $(1-\lambda_j)T_{kj}$. Because transfers depend on land values, the tax on transfers is identical to a land value tax. The tax rate is specified as

$$\lambda_j = \begin{cases} 0 & \text{if } j \notin \mathcal{J}^* \\ \lambda & \text{if } j \in \mathcal{J}^*. \end{cases} \tag{41}$$

Tax revenues are equally distributed among all individuals in the economy. Since land rents are increasing in regulation, the land tax discourages owners from voting for high regulation. This effect is illustrated by the first-order condition for equilibrium regulation:

$$\frac{1-\gamma}{w_j + (1-\lambda_j)T_j}\left(\frac{dw_j}{dz_j} + (1-\lambda_j)\frac{dT_j}{dz_j}\right) + \frac{1}{X_j}\frac{dX_j}{dz_j} = \kappa'(z_j). \tag{42}$$

The condition is similar to the condition for equilibrium regulation (23), except that the benefit of earning land transfers is weakened by the land tax λ_j.

Table 8: Effects of a Land Value Tax

	Benchmark	(1) Optimal land value tax	(2) Same gains as $z_j \leq 0.896$ in superstars
λ	0	0.586	0.286
mean z	1.000	0.438	0.812
s.d. of z	0.266	0.253	0.259
Output, % chg		8.0	3.6
Rents, % chg		-60.4	-29.7
Welfare, % chg		11.2	2.5
owners		-2.0	-1.4
renters		43.4	11.9
Var of log city size	1.18	1.82	1.53
Var of log wages ×100	0.88	1.10	1.01
Var of log rents ×100	8.50	5.38	6.82

Note: The table compares several variables in the benchmark and two counterfactual economies. Column (1) contains results of the experiment in which the land value tax is welfare-maximizing. Column (2) contains results of the experiment in which the land value tax is such that productivity gains are identical to the gains in the experiment where land use regulation is capped at the level of Houston in ten "superstar" cities.

The planner's goal is to choose λ that maximizes aggregate welfare. The welfare-maximizing tax rate turns out to be 58.6%. At this level, owners in "superstar" cities lose any incentive to support land use regulation and vote for minimal regulation. Increasing the tax rate even further would yield no additional gains from deregulation, while causing even larger welfare losses for owners. Even though owners in the "superstars" lose over one-half of their land rent income, the society as a whole benefits. As equation (42) demonstrates, when λ is high incumbents pay more attention to the effect of regulation on wages and amenities and vote for lower regulation. As column (1) of Table 8 shows, the introduction of an optimal land tax yields similar productivity and welfare gains as the system of infrastructure subsidies discussed above.

I also run an experiment in which the land tax is not welfare-maximizing but is set at the level needed to obtain the same productivity gain as in the ad-hoc experiment where land use regulation in "superstar" cities is lowered to the level of Houston. The tax rate that brings the same productivity improvement is 28.6%. The results of this experiment are shown in column (2) of Table 8. Welfare goes up by 2.5%, while in the ad-hoc deregulation experiment it went up by only 1.2%. Panel B of Appendix Table E.4 reports the results of this experiment in each of the ten "superstar" cities and shows that the results are similar to the experiment with infrastructure subsidies.

4.4 Discussion

Comparing the results of ad-hoc deregulation in Section 4.2 and the results of deregulation induced by federal policies in Section 4.3, we see that, for a given productivity growth, welfare gains are much larger when cities optimally deregulate in response to federal incentives. This is partly due to the fact that cities with larger regulatory constraints have greater incentives to relax regulation and partly because in these experiments deregulation brings additional benefits, such as redistribution of infrastructure or land rents. The fact that in both policy experiments welfare-maximizing taxes yield minimal regulation highlights that in this model the benefits of regulation (lower congestion and larger land rents accrued by owners) are swamped by its costs, and therefore it is optimal to have as little regulation as possible. While in practice dramatic deregulation may be undesirable, note that in this model deregulation of housing supply lowers the land share in developers' expenditures and increases the productivity of developers. It does not affect beneficial aspects of regulation, such as safety requirements, separation of residential and industrial areas, etc.

Deregulation increases aggregate output and productivity by reallocating workers to more productive cities. This reallocation effect is compounded by agglomeration externalities. The flipside of aggregate productivity gains is higher income inequality. In all counterfactual experiments the variance of log wages goes up substantially, and even more so in the experiments with infrastructure subsidies and a land value tax. Therefore, even though deregulation of land use may result in greater opportunities for an average worker and reduce the welfare gap between renters and owners, it may also lead to an even greater disparity between U.S. cities.

The model abstracts from internal city structure. However, since there are large differences in regulation and supply constraints within MSAs (Baum-Snow and Han, 2022), the effects of deregulation would be uneven for different locations in an MSA. For example, relaxing housing supply constraints in places with greater access to transportation and jobs could yield large benefits. A federal policy that conditions infrastructure on regulation studied above may make cities denser and more transit-oriented.

Despite aggregate welfare benefits of deregulation, in all counterfactual experiments owners' welfare falls. This suggests that, even though federal policies may offset the negative externality that productive cities impose on the rest of the country by over-regulating land use, such policies may not be politically feasible because the median voter is a homeowner.

At the same time, there may be alternatives to deregulation. If the access to jobs improves due to better commuter transportation, more workers could benefit from the productivity of places such as New York and the Silicon Valley, as discussed in Hsieh and Moretti (2019). However, as we have learned during the Covid-19 pandemic, the access to jobs may improve without better transportation if workers do not have to commute daily and therefore consider living farther from their employers. Delventhal and Parkhomenko (2023) show that when work from home is more widespread, productive metro areas, such as Los Angeles and San Francisco gain workers despite losing residents. In addition, even when workers do not move across metro areas, telecommuting allows for relocations to more distant neighborhoods within metro areas where housing is more affordable and the negative effects of land use regulation on housing supply are less severe.

5 Conclusions

In this paper, I study why land use regulation emerges locally and how it affects the economy of the United States. I build a spatial equilibrium model in which local employment, wages, and rents are determined endogenously, and land use regulation is optimally chosen by local landowners in a political setting. In equilibrium, cities with high productivity and attractive amenities tend to choose excessive regulation. These choices lead to spatial misallocation of labor and, as a result, reduce aggregate output. I argue that hypothetical federal policies that discourage local regulation, such as infrastructure subsidies conditional on the level of regulation or a land value tax, could partly mitigate the negative effects of regulation and yield aggregate productivity and welfare gains. At the same time, I find that overall welfare gains are a combination of large gains for renters and smaller losses for owners. Together with the fact that the majority of households are owners, this result helps explain why regulation is so strict in many locations and why even federal policies that encourage deregulation may not find the support of the median voter.

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A Model Extensions

A.1 Homeownership Costs

The model in Section 2 assumes that homeowners do not incur any costs of owning a house, even though in practice these costs are large (maintenance, mortgage interest expenses, property taxes, etc.). Instead, let ω_j be the per-unit cost of owning a house in city j. Then the disposable income of a homeowner becomes $w_j + T_j - \omega_j \bar{h}_j$. Because all owners are identical and earn the same land value transfer, the ratio $\omega_j \bar{h}_j/(w_j + T_j)$ is the same for all owners in city j. Let us denote this ratio by Ω_j. Therefore, the disposable income of homeowners is $(1 - \Omega_j)(w_j + T_j)$, and the indirect utility is

$$\bar{v}\left(w_j + T_j, X_j\right) = (1-\gamma)\ln\left(1-\Omega_j\right) + (1-\gamma)\ln\left(w_j + T_j\right) + \gamma \ln \bar{h}_j + \ln X_j,$$

How does the introduction of the ownership cost affect the choices of homeowners? Since they do not make the location choice in the benchmark economy, the only relevant choice is voting for regulation. However, since ownership costs are exogenous and additive in the indirect utility function, they do not change the first-order condition for equilibrium regulation (23). Therefore, homeowners would choose the same level of regulation regardless of the size of ownership costs.

