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 effects. I develop and estimate a spatial equilibrium model where local regulation is determined endogenously, by voting. Homeowners in productive cities with attractive amenities vote for strict regulation. The model accounts for one-third of the observed variation in regulation across cities. Quantitative experiments show that excessive local regulation reduces aggregate productivity. I propose federal policies which raise productivity and welfare by weakening incentives to regulate land use.

Key Words: land use regulation, voting, spatial equilibrium, productivity, misallocation, local subsidies, land tax, rent control
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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 or 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.[1]

This paper studies 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 almost one-third 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, confirming and extending 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. The supply of owners in each location is fixed. Renters choose where to live, and their choice depends on wages, housing costs, local amenities, and idiosyncratic location preferences. Rents depend on housing demand, land supply and land use regulation. Regulation may affect housing supply and rents in two ways. First, it may reduce the efficiency of the construction sector. Second, it may increase the share of land in the production function for housing.

Before introducing the political economy of regulation, I first estimate the model in which regulation is exogenously given. Regulation is measured using the Wharton Residential Land Use Regulatory Index, constructed for the year 2007 by Gyourko, Saiz and Summers (2008). The quantitative model comprises 201 metropolitan areas, and its parameters are disciplined by a set of moments that describe local labor and housing markets in the U.S in 2005-2007. Using the model, I perform a series of 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. At the same time, I find smaller productivity gains from the deregulation than previous studies

[1] See Yglesias (2012), The Economist (2016), and White House (2016), among others.

and do not find any welfare gains. I show that productivity gains are more moderate when one takes into account local congestion externalities and individual location preferences. I also show that distinguishing between homeowners and renters substantially lowers estimated welfare gains, as compared to previous studies most of which only feature renters. When land use regulation is relaxed, renters benefit from lower rents but owners are worse off as land loses value.

While these counterfactual experiments are informative, they overlook the important fact that land use regulation is endogenous and determined by cities themselves. To address this issue, I endogenize land use regulation by introducing a standard model of voting with lobbying. Before renters choose location, incumbent homeowners vote in local elections, where candidates run with a proposed level of regulation. Owners have three main considerations when choosing regulation: congestion, agglomeration and land rents. Under weak assumptions on model parameters, stricter regulation increases rents and land prices, and reduces local employment. Owners benefit from lower congestion, but they also lose from lower wages, since local productivity depends on the city size. At the same time, since homeowners own all land in the city, they benefit from higher land prices. However, in order to convince a candidate to promise to implement a high level of regulation, owners must engage in costly lobbying.

In the model, homeowners in cities with high productivity and attractive amenities prefer stricter regulation and, therefore, are willing to pay a high lobbying cost. This result mimics empirical relationships between regulation, productivity and amenities. I introduce this voting framework in the quantitative model and show that the model accounts for nearly one-third of the observed variation in the Wharton Index. In addition, it successfully replicates empirical relationships between regulation and several variables of interest.

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 space.

An important benefit of having a plausible model of 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 which reduce regulation to an ad-hoc lower level. I propose and study two such policies: federal infrastructure subsidies conditional on the level of regulation and a land tax. Under the first policy, "superstar" cities choose to vote for lower regulation in order to obtain federal funds. Under the second policy, homeowners 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 welfare gains. However, by reallocating labor into more productive metropolitan areas they also lead to a rise in wage inequality across locations.

In addition to these two policies, I also study rent control, a policy that instead of encouraging more housing supply curbs housing costs. Rent control endogenously lowers the supply of rental housing and, as a result, makes the most productive areas smaller and leads to aggregate productivity and welfare losses.

Related Literature. This paper joins recent literature on local and aggregate effects of land use regulation.[2] Like Hsieh and Moretti (2019) and Herkenhoff, Ohanian and Prescott (2018), it also studies aggregate implications of reducing regulation.[3] 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) finds 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 half way to the level of Texas would raise U.S. productivity by as much as 12.4-19.5%. In comparison, this paper finds that lowering regulation in a set of ten large and productive "superstar" cities would increase productivity by 2.7%.