B Proofs

B.1 Proof of Proposition 1

Define objective function Φ. Using equation (5), we can characterize the equilibrium supply of renters in city j with function

$$\Phi\left(\tilde{N}_j, z_j\right) = \tilde{N}_j - \frac{C_j^{1/\sigma}}{C}\tilde{N} = 0,$$

where $C_j \equiv w_j r_j^{-\gamma} X_j$ is the composite consumption in location j and $C \equiv \sum_{k \in \mathcal{J}} C_k^{1/\sigma}$. The dependence of variables on $\tilde{N}_j$ and z_j is suppressed for brevity. Using the implicit function theorem, one can write the derivative of the supply of renters with respect to land use regulation as

$$\frac{d\tilde{N}_j}{dz_j} = -\frac{\frac{d\Phi\left(\tilde{N}_j, z_j\right)}{dz_j}}{\frac{d\Phi\left(\tilde{N}_j, z_j\right)}{d\tilde{N}_j}}. \tag{43}$$

Derivative of Φ with respect to regulation. The numerator on the right-hand side of (43) is

$$\frac{d\Phi\left(\tilde{N}_j, z_j\right)}{dz_j} = \frac{d\tilde{N}_j}{dz_j} - \left[\frac{1}{\sigma}\frac{C_j^{1/\sigma}}{C}\frac{1}{C_j}\frac{dC_j}{dz_j} - \frac{1}{\sigma}\frac{C_j^{1/\sigma}}{C}\sum_{k\in\mathcal{J}}\frac{C_k^{1/\sigma}}{C}\frac{1}{C_k}\frac{dC_k}{dz_j}\right]\tilde{N}.$$

Let $\mathcal{E}(y_k, x_j) \equiv \frac{1}{y_k}\frac{dy_k}{dx_j}$ denote the semi-elasticity of variable y_k with respect to x_j. Then the previous expression can be written as

$$\frac{d\Phi\left(\tilde{N}_j, z_j\right)}{dz_j} = \frac{d\tilde{N}_j}{dz_j} - \frac{1}{\sigma}\frac{C_j^{1/\sigma}}{C}\left[\left(1 - \frac{C_j^{1/\sigma}}{C}\right)\mathcal{E}(C_j, z_j) - \sum_{k\neq j}\frac{C_k^{1/\sigma}}{C}\mathcal{E}(C_k, z_j)\right]\tilde{N}.$$

The term in the summation operator is the average semi-elasticity of composite consumption in city k with respect to regulation in city j. Since regulation in city j affects outcomes in other cities only indirectly, its magnitude is negligible relative to the semi-elasticity of consumption in city j. Therefore, the previous expression can be approximated as

$$\frac{d\Phi\left(\tilde{N}_j, z_j\right)}{dz_j} \approx \frac{d\tilde{N}_j}{dz_j} - \frac{1}{\sigma}\mathcal{E}(C_j, z_j)\tilde{N}\frac{C_j^{1/\sigma}}{C}\left(1 - \frac{C_j^{1/\sigma}}{C}\right).$$

Using the definition of C_j, one can write the previous expression as

$$\frac{d\Phi\left(\tilde{N}_j, z_j\right)}{dz_j} \approx \frac{d\tilde{N}_j}{dz_j} - \frac{\left(1 - \tilde{n}_j\right)\tilde{N}_j}{\sigma}\mathcal{E}(C_j, z_j), \tag{44}$$

where $\tilde{n}_j \equiv \tilde{N}_j/\tilde{N}$. Note that the semi-elasticity of composite consumption with respect to regulation can be decomposed as

$$\mathcal{E}(C_j, z_j) = \mathcal{E}(w_j, z_j) + \mathcal{E}(X_j, z_j) - \gamma\mathcal{E}(r_j, z_j).$$

Consider separately each of the three elasticities. The semi-elasticity of wages with respect to regulation is

$$\mathcal{E}(w_j, z_j) = \frac{1}{w_j}\frac{dw_j}{dz_j} = \frac{1}{w_j}\frac{\partial w_j}{\partial N_j}\frac{dN_j}{dz_j} = \frac{\rho}{N}\frac{d\tilde{N}_j}{dz_j}. \tag{45}$$

The semi-elasticity of amenities is given by

$$\mathcal{E}(X_j, z_j) = \frac{1}{X_j}\frac{dX_j}{dz_j} = \frac{1}{X_j}\frac{\partial X_j}{\partial N_j}\frac{dN_j}{dz_j} = -\frac{\theta}{N}\frac{d\tilde{N}_j}{dz_j}. \tag{46}$$

Finally, the semi-elasticity of rents is

$$\mathcal{E}(r_j, z_j) = \frac{1}{r_j}\frac{dr_j}{dz_j} = \eta'(z_j)\left(\ln\left(\frac{1-\eta(z_j)}{\eta(z_j)}\right) + \ln l_j\right) - \chi_j'(z_j) + \eta(z_j)\mathcal{E}(l_j, z_j), \tag{47}$$

where the semi-elasticity of land prices with respect to regulation is

$$\mathcal{E}(l_j, z_j) = \frac{1}{l_j}\frac{dl_j}{dz_j} = \frac{\eta'(z_j)}{\eta(z_j)} + \left(\frac{\rho}{N_j} + \frac{1}{\tilde{N}_j}\right)\frac{d\tilde{N}_j}{dz_j}. \tag{48}$$

Combining all semi-elasticities and plugging them into (44), we have

$$\begin{aligned}
\frac{d\Phi\left(\tilde{N}_j, z_j\right)}{dz_j} &\approx \frac{d\tilde{N}_j}{dz_j} - \frac{\left(1-\tilde{n}_j\right)\tilde{N}_j}{\sigma}\frac{\rho-\theta}{N_j}\frac{d\tilde{N}_j}{dz_j} \\
&\quad + \frac{\gamma\left(1-\tilde{n}_j\right)\tilde{N}_j}{\sigma}\left[\eta'(z_j)\left(1+\ln\left(\frac{1-\eta(z_j)}{\eta(z_j)}\right)+\ln l_j\right) - \chi_j'(z_j) + \eta(z_j)\left(\frac{\rho}{N_j}+\frac{1}{\tilde{N}_j}\right)\frac{d\tilde{N}_j}{dz_j}\right] \\
&= \left[1 - \frac{\left(1-\tilde{n}_j\right)\tilde{N}_j}{\sigma}\left(\frac{\rho-\theta}{N_j} - \gamma\eta(z_j)\left(\frac{\rho}{N_j}+\frac{1}{\tilde{N}_j}\right)\right)\right]\frac{d\tilde{N}_j}{dz_j} \\
&\quad + \frac{\gamma\left(1-\tilde{n}_j\right)\tilde{N}_j}{\sigma}\left[\eta'(z_j)\left(1+\ln\left(\frac{1-\eta(z_j)}{\eta(z_j)}\right)+\ln l_j\right) - \chi_j'(z_j)\right].
\end{aligned} \tag{49}$$