Another closely related paper is Bunten (2017). It 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. However, unlike this paper, which offers a specific policy, Bunten (2017) does not explain how the optimum may be achieved. It also assumes that the main reason why local residents regulate housing supply is congestion, while this paper also gives role to the land rent and the labor productivity channels. Most importantly, given that regulation in Bunten (2017) is modeled as a limit on population, it is unclear if regulation predicted by the model is comparable to the levels we see in the data.

[2]Gyourko and Molloy (2015) provide an excellent review of the literature. Turner, Haughwout and van der Klaauw (2014) find significant negative local welfare effects of regulation.

[3]Another study of aggregate effects of regulation is Ganong and Shoag (2017). It shows that regulation became more different across states in recent decades, and weakened income convergence across states.

The political economy model of this paper builds upon the extensive, largely theoretical, literature on the political economy of regulation and optimal zoning. The three most closely related papers are Brueckner (1996), 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.[4]

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.[5] 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.[6] More broadly, this paper relates to the literature which studies how various local and national policies result in spatial misallocation.[7]

This paper is organized as follows. Section 2 describes the theoretical framework in which land use regulation is an exogenous input. Section 3 discusses the data, estimation and calibration of model parameters and the benchmark quantitative economy. Section 4 studies aggregate and city-specific effects of deregulating land use, and compares the results to previous studies. Section 5 endogenizes land use regulation using a voting model. Section 6 describes hypothetical federal policies which discourage local regulation, studies their effects on the economy and compares them with rent control. Section 7 concludes.

2 Environment

This section introduces a Rosen-Roback spatial equilibrium model in which land use regulation is an exogenous input in the local production function for housing.[8] Then, Section 5 endogenizes regulation using a political economy mechanism.

[4]Earlier work on the political economy of land use regulation and optimal zoning includes Brueckner (1995), Helsley and Strange (1995), Rossi-Hansberg (2004), Calabrese, Epple and Romano (2007), and Solé-Ollé and Viladecans-Marsal (2012). More recently, Albouy et al (2017) and Duranton and Puga (2019) also endogenize housing supply restrictions.

[5]See Glaeser, Gyourko and Saks (2005b), Albouy and Ehrlich (2016), Gyourko, Mayer and Sinai (2013), Van Nieuwerburgh and Weill (2010), Cun and Pesaran (2018), and Yao (2019).

[6]The geographic channel of inequality is studied in Moretti (2013), Baum-Snow and Pavan (2013), Diamond (2016), and Giannone (2018), among others.

[7]See Albouy (2009), Eeckhout and Guner (2017), Fajgelbaum, Morales, Suárez Serrato and Zidar (2018), and Furth (2019), among others.

[8]See Rosen (1979) and Roback (1982).

2.1 Individuals and Cities

The economy is populated by a measure one of individuals who live for one period. The economy consists of J cities, which are indexed by j and belong to set $\mathcal{J} \equiv \{1, ..., J\}$.[9] Each individual lives and works in one of the cities, and local employment is equal to N_j. The total labor supply in the economy is N.

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

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

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

Owners and Renters. In each city, there are $\bar{N}_j$ incumbent workers and $\tilde{N}_j$ immigrant workers, such that $\bar{N}_j + \tilde{N}_j = N_j$. The share of immigrants is denoted by $\hat{n}_j \equiv \tilde{N}_j / N_j$. Incumbents own their houses, while immigrants rent. There is no tenure choice: incumbents were born homeowners and houses occupied by immigrants are owned by developers and cannot be sold to tenants.[10] The number of owners in city j is exogenous, whereas the number of renters is endogenous and determined by optimal location choice.[11] Homeowners do not incur the cost of housing services.[12] An owner in city j consumes an exogenous amount of housing, $\bar{h}_j$. Renters pay rent r_j per unit of housing.

Optimal Choices. Homeowners spend all their disposable income on the consumption of the numeraire. Renters must solve for the optimal amounts of the numeraire and housing. Besides owning their houses, homeowners also own all land in the city, and the lump-sum transfer T_j represents proceeds from land ownership. The owners' budget constraint is $c_j \leq w_j + T_j$, while the renters' budget constraint is $c_j + r_j h_j \leq w_j$. Therefore,

[9] I use interchangeably the notions "city", "location", and "metropolitan statistical area."