Derivative of Φ with respect to labor supply. Let us now turn to the denominator on the right-hand side of the expression (43). It is equal to

$$\begin{aligned}
\frac{d\Phi\left(\tilde{N}_j, z_j\right)}{dN_j} &= 1 - \left[\frac{1}{\sigma}\frac{C_j^{1/\sigma}}{C}\frac{1}{C_j}\frac{dC_j}{d\tilde{N}_j} - \frac{1}{\sigma}\frac{C_j^{1/\sigma}}{C}\sum_{k\in\mathcal{J}}\frac{C_k^{1/\sigma}}{C}\frac{1}{C_k}\frac{dC_k}{d\tilde{N}_j}\right]\tilde{N} \\
&= 1 - \frac{1}{\sigma}\frac{C_j^{1/\sigma}}{C}\left[\left(1-\frac{C_j^{1/\sigma}}{C}\right)\mathcal{E}(C_j, \tilde{N}_j) - \sum_{k\neq j}\frac{C_k^{1/\sigma}}{C}\mathcal{E}(C_k, \tilde{N}_j)\right]\tilde{N}.
\end{aligned}$$

As before, note that the average semi-elasticity of composite consumption in cities other than j with respect to the supply of renters in j is negligible relative to the semi-elasticity of consumption in j. As a result, the previous expression can be approximated as

$$\frac{d\Phi\left(\tilde{N}_j, z_j\right)}{d\tilde{N}_j} \approx 1 - \frac{\left(1-\tilde{n}_j\right)\tilde{N}}{\sigma}\mathcal{E}(C_j, \tilde{N}_j).$$

The semi-elasticity of composite consumption with respect to the supply of renters can be decomposed as

$$\mathcal{E}(C_j, N_j) = \mathcal{E}(w_j, N_j) + \mathcal{E}(X_j, N_j) - \gamma\mathcal{E}(r_j, N_j).$$

Consider separately each of the three elasticities. The semi-elasticity of wages with respect to the supply of renters is

$$\mathcal{E}(w_j, \tilde{N}_j) = \frac{1}{w_j}\frac{dw_j}{d\tilde{N}_j} = \frac{\rho}{N}.$$

The semi-elasticity of amenities with respect to the supply of renters is given by

$$\mathcal{E}(X_j, \tilde{N}_j) = \frac{1}{X_j}\frac{dX_j}{d\tilde{N}_j} = -\frac{\theta}{N}.$$

Finally, the semi-elasticity of rents with respect to the supply of renters is

$$\mathcal{E}(r_j, \tilde{N}_j) = \frac{1}{r_j}\frac{dr_j}{d\tilde{N}_j} = \eta(z_j)\mathcal{E}(l_j, \tilde{N}_j),$$

where the semi-elasticity of land prices with respect to the supply of renters is

$$\mathcal{E}(l_j, \tilde{N}_j) = \frac{1}{l_j}\frac{dl_j}{d\tilde{N}_j} = \frac{\rho}{N_j} + \frac{1}{\tilde{N}_j}.$$

Combining all semi-elasticities, one can write $d\Phi\left(\tilde{N}_j, z_j\right)/d\tilde{N}_j$ as

$$\frac{d\Phi\left(\tilde{N}_j, z_j\right)}{d\tilde{N}_j} \approx 1 - \frac{\left(1-\tilde{n}_j\right)\tilde{N}}{\sigma}\left[\frac{\rho-\theta}{N} - \gamma\eta(z_j)\left(\frac{\rho}{N_j} + \frac{1}{\tilde{N}_j}\right)\right]. \tag{50}$$

Relationship between regulation and labor supply. Plugging in expressions (49) and (50) into (43), we obtain

$$\frac{d\tilde{N}_j}{dz_j} = \frac{\gamma}{2}\left(\eta'(z_j)\left(1 + \ln\left(\frac{1-\eta(z_j)}{\eta(z_j)}\right) + \ln l_j\right) - \chi_j'(z_j)\right)\left(\frac{(1-\gamma\eta(z_j))\rho - \theta}{N_j} - \frac{\gamma\eta(z_j) + \sigma/(1-\tilde{n}_j)}{\tilde{N}_j}\right)^{-1} \tag{51}$$

Proof of part (a) of Proposition 1. Let condition (20) hold. Then

$$\frac{(1-\gamma\eta(z_j))\rho - \theta}{N_j} - \frac{\gamma\eta(z_j) + \sigma/(1-\tilde{n}_j)}{\tilde{N}_j} < 0,$$

i.e., the second term in the parenthesis in equation (51) is negative. Since $\chi_j'(z_j) \leq 0$ and assuming l_j is sufficiently large (prices can always be rescaled without loss of generality), we have

$$\ln l_j > \frac{\chi_j'(z_j)}{\eta'(z_j)} - \ln\left(\frac{1-\eta(z_j)}{\eta(z_j)}\right) - 1,$$

Therefore,

$$\frac{d\tilde{N}_j}{dz_j} < 0,$$

i.e., the equilibrium supply of renters is decreasing in the stringency of regulation ■

Proof of part (b) of Proposition 1. Using expressions (47), (48) and (51), one can write the semi-elasticity of rents with respect to regulation as

$$\frac{1}{r_j}\frac{dr_j}{dz_j} = \frac{2}{\gamma}\left(\frac{(1-\gamma\eta(z_j))\rho - \theta}{N_j} - \frac{\gamma\eta(z_j) + \sigma/(1-\tilde{n}_j)}{\tilde{N}_j}\right)\frac{d\tilde{N}_j}{dz_j} + \eta(z_j)\left(\frac{\rho}{N_j} + \frac{1}{\tilde{N}_j}\right)\frac{d\tilde{N}_j}{dz_j}.$$

As long as $d\tilde{N}_j/dz_j < 0$, the necessary and sufficient condition for rents to be increasing in regulation is

$$\frac{(1-\gamma\eta(z_j))\rho - \theta}{N_j} - \frac{\gamma\eta(z_j) + \sigma/(1-\tilde{n}_j)}{\tilde{N}_j} + \frac{\gamma\eta(z_j)}{2}\left(\frac{\rho}{N_j} + \frac{1}{\tilde{N}_j}\right) < 0,$$

which, after a few steps of algebra becomes

$$\frac{\rho - \theta}{N_j} - \frac{1}{2}\frac{\gamma\eta(z_j)\rho}{N_j} - \frac{1}{2}\frac{\gamma\eta(z_j)}{\tilde{N}_j} - \frac{\sigma/(1-\tilde{n}_j)}{\tilde{N}_j} < 0.$$

This inequality holds as long as condition (20) holds ■

Proof of part (c) of Proposition 1. From expression (48), land prices are increasing in regulation if and only if

$$\frac{\eta'(z_j)}{\eta(z_j)} + \left(\frac{\rho}{N_j} + \frac{1}{\tilde{N}_j}\right)\frac{d\tilde{N}_j}{dz_j} > 0.$$

or

$$\frac{\eta'(z_j)}{\eta(z_j)} > -(1+\rho\hat{n}_j)\mathcal{E}(\tilde{N}_j, z_j) \quad ■$$

B.2 Proof of Corollary 1

Since the utility function is Cobb-Douglas, housing demand in city j is given by

$$H_j = \frac{\gamma w_j \tilde{N}_j}{r_j}.$$

If conditions (19) and (20) are satisfied, then $\tilde{N}_j$ is decreasing in z_j and r_j is increasing in z_j, as shown in parts (a) and (b) of Proposition 1. Furthermore, as demonstrated in equation (45) above, w_j is decreasing in z_j. Therefore, $dH_j/dz_j < 0$. This proves part (a) of the Corollary, and equation (45) proves part (b). Finally, part (c) is a direct result of part (a) of Proposition 1 the fact that local amenities is a decreasing function of local employment (equation 8) ■

B.3 Proof of Proposition 2

Define objective function Ψ. Using expression (23), define function

$$\Psi(z_j) \equiv \frac{1-\gamma}{w_j + T_j}\left(\frac{dw_j}{dz_j} + \frac{dT_j}{dz_j}\right) + \frac{1}{X_j}\frac{dX_j}{dz_j} - \kappa'(z_j) = 0.$$

Consider the derivative of regulation with respect to a variable or a parameter x. Thanks to the implicit function theorem, it can be written as

$$\frac{dz_j}{dx_j} = -\frac{\frac{d\Psi(z_j)}{dx_j}}{\frac{d\Psi(z_j)}{dz_j}}. \tag{52}$$

For convenience, rewrite Ψ as

$$\Psi(z_j) = (1-\gamma)\left[\left(1 + \frac{T_j}{w_j}\right)^{-1} \mathcal{E}(w_j, z_j) + \left(1 + \frac{w_j}{T_j}\right)^{-1} \mathcal{E}(T_j, z_j)\right] + \mathcal{E}(X_j, z_j) - \kappa'(z_j), \tag{53}$$

where $\mathcal{E}(y_k, x_j) \equiv \frac{1}{y_k}\frac{dy_k}{dx_j}$ is the semi-elasticity of variable y_k with respect to x_j.