[10] I use interchangeably the notions "incumbent" and "homeowner", and "immigrant" and "renter."

[11] It is equivalent to assume that the number of incumbents was determined endogenously in a preceding period when they chose where to live and whether to own a house. In the current period, their location and tenure do not change as they face a sufficiently high moving cost and find it suboptimal to sell their houses.

[12] I abstract from costs of homeownership, such as maintenance, depreciation, and the opportunity cost of occupying the unit instead of renting it out.

the indirect utility of owners is given by

$$\bar{v}\left(w_j + T_j, X_j\right) = (1-\gamma)\ln\left(w_j + T_j\right) + \gamma \ln \bar{h}_j + \ln X_j, \tag{2.1}$$

and the indirect utility of renters is

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

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

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

As is common in discrete choice models, the preference shocks follow the standard Extreme Value Type I distribution.[13] Parameter $\sigma > 0$ determines the importance of individual preferences relative to common features of a location, i.e. wages, rents and amenities. Higher values of σ imply lower elasticity of local labor supply with respect to the fundamentals. The probability that a renter will choose to reside in location j is

$$\tilde{\pi}_j = \frac{\exp\left(\tilde{v}\left(w_j, r_j, X_j\right)\right)^{1/\sigma}}{\sum_{j'\in\mathcal{J}} \exp\left(\tilde{v}\left(w_{j'}, r_{j'}, X_{j'}\right)\right)^{1/\sigma}} = \frac{\left(w_j r_j^{-\gamma} X_j\right)^{1/\sigma}}{\sum_{j'\in\mathcal{J}} \left(w_{j'} r_{j'}^{-\gamma} X_{j'}\right)^{1/\sigma}}, \tag{2.2}$$

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

$$\tilde{N}_j = \tilde{\pi}_j \tilde{N}, \tag{2.3}$$

where $\tilde{N}$ is the exogenous number of all renters in the economy. Since the number of owners in each city is fixed, equation (2.3) also characterizes the equilibrium city size, N_j.

2.2 Local Labor Markets

In every city, there is a large number of perfectly competitive firms which use labor to produce the numeraire consumption good. The numeraire is traded across cities at zero

[13]The benefit of this distributional assumption is the possibility of obtaining closed-form solutions for the conditional probability of choosing an item in the choice set, which was first shown in McFadden (1973).

cost. Each worker supplies one unit of labor inelastically. The production technology is

$$Y_j = A_j N_j,$$

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

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

Parameter $\bar{A}_j$ is the exogenous component of the productivity, while parameter $\rho > 0$ represents the agglomeration externality which captures the idea that productivity increases with city size.[14] The equilibrium wage in city j is equal to the marginal product of labor and is given by

$$w_j = \bar{A}_j N_j^{\rho}. \tag{2.4}$$

2.3 Amenities

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

$$X_j = \alpha_j m_j(N_j), \tag{2.5}$$

where α_j is the exogenous component of amenities and

$$m_j(N_j) = \xi_j N_j^{-\theta} \tag{2.6}$$

represents the amount of leisure time that an worker can spend enjoying amenities α_j. When $\theta > 0$, leisure time decreases in city size, possibly due to longer commutes.[15] Parameter ξ_j measures city-specific factors, other than city size, that affect local leisure time, for instance, quality of transportation infrastructure or availability of public transit.

2.4 Local Housing Markets

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

[14]The theory and empirical estimates of agglomeration externalities are discussed in Duranton and Puga (2004) and Combes and Gobillon (2015).

[15]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.[16] The construction technology is

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

where e^{χ_j} is the productivity of developers and η_j is the share of land in construction.[17] The non-land inputs are produced using the numeraire at no cost, 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 as well. 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. $L_j = \tilde{\Lambda}_j$.[18]

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

$$l_j = \frac{\gamma \eta_j w_j \tilde{N}_j}{\tilde{\Lambda}_j}, \tag{2.7}$$

and equilibrium rent

$$r_j = \frac{l_j^{\eta_j}}{e^{\chi_j} \eta_j^{\eta_j} (1-\eta_j)^{1-\eta_j}}. \tag{2.8}$$

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

$$T_j = \frac{l_j \tilde{\Lambda}_j}{\bar{N}_j}. \tag{2.9}$$

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

$$H_j = (e^{\chi_j})^{\frac{1}{\eta_j}} \left((1-\eta_j) r_j\right)^{\frac{1-\eta_j}{\eta_j}} \tilde{\Lambda}_j \tag{2.10}$$

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[16]Perfect competition is a common assumption in the literature and most empirical studies, as summarized in Glaeser, Gyourko and Saks (2005c), support it. Though, more recent evidence documented by Cosman and Quintero (2018) suggests that market concentration in the homebuilding industry has increased since 2005.

[17]Combes, Duranton and Gobillon (2019) find empirical support for the Cobb-Douglas housing production function.

[18]As Cosman, Davidoff and Williams (2019) show, local housing costs depend not only on the amount of available land but also on the rate of growth of the available land. In the static framework of this paper, the growth channel is absent.

Land use regulation. Every city has a certain level of land use regulation. Land use regulation is a set of policies which determine how restricted the use of land for residential development is. 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, commonly known as the NIMBY movement.[19]

The stringency of land use regulation z_j affects housing markets through two channels, both of which impact the housing production function. First, it can reduce χ_j, the efficiency with which developers can convert land into housing. 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 one land parcel can only contain a limited amount of housing and developers face a relatively high η_j.[20]

To formalize the effect of land use regulation on the housing production function, I assume the following functional forms for χ_j and η_j:

$$\chi_j(z_j) = \bar{\chi}_j + \hat{\chi} z_j, \tag{2.11}$$

$$\eta(z_j) = \bar{\eta} + \hat{\eta} z_j. \tag{2.12}$$

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 $\hat{\eta} \geq 0$. These assumptions are confirmed by empirical findings described in Section 3.

2.5 Equilibrium

Definition 2.1 characterizes a spatial equilibrium in an economy with exogenous regulation.

Definition 2.1. 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,

[19] The "Not In My Back Yard" (NIMBY) is a characterization of opposition of residents to real estate development in their neighborhood. According to Fischel (2015), the NIMBY movement became widespread in the U.S. in the 1980s and has grown stronger ever since.

[20] Albouy and Ehrlich (2016) also argue that regulation may affect housing supply via these two channels.

such that equations (2.3), (2.4), (2.5), (2.7), (2.8), (2.9) and (2.10) are satisfied.

How does land use regulation affect equilibrium employment, rents and land prices? Proposition 2.1 states that under several non-negativity constraints and a fairly weak assumption that the variance of the location preference shock is large enough compared to net gains from city size, stricter regulation increases rents and lowers local employment.[21] Moreover, whenever the land share is more elastic with respect to land use regulation than agglomeration-adjusted labor supply is, stricter regulation increases land prices.[22]

Proposition 2.1. Let $\sigma > ((1-\gamma)\rho - \theta)\,\hat{n}_j - \gamma\eta(z_j)$; $\eta(z_j) \geq 0$; $N_j > 0$; and $\tilde{N}_j > 0$. Then

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

(b) $dr_j/dz_j > 0$, i.e. rents increase in the level of land use regulation

(c) $dl_j/dz_j > 0$, i.e. land prices increase in the level of land use regulation, if, in addition, $\eta'(z_j)/\eta(z_j) > -(1+\rho\hat{n}_j)(d\tilde{N}_j/dz_j)/\tilde{N}_j$.

The proof is in Appendix A.1.1.

3 Benchmark Economy

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

3.1 Data

Information on wages, rents, local labor supply, and commuting come from the American Community Survey (ACS) in 2005-2007.[23] The quantitative model has 201 locations, which correspond to metropolitan areas in the data.[24] The measure of incumbent residents in

[21] Expression $((1-\gamma)\rho - \theta)\,\hat{n}_j - \gamma\eta(z_j)$ measures the net benefit from city size for renters and combines agglomeration gains, congestion costs and housing costs.