From equation (15), the semi-elasticity of transfers with respect to regulation is

$$\mathcal{E}(T_j, z_j) = \frac{\eta'(z_j)}{\eta(z_j)} + \mathcal{E}(w_j, z_j) + \mathcal{E}(\tilde{N}_j, z_j). \tag{54}$$

Also, from expressions (45) and (46), we find that the semi-elasticities of wages and amenities are

$$\mathcal{E}(w_j, z_j) = \rho \hat{n}_j \mathcal{E}(\tilde{N}_j, z_j) \tag{55}$$

and

$$\mathcal{E}(X_j, z_j) = -\theta \hat{n}_j \mathcal{E}(\tilde{N}_j, z_j), \tag{56}$$

where $\hat{n}_j \equiv \tilde{N}_j / N_j$. Plugging in expressions (54), (55) and (56) into (53) and dividing it by $\hat{n}_j$, we can rewrite function Ψ as

$$\Psi(z_j) = \frac{(1-\gamma)\gamma}{1-(1-\eta(z_j)\gamma)\hat{n}_j}\left(\eta'(z_j) + \eta(z_j)\mathcal{E}(\tilde{N}_j, z_j)\right) + ((1-\gamma)\rho - \theta)\,\mathcal{E}(\tilde{N}_j, z_j) - \frac{\kappa'(z_j)}{\hat{n}_j}. \tag{57}$$

Derivatives of semi-elasticities. Using expression (51), we can write the semi-elasticity of the supply of renters with respect to regulation as

$$\mathcal{E}(\tilde{N}_j, z_j) = \frac{\gamma}{2}\frac{\Delta_j^1}{\Delta_j^2}, \tag{58}$$

where

$$\Delta_j^1 \equiv \eta'(z_j)\left(1 + \ln\left(\frac{1-\eta(z_j)}{\eta(z_j)}\right) + \ln l_j\right) - \chi_j'(z_j),$$
$$\Delta_j^2 \equiv \left((1-\gamma\eta(z_j))\rho - \theta\right)\hat{n}_j - \gamma\eta(z_j) - \sigma/(1-\tilde{n}_j).$$

Note that, condition (20) implies that $\Delta_j^2 < 0$. At the same time $\chi_j'(z_j) \leq 0$ and the assumption that land prices are high enough (prices can always be rescaled without loss of generality) imply that $\Delta_j^2 > 0$. The derivative of $\mathcal{E}(\tilde{N}_j, z_j)$ with respect to a variable x is equal to

$$\frac{d\mathcal{E}(\tilde{N}_j, z_j)}{dx} = \mathcal{E}(\tilde{N}_j, z_j)\mathcal{E}_x(\tilde{N}_j, z_j), \tag{59}$$

where

$$\mathcal{E}_x(\tilde{N}_j, z_j) \equiv \frac{1}{\Delta_j^1}\frac{d\Delta_j^1}{dx} - \frac{1}{\Delta_j^2}\frac{d\Delta_j^2}{dx}$$

Derivatives of function Ψ. Using equations (57) and (59), we can find the derivative of function Ψ with respect to a variable of interest x:

$$\frac{d\Psi(z_j)}{dx_j} = \Psi_j^1\frac{dz_j}{dx_j} + \Psi_j^2\mathcal{E}_x(\tilde{N}_j, z_j)\mathcal{E}(\tilde{N}_j, z_j) + \Psi_j^3\mathcal{E}(\tilde{N}_j, x_j),$$

where Ψ_j^1, Ψ_j^2 and Ψ_j^3 are independent of x and are defined as

$$\Psi_j^1 \equiv \frac{(1-\gamma)\gamma}{1-(1-\eta(z_j)\gamma)\hat{n}_j}\left(\eta'(z_j)\mathcal{E}(\tilde{N}_j, z_j) - \frac{\eta'(z_j)\gamma\hat{n}_j}{1-(1-\eta(z_j)\gamma)\hat{n}_j}\right) - \frac{1}{\hat{n}_j}\kappa''(z_j),$$
$$\Psi_j^2 \equiv \frac{(1-\gamma)\eta(z_j)\gamma}{1-(1-\eta(z_j)\gamma)\hat{n}_j} + \Big((1-\gamma\eta(z_j))\rho - \theta\Big),$$
$$\Psi_j^3 \equiv \frac{1-\hat{n}_j}{\hat{n}_j}\kappa'(z_j) + \frac{(1-\gamma)\gamma(1-\eta(z_j)\gamma)(1-\hat{n}_j)\hat{n}_j}{\Big(1-(1-\eta(z_j)\gamma)\hat{n}_j\Big)^2}.$$

At the same time, the derivative of Ψ with respect to regulation is

$$\frac{d\Psi(z_j)}{dz_j} = \Psi_j^4\mathcal{E}(\tilde{N}_j, z_j) - \frac{1}{\hat{n}_j}\kappa''(z_j). \tag{60}$$

where

$$\Psi_j^4 \equiv \frac{(1-\gamma)\gamma}{1-(1-\eta(z_j)\gamma)\hat{n}_j}\Bigg[\Big(\eta'(z_j) + \eta(z_j)\mathcal{E}_z(\tilde{N}_j, z_j)\Big)$$
$$+ \frac{(1-\eta(z_j)\gamma)(1-\hat{n}_j)\hat{n}_j - \eta'(z_j)\gamma\hat{n}_j\mathcal{E}(\tilde{N}_j, z_j)^{-1}}{1-(1-\eta(z_j)\gamma)\hat{n}_j}\Big(\eta'(z_j) + \eta(z_j)\mathcal{E}(\tilde{N}_j, z_j)\Big)\Bigg]$$
$$+ \left((1-\gamma)\rho - \theta\right)\mathcal{E}_z(\tilde{N}_j, z_j) + \frac{1-\hat{n}_j}{\hat{n}_j}\kappa'(z_j).$$

Plugging in the derivatives of Ψ into (52), we obtain

$$\frac{dz_j}{dx_j} = -\frac{\Psi_j^1\frac{dz_j}{dx_j} + \Psi_j^2\mathcal{E}_x(\tilde{N}_j, z_j)\mathcal{E}(\tilde{N}_j, z_j) + \Psi_j^3\mathcal{E}(\tilde{N}_j, x_j)}{\Psi_j^4\mathcal{E}(\tilde{N}_j, z_j) - \kappa''(z_j)/\hat{n}_j}.$$

Solving out for $\frac{dz_j}{dx_j}$ yields

$$\frac{dz_j}{dx_j} = -\frac{\Psi_j^2\mathcal{E}_x(\tilde{N}_j, z_j)\mathcal{E}(\tilde{N}_j, z_j) + \Psi_j^3\mathcal{E}(\tilde{N}_j, x_j)}{\Psi_j^1 + \Psi_j^4\mathcal{E}(\tilde{N}_j, z_j) - \kappa''(z_j)/\hat{n}_j}. \tag{61}$$

Next, I examine two separate cases. In Case 1, the congestion externalities are relatively strong, so that

$$\theta \geq (1-\gamma\eta(z_j))\rho + \frac{(1-\gamma)\gamma\eta(z_j)}{1-(1-\gamma\eta(z_j))\hat{n}_j}. \tag{62}$$

In Case 2, they are relatively weak, and condition (62) does not hold.