[22] Extensive literature finds that stricter regulation indeed causes higher land and house prices and lower housing supply: see Mayer and Somerville (2000), Ihlanfeldt (2007), Severen and Plantinga (2018), and a review by Quigley and Rosenthal (2005). Emrath (2016) estimates that regulation accounts for 24% of the final price of newly constructed single-family houses in 2016. Yet, higher regulation may also reduce prices if the resulting labor outflow to other locations is large, as in Chatterjee and Eyigungor (2017). In this model, the magnitude of the effect of regulation is the same for positive and negative demand shocks. Alternatively, regulation could bind only when the demand shocks are positive, as in Glaeser and Gyourko (2005).

[23] The ACS data were downloaded from the IPUMS (Ruggles et al, 2015). This choice of the time interval is motivated by the following reasons. The data on regulation is only available for 2007, hence other data must be close to this year. Using years after 2007 is undesirable, since they would correspond to the Great Recession. Since the data on land prices is only available for 2005-2010, I focus on the period of 2005-2007.

[24] The ACS data available via IPUMS allows identification of about 300 MSAs. However, some MSAs, typically small ones, had to be dropped from the analysis due to the unavailability of data on land supply, land use regulation or land prices.

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 original index is reported at the municipal level for 2007.[25] I first aggregate the index to the MSA level using population weights and then convert it to units suitable for the housing supply specification in this paper by taking the log of the index and adding 2.8479.[26] This transformation ensures that regulation is positive in all cities and its average is equal to 1.[27] The original Wharton Index has zero mean and a standard deviation of one. The transformed index has a mean of 1 and a standard deviation of 0.266. See Appendix A.2 for more details on the data.

3.2 Parameter Values and Model Fit

Labor Market Parameters. Taking log of equation (2.4), we obtain the following empirical labor demand relationship,

$$\ln w_j = \beta^w + \rho \ln N_j + \epsilon_j^w, \tag{3.1}$$

where w_j are mean hourly wages in city j in 2005-2007, previously controlled for race, 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, $\bar{A}_j = \exp(\beta^w + \epsilon_j^w)$.

Land Market Parameters. Using equation (2.7) and plugging in the definition of $\eta(z_j)$ from equation (2.12), one can estimate the log land demand relationship as

$$\ln l_j = \beta^l + \ln \gamma + \ln(\bar{\eta} + \hat{\eta} z_j) + \ln w_j + \ln \tilde{N}_j - \ln \tilde{\Lambda}_j + \epsilon_j^l, \tag{3.2}$$

where l_j is the average land price per acre over 2005-2007 in metro area j, as estimated in Albouy, Ehrlich and Shin (2018) using data on individual land transactions. $\tilde{N}_j$ is the average number of renters in each city and z_j is the normalized Wharton Index discussed above. The relative preference for housing is equal to $\gamma = 0.24$ and represents the housing

[25]Unfortunately, there is no direct measure of land use regulation that is available for a large nationally representative set of locations over a long period of time.

[26]Baum-Snow and Han (2019) show that housing supply elasticities also differ within metro areas.

[27]A similar transformation is used in Saiz (2010). Monotonic transformations of the index do not change any of the results in this paper. First, the quantities that matter for the effect of regulation on rents and prices are the multiples $\hat{\chi} z_j$ and $\hat{\eta} z_j$. Second, the original Wharton Index does not have a cardinal interpretation.

expenditure share of renters, following Davis and Ortalo-Magné (2011). The constant and the residual are denoted by β^l and ϵ^l_j.

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 $\zeta = 1.502$ is the ratio of the national median square footage per person in owner-occupied properties to the square footage in rental properties.[28] I assume that a unit of owner-occupied housing uses the same amount of land as a unit of rental housing.[29] Therefore, the amount of land 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, from Albouy, Ehrlich and Shin (2018).[30]

Housing Market Parameters. From equations (2.8), (2.11) and (2.12), the log rent relationship can be estimated as

$$\ln r_j = \beta^r - \hat{\chi} z_j + (\bar{\eta} + \hat{\eta} z_j) \ln l_j - (\bar{\eta} + \hat{\eta} z_j) \ln(\bar{\eta} + \hat{\eta} z_j) - (1 - \bar{\eta} - \hat{\eta} z_j) \ln(1 - \bar{\eta} - \hat{\eta} z_j) + \epsilon^r_j, \quad (3.3)$$

where rents r_j are the estimated hedonic rent indices for each metropolitan area. To obtain the rent indices, I follow the hedonic regression approach used in Eeckhout, Pinheiro and Schmidheiny (2014) and control 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. The city-specific construction productivity term can be reconstructed from the sum of the constant and the residual as $\bar{\chi}_j = -(\beta^r + \epsilon^r_j)$.

Congestion Parameters. Taking log of equation (2.6) gives the following estimating expression for local congestion,

$$\ln m_j = \beta^m - \theta \ln N_j + \epsilon^m_j. \quad (3.4)$$

Leisure time m_j is equal to the time spent on leisure relative to the combined time spent on leisure and commuting. The 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

[28]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.

[29]However, since owners consume more units of housing, their houses occupy more land than those of renters, consistent with empirical evidence in Yao (2019).

[30]Albouy, Ehrlich and Shin (2018) do not directly report land supply, however one can calculate it by dividing the total value of land in a city by land price per acre.

individuals on weekdays in 2006 from the American Time Use Survey.[31] 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, $\xi_j = \exp(\beta^m + \epsilon_j^m)$.

Instrumental Variables. Note that the right-hand side variables in equations (3.1), (3.2), (3.3) and (3.4) are likely to be correlated with error terms due to endogeneity between left-hand and right-hand side variables. To obtain unbiased parameter estimates, I need to use instruments for the right-hand side variables. In particular, equations (3.1) and (3.4) require instruments for N_j, equation (3.2) requires an instrument for z_j, and equation (3.3) requires instruments for z_j and l_j.[32]

The instrument for N_j is the population of each metropolitan area in 1920.[33] Historical population levels have been widely used as instruments for local labor supply.[34] The identifying assumption is that population levels in 1920 affect local labor supply in 2005-2007, however do not directly affect wages and productivity in 2005-2007, possibly because industrial structure and labor force composition of each city have changed substantially since 1920.

I instrument for the level of regulation z_j using the share of Republican votes in each metro area in the presidential election of 1992.[35] The first identifying assumption is that the share of Republican votes in 1992 determines the overall taste for regulation in a city, and therefore affects the level of land use regulation in 2007, however it does not directly affect land prices and rents in 2007. The second identifying assumption is that the level of regulation in 2007 has no effect on voting shares in 1992.

Finally, the instrument for land prices l_j is the fraction of land not suitable for development for geographical reasons from Saiz (2010).[36] The identifying assumption is that

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

[32]Note that instruments are not required for w_j, $\tilde{N}_j$ and $\tilde{\Lambda}_j$ in equation (3.2), since the coefficient on these variables is equal to 1, as dictated by the theoretical model.

[33]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.

[34]It is common to use Bartik (1991) instruments for *changes* in local employment. However, the theoretical model of this paper cannot be estimated in changes, since there is no available data on changes in land use regulation and metro area land prices. As a result, I must use instruments for *levels*. See Combes and Gobillon (2015) for a review of commonly used instruments for levels of local employment. Ciccone and Hall (1996) uses historical population to estimate a relationship similar to (3.1).

[35]A similar instrument for land-use regulation was used in Mayer and Somerville (2000). In addition, Kahn (2011) shows that cities in California with higher liberal voter share tend to grant fewer housing permits. The county-level data on votes was obtained from Dave Leip's Atlas of U.S. Presidential Elections.

[36]The fraction of land not suitable for development represents the fraction of territory within a 50km radius from the population centroid of a metro area that is occupied by water or slopes steeper than 15%.

geographic restrictions lead to higher land prices but affect rents only indirectly, via land prices.[37]

Tables A.1, A.2 and A.3 in the Appendix confirm that these instrumental variables are indeed statistically significant determinants of each of the instrumented variables. The result of the Hansen test of overidentifying restrictions discussed below also shows that the instruments are jointly valid.