B.3.1 Case 1

The following lemma characterizes sufficient conditions for $dz_j/dx_j > 0$.

Lemma 1. Suppose that conditions (20) and (21) hold, and let the lobbying cost be convex, i.e., $\kappa''(z) > 0$. Furthermore, assume that parameters γ, θ and ρ, and the land share $\eta(z_j)$ satisfy

$$2\left(1+\rho\hat{n}_j\right)\left[\hat{n}_j - \frac{\gamma\eta(z_j) - \frac{\sigma}{1-\tilde{n}_j}}{(1-\gamma\eta(z_j))\rho - \theta}\right] < \left(1-\hat{n}_j\right)\hat{n}_j\left[\left(1+\ln\left(\frac{1-\eta(z_j)}{\eta(z_j)}\right)+\ln l_j\right) - \frac{\chi_j'(z_j)}{\eta'(z_j)}\right] \quad (63)$$

Then the sufficient conditions for $dz_j/dx_j > 0$ are

(a) $\mathcal{E}_x(\tilde{N}_j, z_j) > 0$

(b) $\mathcal{E}(\tilde{N}_j, x_j) > 0$.

Proof. The term $\mathcal{E}_z(\tilde{N}_j, z_j)$ is equal to

$$\mathcal{E}_z(\tilde{N}_j, z_j) = \frac{(1+\rho\hat{n}_j)\mathcal{E}(\tilde{N}_j, z_j) - \frac{\eta'(z_j)}{1-\eta(z_j)}}{1+\ln\left(\frac{1-\eta(z_j)}{\eta(z_j)}\right)+\ln l_j - \frac{\chi_j'(z_j)}{\eta'(z_j)}} - \frac{\left[\left((1-\gamma\eta(z_j))\rho-\theta\right)\hat{n}_j(1-\hat{n}_j) - \frac{\sigma\tilde{n}_j}{(1-\tilde{n}_j)^2}\right]\mathcal{E}(\tilde{N}_j, z_j) - \eta'(z_j)\gamma(1+\rho\hat{n}_j)}{\left((1-\gamma\eta(z_j))\rho-\theta\right)\hat{n}_j - \gamma\eta(z_j) - \frac{\sigma}{1-\tilde{n}_j}}.$$

Since $\mathcal{E}(\tilde{N}_j, z_j) < 0$, the first ratio is negative. When condition (20) and condition 63 hold, the second ratio is positive.[35] Hence, $\mathcal{E}_z(\tilde{N}_j, z_j) < 0$. Furthermore, as can be seen from equation (60), condition (21) implies that $\Psi_j^4 > 0$. Condition (62) implies that $\Psi_j^2 < 0$. Also notice that $\Psi_j^3 > 0$. Finally, because $\mathcal{E}(\tilde{N}_j, z_j) < 0$, we have $\Psi_j^1 < 0$.

Expression (61) illustrates that, whenever $\Psi_j^1 < 0$, $\Psi_j^2 < 0$, $\Psi_j^3 > 0$, $d\Psi(z_j)/dz_j < 0$ and $\mathcal{E}(\tilde{N}_j, z_j) < 0$, and when condition (3) holds, sufficient conditions for $dz_j/dx_j > 0$ are $\mathcal{E}_x(\tilde{N}_j, z_j) > 0$ and $\mathcal{E}(\tilde{N}_j, x_j) > 0$ ■

Proof of part (a) of Proposition 2. According to Lemma 1, in order to demonstrate that $dz_j/d\bar{A}_j > 0$, it is sufficient to show that $\mathcal{E}_{\bar{A}}(\tilde{N}_j, z_j) > 0$ and $\mathcal{E}(\tilde{N}_j, \bar{A}_j) > 0$.

[35] It is easy to show that condition 63 is equivalent to $\frac{\eta'(z_j)\gamma(1+\rho\hat{n}_j)}{(1-\hat{n}_j)\hat{n}_j\mathcal{E}(\tilde{N}_j, z_j)} < (1-\gamma\eta(z_j))\rho - \theta$. Also, it will hold when land prices are high enough, which can be achieved by scaling up prices.

First, consider $\mathcal{E}(\tilde{N}_j, \bar{A}_j)$. This part of the proof uses results from the proof of Proposition 1. From equation (5), the equilibrium supply of renters in city j is characterized by function

$$\Phi\left(\tilde{N}_j, \bar{A}_j\right) = \tilde{N}_j - \frac{C_j^{1/\sigma}}{C}\tilde{N} = 0,$$

where $C_j \equiv w_j r_j^{-\gamma} X_j$ is the composite consumption in location j and $C \equiv \sum_{k \in \mathcal{J}} C_k^{1/\sigma}$. Using the implicit function theorem, one can write the derivative of the supply of renters with respect to land use regulation as

$$\frac{d\tilde{N}_j}{d\bar{A}_j} = -\frac{\frac{d\Phi\left(\tilde{N}_j, \bar{A}_j\right)}{d\bar{A}_j}}{\frac{d\Phi\left(\tilde{N}_j, \bar{A}_j\right)}{d\tilde{N}_j}}. \tag{64}$$

Using steps from the proof of Proposition 1, we find that the numerator is equal to

$$\frac{d\Phi\left(\tilde{N}_j, \bar{A}_j\right)}{d\bar{A}_j} = \left[1 - \frac{(1-\tilde{n}_j)\tilde{N}_j}{\sigma}\left(\frac{\rho-\theta}{N_j} - \eta(z_j)\gamma\left(\frac{\rho}{N_j} + \frac{1}{\tilde{N}_j}\right)\right)\right]\frac{d\tilde{N}_j}{d\bar{A}_j} - \frac{(1-\tilde{n}_j)\tilde{N}_j}{\sigma}\frac{1}{\bar{A}_j} \tag{65}$$

Similarly, the denominator is given by the expression (50). Plugging in expressions (65) and (50) into (64), we obtain

$$\frac{d\tilde{N}_j}{d\bar{A}_j} = \frac{1}{2\bar{A}_j}\left(\frac{\gamma\eta(z_j) + \sigma/(1-\tilde{n}_j)}{\tilde{N}_j} - \frac{(1-\gamma\eta(z_j))\rho - \theta}{N_j}\right)^{-1}.$$

As long as condition (20) holds, we have $d\tilde{N}_j/d\bar{A}_j > 0$, and therefore $\mathcal{E}(\tilde{N}_j, \bar{A}_j) > 0$.

Second, consider $\mathcal{E}_{\bar{A}}(\tilde{N}_j, z_j)$. It is equal to

$$\mathcal{E}_{\bar{A}}(\tilde{N}_j, z_j) = \frac{1}{\Delta_j^1}\frac{d\Delta_j^1}{d\bar{A}_j} - \frac{1}{\Delta_j^2}\frac{d\Delta_j^2}{d\bar{A}_j}.$$

The derivative of Δ_j^1 with respect to $\bar{A}_j$ is

$$\frac{d\Delta_j^1}{d\bar{A}_j} = \eta'(z_j)\left((1+\rho\hat{n}_j)\mathcal{E}(\tilde{N}_j, \bar{A}_j) + \frac{1}{\bar{A}_j}\right).$$

The derivative of Δ_j^2 with respect to $\bar{A}_j$ is

$$\frac{d\Delta_j^2}{d\bar{A}_j} = \left[\left((1-\eta(z_j)\gamma)\rho - \theta\right)(1-\hat{n}_j)\hat{n}_j - \frac{\sigma\tilde{n}_j}{(1-\tilde{n}_j)^2}\right]\mathcal{E}(\tilde{N}_j, \bar{A}_j).$$

Then, combining the previous two expressions, we obtain

$$\mathcal{E}_{\bar{A}}(\tilde{N}_j, z_j) = \left[\frac{1}{\Delta_j^1}\eta'(z_j)(1+\rho\hat{n}_j) - \frac{1}{\Delta_j^2}\left(\left((1-\eta(z_j)\gamma)\rho - \theta\right)(1-\hat{n}_j)\hat{n}_j - \frac{\sigma\tilde{n}_j}{(1-\tilde{n}_j)^2}\right)\right]\mathcal{E}(\tilde{N}_j, \bar{A}_j) + \frac{1}{\Delta_j^1}\frac{\eta'(z_j)}{\bar{A}_j}.$$

Because condition (20) holds, and since $\Delta_j^1 > 0$, $\Delta_j^2 < 0$, and $\mathcal{E}(\tilde{N}_j, \bar{A}_j) > 0$, we have $\mathcal{E}_{\bar{A}}(\tilde{N}_j, z_j) > 0$ ■

Proof of part (b) of Proposition 2. According to Lemma 1, in order to demonstrate that $dz_j/d\alpha_j > 0$, it is sufficient to show that $\mathcal{E}_\alpha(\tilde{N}_j, z_j) > 0$ and $\mathcal{E}(\tilde{N}_j, \alpha_j) > 0$. The proof is similar to the proof of part (a), hence some steps are omitted.

First, consider $\mathcal{E}(\tilde{N}_j, \alpha_j)$. The derivative of the supply of renters with respect to amenities is

$$\frac{d\tilde{N}_j}{d\alpha_j} = -\frac{\frac{d\Phi\left(\tilde{N}_j, \alpha_j\right)}{d\alpha_j}}{\frac{d\Phi\left(\tilde{N}_j, \alpha_j\right)}{d\tilde{N}_j}}, \tag{66}$$

where $\Phi\left(\tilde{N}_j, \alpha_j\right) = \tilde{N}_j - \frac{C_j^{1/\sigma}}{C}\tilde{N} = 0$. The numerator is equal to

$$\frac{d\Phi\left(\tilde{N}_j, \alpha_j\right)}{d\alpha_j} = \left[1 - \frac{(1-\tilde{n}_j)\tilde{N}_j}{\sigma}\left(\frac{\rho-\theta}{N_j} - \eta(z_j)\gamma\left(\frac{\rho}{N_j} + \frac{1}{\tilde{N}_j}\right)\right)\right]\frac{d\tilde{N}_j}{d\alpha_j} - \frac{(1-\tilde{n}_j)\tilde{N}_j}{\sigma}\frac{1}{\alpha_j}, \tag{67}$$

and the denominator is given by the expression (50). Plugging in expressions (67) and (50) into (66), we obtain

$$\frac{d\tilde{N}_j}{d\alpha_j} = \frac{1}{2\alpha_j}\left(\frac{\gamma\eta(z_j) + \sigma/(1-\tilde{n}_j)}{\tilde{N}_j} - \frac{(1-\gamma\eta(z_j))\rho - \theta}{N_j}\right)^{-1}.$$

As long as condition (20) holds, $d\tilde{N}_j/d\alpha_j > 0$, and therefore $\mathcal{E}(\tilde{N}_j, \alpha_j) > 0$.

Second, consider $\mathcal{E}_\alpha(\tilde{N}_j, z_j)$. It is equal to

$$\mathcal{E}_\alpha(\tilde{N}_j, z_j) = \frac{1}{\Delta_j^1}\frac{d\Delta_j^1}{d\alpha_j} - \frac{1}{\Delta_j^2}\frac{d\Delta_j^2}{d\alpha_j}.$$

The derivative of Δ_j^1 with respect to α_j is

$$\frac{d\Delta_j^1}{d\alpha_j} = \eta'(z_j)(1+\rho\hat{n}_j)\mathcal{E}(\tilde{N}_j, \alpha_j).$$

The derivative of Δ_j^2 with respect to α_j is

$$\frac{d\Delta_j^2}{d\alpha_j} = \left[\Big((1-\eta(z_j)\gamma)\rho - \theta\Big)(1-\hat{n}_j)\hat{n}_j - \frac{\sigma\tilde{n}_j}{(1-\tilde{n}_j)^2}\right]\mathcal{E}(\tilde{N}_j, \alpha_j).$$

Then, combining the previous two expressions, we obtain

$$\mathcal{E}_\alpha(\tilde{N}_j, z_j) = \left[\frac{1}{\Delta_j^1}\eta'(z_j)(1+\rho\hat{n}_j) - \frac{1}{\Delta_j^2}\left(\Big((1-\eta(z_j)\gamma)\rho - \theta\Big)(1-\hat{n}_j)\hat{n}_j - \frac{\sigma\tilde{n}_j}{(1-\tilde{n}_j)^2}\right)\right]\mathcal{E}(\tilde{N}_j, \alpha_j).$$

Because condition (20) holds, and since $\Delta_j^1 > 0$, $\Delta_j^2 < 0$, $\mathcal{E}(\tilde{N}_j, \alpha_j) > 0$, we have $\mathcal{E}_\alpha(\tilde{N}_j, z_j) > 0$
■

B.3.2 Case 2

If θ does not satisfy condition 62, then the sufficient condition for results (a) and (b) is that

$$\Psi_j^2\mathcal{E}_x(\tilde{N}_j, z_j)\mathcal{E}(\tilde{N}_j, z_j) + \Psi_j^3\mathcal{E}(\tilde{N}_j, x_j) > 0.$$

Given that $\mathcal{E}_x(\tilde{N}_j, z_j)\mathcal{E}(\tilde{N}_j, z_j) = \frac{\partial\mathcal{E}(\tilde{N}_j, z_j)}{\partial x_j}$, this condition can be written as

$$\frac{\Psi_j^3}{\Psi_j^2}\mathcal{E}(\tilde{N}_j, x_j) > -\frac{\partial\mathcal{E}(\tilde{N}_j, z_j)}{\partial x_j}. \tag{68}$$

If this condition holds, then the results (a) and (b) can be proved following the same steps as for Case 1.

C Data

Table C.1 reports summary statistics for key data variables used in the quantitative model. Employment, wages and rents for each metropolitan area are calculated using individual level data from the 3% sample of the American Community Survey in 2005–2007. The data was extracted from the IPUMS (Ruggles et al., 2015). The sample is limited to heads of household and their spouses in prime working age (25–64 years old), who are employed and worked at least 35 hours a week for at least 27 weeks in the sample year. Individuals who live in group quarters, work for the government or the military, and those who live in farm houses, mobile homes, trailers, boats, tents, etc., are exluded from the sample. Also excluded are observations with reported annual wage and salary income equivalent

Table C.1: Summary Statistics

	mean	median	s.d.	min	p10	p90	max
Employment share (N_j), %	0.50	0.20	0.93	0.04	0.07	1.16	8.71
Share of incumbents ($\bar{N}_j/N_j$), %	74.4	74.9	6.0	49.5	67.2	81.3	89.0
Residual hourly wage (w_j), $	13.20	13.01	1.28	10.38	11.85	15.11	18.30
Rent index (r_j), $	548	508	154	307	402	720	1140
Land price (l_j), 1000 $ per acre	377	246	440	35	124	608	3178
Urban land area (Λ_j), sq miles	331	180	429	29	57	785	2953
Normalized Wharton Index (z_j)	1.00	1.04	0.27	0.16	0.66	1.31	1.62

Note: The table reports summary statistics for key variables used in the quantitative model.

to less than half the minimum federal hourly wage.