Parameter Estimates. Equations (3.1), (3.2), (3.3) and (3.4) are estimated jointly using a two-step instrumental variable generalized method of moments (IV-GMM). The system of equations has 5 elasticities to be estimated, ρ, $\bar{\eta}$, $\hat{\eta}$, $\hat{\chi}$ and θ, as well as 4 constants, β^w, β^l, β^r and β^m. Estimation uses 5 instrumental variables and 4 constants, hence the system is just-identified. The instrument for equations (3.1) and (3.4) is the metro area population in 1920, the instrument for equation (3.2) is the Republican vote share in 1992, and the instruments for equation (3.3) are the Republican vote share and the measure of land unavailability.

Column (1) of Table 1 presents the estimates of the 5 elasticities. The estimated agglomeration effect ρ is 0.0401, consistent with the estimates obtained in the literature.[38] The estimated congestion effect θ is 0.0208, which is lower than the estimates in the literature, however most available estimates include housing costs or focus on disamenities other than commuting time.[39] The values of the land share parameters, $\bar{\eta}$ and $\hat{\eta}$, suggest that land share is increasing in regulation and may be negligible when regulation is very low. At the same, the estimated value of parameter $\hat{\chi}$ suggests that construction costs increase in regulation, however the estimate is not statistically different from zero.

The fact that the estimate of $\hat{\chi}$ contains a large standard error may indicate that construction efficiency is not strongly related to land use regulation. Forcing the emprical model to contain such relationship may also lead to large standard errors of other estimates. Hence, I set $\hat{\chi} = 0$ and re-estimate the model using the same set of instruments. The system becomes over-identified, and the Hansen test for overidentifying restrictions does not reject the hypothesis that the instruments are jointly uncorrelated with unobserved determinants of wages, land prices, rents and commuting costs, with a p-value of 0.74. The estimates are reported in column (2) of Table 1. Importantly, when $\hat{\chi}$ is excluded from estimation, parameters $\bar{\eta}$ and $\hat{\eta}$ are estimated more precisely and are equal to -0.0136 and

[37] Davidoff (2015) argues that land unavailability may also affect rents via other channels.

[38] Combes and Gobillon (2015) summarize the literature on agglomeration effects and report that the estimates vary from 0.04 to 0.07.

[39] Combes, Duranton and Gobillon (2018) find that the elasticity of urban costs with respect to city size is between 0.03 and 0.08.

0.2663. Given that the average value of the regulation index is 1, these numbers imply the average land share of around 0.25, similar to the estimates obtained in the literature.[40]

As an alternative, I also instrument for regulation using the share of Christians in non-traditional denominations in each metro area in 1971, as in Saiz (2010). The results are reported in column (3) of Table 1. This instrument for regulation results in different parameter values, however the Hansen test rejects the null hypothesis that all moment restrictions are true, with a p-value of 0.04.

Therefore, my preferred empirical specification uses Republican vote shares as an instrument for land use regulation and excludes $\hat{\chi}$ from estimation. The quantitative model uses parameters listed in column (2) of Table 1.

Table 1: Parameter Estimates

Parameter	(1)	(2)	(3)
Agglomeration externality, ρ	0.0401	0.0399	0.0417
	(0.0079)	(0.0078)	(0.0077)
Congestion externality, θ	0.0208	0.0208	0.0212
	(0.0017)	(0.0017)	(0.0016)
Land share level, $\bar{\eta}$	-0.0312	-0.0136	0.2070
	(0.0923)	(0.0807)	(0.0802)
Land share elasticity, $\hat{\eta}$	0.3062	0.2663	0.1171
	(0.1304)	(0.0543)	(0.0536)
Construction efficiency elasticity, $\hat{\chi}$	0.1416		
	(0.4195)		
Hansen's J, p-value	–	0.74	0.04
N	201	201	201

Note: This table reports parameter estimates from the IV-GMM estimation. Standard errors are in parentheses. Column (1) shows estimation results based on a model where construction efficiency depends on land use regulation. Column (2) shows results based on a model where construction efficiency does not depend on land use regulation. Column (3) shows results where the share of Christians in non-traditional denominations is used as an instrument for land use regulation. See Section 3.2 for more details.