The geographical unit of analysis is metropolitan statistical area (MSA). An MSA consists of a county or several adjacent counties, and is defined by the Census Bureau such that the population of its urban core area is at least 50,000 and job commuting flows between the counties are sufficient for the area to be considered a single labor market. There are 201 MSAs in the 48 contiguous U.S. states such that (1) they can be identified in the IPUMS ACS sample in 2005–2007, (2) the Wharton Index is available for municipalities in the MSA, and (3) the land price data from Albouy, Ehrlich, and Shin (2018) is available. Thus the sample used in this paper only includes individuals residing in one of these 201 MSAs.

Hourly wage is calculated as the reported annual wage income divided by the number of weeks worked per year times the usual hours worked per week. Wages are adjusted for the effects of gender, race, two-digit industry, two-digit occupation, age, and college attainment.

Rents are calculated as follows. For each metro area I construct a quality-adjusted rent index using self-reported rent payments. Each index is calculated using a hedonic regression that controls for housing unit characteristics, such as the number of rooms, the number of units in the building, and the construction year, as in Eeckhout, Pinheiro, and Schmidheiny (2014). Land prices and urban land area are taken from Albouy, Ehrlich, and Shin (2018).

As a measure of regulation, I use the Wharton Residential Land Use Regulatory Index (WRLURI) developed by Gyourko, Saiz, and Summers (2008), based on a survey conducted in 2007. The survey questionnaire was sent to an official responsible for planning and zoning in every municipality in the U.S. and contained a set of questions about local rules of residential land use. The answers were then used to create an index of regulation that summarizes the strictness of regulatory environment for each municipality. The original

WRLURI was constructed at the municipality level. I use the WRLURI aggregated to the MSA level using population weights. Furthermore, I convert it to units suitable for the housing supply specification in this paper by taking the log of the index and adding a constant, so that regulation is positive in all cities and its average is equal to one.[36]

D Comparison to Previous Studies

Several previous papers, including Hsieh and Moretti (2019) and Herkenhoff, Ohanian, and Prescott (2018), also studied how lowering land use restrictions would affect the economy. In the next two experiments, I use my model to repeat the counterfactual experiments conducted in those two papers.

First, following Hsieh and Moretti (2019), I lower regulation in just three cities – New York, San Francisco, and San Jose – fixing it at the national median level of regulation. The results of this experiment are reported in column (2) of Table D.1. Lowering regulation in these three cities to the median results in a 2.1% improvement in labor productivity but a 0.2% decline in welfare. This productivity growth is lower than the one found by Hsieh and Moretti (2019). Specifically, in a version of the model with idiosyncratic location preferences, similar to those used in this paper, they estimate that deregulation in the three cities would lead to a 3.7% increase in output and a comparable welfare gain. They also study deregulation in a model without location preferences and find much larger aggregate effects.

Then, following Herkenhoff, Ohanian, and Prescott (2018), I perform a 50% deregulation toward the average level observed in Texas (z_{TX}), as follows. If city j has $z_j \leq z_{\mathrm{TX}}$, then z_j is kept at the observed level. Otherwise, z_j is lowered 50% toward z_{TX}, i.e. set at the level $z_j - 0.5(z_j - z_{\mathrm{TX}})$. The results are in column (3) of Table D.1. While Herkenhoff, Ohanian, and Prescott (2018) find that a deregulation of this sort would increase labor productivity by 12.4% and welfare by 10.3%, I find that, under the same experiment, labor productivity would increase by much less, 1.9%, and welfare not change much. The model in this paper generates much smaller productivity gains for two main reasons. First, in Herkenhoff, Ohanian, and Prescott (2018), workers do not have individual location preferences and there are no congestion effects. As a result, local labor supply is perfectly elastic. Second, their measures of regulation are model residuals and they find that the parameter which accounts for the stringency of land use restrictions in Texas is several times smaller than

[36]Saiz (2010) uses a similar transformation. Monotonic transformations of the index do not change any of the results in this paper because the quantities that matter for the effect of regulation on rents and prices are the multiples $\hat{\chi} z_j$ and $\hat{\eta} z_j$, and the estimated $\hat{\chi}$ and $\hat{\eta}$ change when the scale of z_j changes.

Table D.1: Effects of Deregulation. Comparison to Other Studies

	Benchmark	(1) $z_j \leq 0.896$ in superstars	(2) Hsieh & Moretti	(3) Herkenhoff et al.	(4) $z_j \leq 0.896$ in superstars (no cong., low σ)
Output, % chg		3.6	2.1	1.9	8.9
Rents, % chg		-19.1	-9.4	-14.5	-14.0
Welfare, % chg		1.2	-0.2	0.1	1.4
owners		-2.2	-1.8	-1.8	-3.4
renters		9.5	4.0	4.9	13.0
Var of log city size	1.18	1.45	1.34	1.39	2.26
Var of log wages ×100	0.88	0.97	0.93	0.97	1.20
Var of log rents ×100	8.50	6.99	8.01	6.20	7.55

Note: The table compares several variables in the benchmark and three counterfactual economies. Column (1) contains results from the counterfactual where land use regulation is capped at the level of Houston in "superstar" cities and corresponds to column (3) in Table 5. Column (2) replicates the experiment in Hsieh and Moretti (2019) using the model of this paper. Column (3) replicates the experiment in Herkenhoff, Ohanian, and Prescott (2018). Column (4) repeats the counterfactual in column (1) using a re-calibrated model with $\sigma = 0.05$ and $\theta = 0$.

the parameter for coastal regions. This paper uses the Wharton Index, according to which the average regulation in Texas is 0.9332, only 0.25 standard deviations below the national mean.

To confirm that strong location preferences and the congestion externality are responsible for smaller productivity gains from deregulation in my paper, I recalibrate the model with $\sigma = 0.05$ and set θ to zero.[37] As a result, the long-run elasticity of employment with respect to a productivity shock increases from 4.16 to 8.03. Results in column (4) of Table D.1 show that with weaker idiosyncratic preferences for locations and without congestion effects, a deregulation to the level of Houston results in a much larger, 8.9% productivity gain, as well as a welfare gain.

Notably, this paper finds negative effects of deregulation on the welfare of owners and, as a result, deregulation brings at most very modest aggregate welfare gains, unlike in Hsieh and Moretti (2019) and Herkenhoff, Ohanian, and Prescott (2018). These two studies only consider renters and therefore may overstate the benefits of deregulating land use.

Why are aggregate welfare gains so small in the last experiment, even though output

[37]In this model σ cannot be lowered to zero. Since $\rho > \theta$, a positive σ is required to obtain a unique spatial equlibrium. See Allen and Arkolakis (2014).

jumps by nearly 9%? Note that wage gains in a given city are relatively small because wages only increase due to agglomeration externalities. With the agglomeration elasticity of $\rho = 0.0401$, this means that even when employment doubles local wages go up by just 4%. At the same time, incumbent owners will lose a substantial part of their transfer income because of lower rents. Moreover, most of the increase in aggregate wages comes from the relocation of labor from less to more productive areas; however, as I describe in Section 4.1, I assume that owners who move become renters and their welfare gains will not be a part of owners' gains.

E Additional Tables and Figures

Table E.1: First-stage regressions

Panel A: Local Employment Instrument

Dependent variable:	$\ln N_j^{2005-2007}$
$\ln Pop_j^{1920}$	0.5576***
	(0.0567)
R^2	0.422

Panel B: Land Use Regulation Instrument

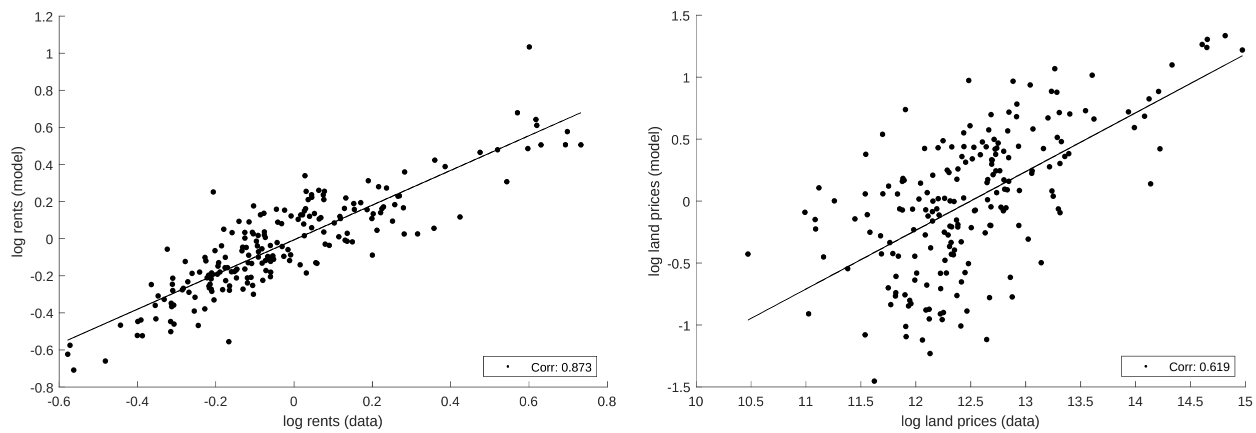
Dependent variable:	z_j
Share of non-traditional Christians	-0.4154***
	(0.0851)
Revenue share of protective inspections	37.334***
	(9.309)
R^2	0.184

Panel C: Land Price Instrument

Dependent variable:	$\ln l_j$
Log of 1 + distance to coast, km	-0.0869***
	(0.0247)
Natural amenities scale	0.1262***
	(0.0149)
R^2	0.424

Notes: Panel A reports the coefficient of an OLS regression of log employment of a metro area in 2005-2007 on log metro area population in 1920. Panel B reports the coefficients of an OLS regression of the normalized Wharton index on the share of local population that belong to non-traditional Christian denominations and the share of protective inspections in the revenues of municipal budgets. Panel C reports the coefficients of an OLS regression of log land prices on log distance to the nearest saltwater coast and the Natural amenities scale. The number of observations in each regression is 201 MSAs. Robust standard errors are reported in parentheses. *, **, and *** indicate 10%, 5%, and 1% significance levels.

Figure E.1: Rents and Land Prices: Model vs Data



Note: The figure shows the relationship between observed and model-predicted local rents and land prices.

Table E.2: Amenities: Model vs Data

Amenity	Corr with $\ln X_j$
Ln College-Employment Ratio	0.42
Ln Student-Teacher Ratio	0.06
Ln K-12 Spending per Student	0.25
Ln Apparel Stores per 1000 Residents	-0.02
Ln Eating and Drinking Places per 1000 Residents	-0.18
Ln Movie Theaters per 1000 Residents	-0.21
Ln Property Crimes per 1000 Residents	0.12
Ln Violent Crimes Per 1000 Residents	0.42
Ln Avg Daily Traffic- Interstates	0.49
Ln Avg Daily Traffic- Major Roads	0.55
Ln EPA Air Quality Index	0.20
Ln Gov Spending on Parks per capita	0.31
Ln Employment Rate	0.10
Ln Patents Per Capita	0.20

Note: The table displays unweighted correlations between the log of amenity levels generated by the model, $\ln X_j$, and several types of amenities observed in the data, as calculated in Diamond (2016).

Table E.3: "Superstar" Cities

MSA	Regulation	Wages	Rents	Combined
Boston, MA-NH	2	4	7	13
San Francisco, CA	10	2	2	14
New York, NY-NJ	11	5	6	22
San Jose, CA	24	1	1	26
Seattle, WA	8	6	12	26
Baltimore, MD	3	11	14	28
Philadelphia, PA-NJ	5	7	16	28
San Diego, CA	16	9	3	28
Washington, DC	20	3	5	28
Los Angeles, CA	15	14	4	33

Note: The table displays ranks of metro areas by regulation (Wharton Index), wages and rents among the 50 largest metro areas. The combined rank is the sum of the three ranks. See Section 4 for details.

Table E.4: Policy Counterfactuals, City-level Results

Panel A: Infrastructure Subsidies

MSA	Exog. prod.	Exog. amen.	Reg., BM	Reg., CF	Emp., % chg	Wages, % chg	Rents, % chg	Land pr., % chg	$\hat{Y}_j$, p.p.
Baltimore, MD	1.08	1.29	1.493	0.604	76	2.3	-57	-56	1.0
Boston, MA-NH	1.12	1.45	1.515	0.714	70	2.2	-51	-46	1.7
Los Angeles, CA	1.01	1.83	1.207	0.849	54	1.8	-31	-17	3.5
New York, NY-NJ	1.09	1.84	1.253	0.858	56	1.8	-34	-18	5.9
Philadelphia, PA	1.05	1.43	1.380	0.489	60	1.9	-58	-68	1.6
San Diego, CA	1.09	1.39	1.197	0.760	43	1.4	-35	-35	0.6
San Francisco, CA	1.21	1.34	1.256	0.732	66	2.1	-43	-32	1.9
San Jose, CA	1.32	1.07	1.117	0.637	57	1.8	-43	-39	0.7
Seattle, WA	1.09	1.26	1.327	0.641	65	2.0	-50	-48	1.0
Washington, DC	1.15	1.42	1.150	0.524	47	1.6	-49	-59	1.5
Other cities	0.99	1.22	1.023	0.848	-23	-0.5	-23	-49	-16.0

Panel B: Land Tax

MSA	Exog. prod.	Exog. amen.	Reg., BM	Reg., CF	Emp., % chg	Wages, % chg	Rents, % chg	Land pr., % chg	$\hat{Y}_j$, p.p.
Baltimore, MD	1.08	1.29	1.493	0.638	75	2.3	-56	-53	1.0
Boston, MA-NH	1.12	1.45	1.515	0.761	68	2.1	-49	-43	1.6
Los Angeles, CA	1.01	1.83	1.207	0.889	54	1.7	-28	-12	3.5
New York, NY-NJ	1.09	1.84	1.253	0.900	56	1.8	-31	-13	5.9
Philadelphia, PA	1.05	1.43	1.380	0.523	58	1.9	-57	-65	1.6
San Diego, CA	1.09	1.39	1.197	0.814	40	1.4	-31	-31	0.6
San Francisco, CA	1.21	1.34	1.256	0.760	68	2.1	-41	-27	2.0
San Jose, CA	1.32	1.07	1.117	0.657	59	1.9	-41	-36	0.7
Seattle, WA	1.09	1.26	1.327	0.677	64	2.0	-48	-44	1.0
Washington, DC	1.15	1.42	1.150	0.559	46	1.5	-47	-55	1.4
Other cities	0.99	1.22	1.023	0.854	-23	-0.4	-23	-49	-15.8

Note: This table shows counterfactual results for each of the ten "superstar" cities as well as all non-"superstar" cities combined. Panel A shows the results for the policy in which the federal government offers infrastructure subsidies conditional on deregulation, as described in column (2) of Table 7. Panel B shows the results for the federal land tax policy, as described in column (2) of Table 8. The columns show the exogenous productivity $\bar{A}_j$, exogenous amenities α_j, benchmark level of regulation (the normalized Wharton index), counterfactual level of regulation, counterfactual changes in employment, wages, rents, land prices, as well as contribution to counterfactual output growth in percentage points.