Parameters Calibrated within the Model. The vector of exogenous amenity parameters α_j is calibrated so as to match the observed distribution of employment across

[40]Albouy and Ehrlich (2016) find that the land share is about 1/3 for the U.S., while Combes, Duranton and Gobillon (2019) estimate a value of about 0.2 for France.

MSAs. 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 (2019).[41] The calibrated value of σ is 0.1503.

Model Fit. Table 2 summarizes parameters of the quantitative model. 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 besides the size of employment. Figure A.1 shows that local land prices and rents predicted by the model are highly correlated with those observed in the data.

Table 2: Parameters

Parameter	Value	Source or Target	Moment	
			Model	Data
Internally and externally calibrated parameters				
Exogenous amenities	α_j: multiple values	Labor force by MSA	dist<0.0001%	
Labor supply elasticity	$\sigma = 0.1503$	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	IV-GMM estimation		
Agglomeration externality	$\rho = 0.0399$	IV-GMM estimation		
Construction productivity term	$\bar{\chi}_j$: multiple values	IV-GMM estimation		
Elasticity of χ_j wrt regulation	$\hat{\chi} = 0$	IV-GMM estimation		
Land share, common term	$\bar{\eta} = -0.0136$	IV-GMM estimation		
Elasticity of η_j wrt regulation	$\hat{\eta} = 0.2663$	IV-GMM estimation		
City-specific congestion term	ξ_j: multiple values	IV-GMM estimation		
Congestion elasticity	$\theta = 0.0208$	IV-GMM estimation		

Note: The table summarizes parameters used in quantitative the model. See Section 3.2 for details.

[41] Since this paper focuses on stationary spatial equilibria, the period over which elasticities are estimated has to be long enough to allow for a transition between spatial equilibria. Beaudry, Green and Sand (2014) compare various local elasticities at 10 and 20 year spans and find significant differences between them. Hornbeck and Moretti (2019) also compare labor and housing market elasticities to TFP shocks at 10, 20 and 30 years and find large differences between the 10 and 20 year estimates but small differences between 20 and 30 year estimates. These findings suggest that 20 years is a reasonable amount of time required to attain a spatial equilibrium in the U.S.

4 Counterfactual Experiments

4.1 A Counterfactual Economy

Homeowners and land use in a counterfactual economy. In the model, the number of homeowners in each city is exogenous. However, in the long run, changes to the economy brought by a policy change in a counterfactual experiment are likely to reallocate not only renters, but also owners. To address this issue, I assume that in a counterfactual economy homeowners also receive 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 spatial equilibrium. A homeowner who relocates loses the house and becomes a renter in the destination of choice.[42] However, the homeowner can sell the land he owned in the previous city to the homeowners 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 a homeowner who lived in city k in the benchmark economy and lives in city j in the counterfactual economy is

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

where the superscript 0 denotes variables in the benchmark economy.

When a homeowner i in city k chooses whether to move to city j, she compares the value of remaining a homeowner in city k, $\bar{v}(w_k + T_{kk}, X_k) + \sigma\varepsilon_{ik}$, 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

$$\bar{\pi}_{kj} = \frac{\left(\gamma^\gamma (1-\gamma)^{1-\gamma}(w_j + T_{kj}) r_j^{-\gamma} X_j\right)^{1/\sigma}}{\left((w_k + T_{kk})^{1-\gamma}\, \bar{h}_k^\gamma X_k\right)^{1/\sigma} + \sum_{j' \neq k}\left(\gamma^\gamma (1-\gamma)^{1-\gamma} w_{j'} r_{j'}^{-\gamma} X_{j'}\right)^{1/\sigma}}, \tag{4.1}$$

where $\bar{h}_k$ is the exogenous housing consumption of owners. The total number of owners in location j in the counterfactual economy is

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

[42] I ignore the possibility that an owner who moves could benefit from selling a house. However, this simplifying assumption makes relocation less desirable for owners and results in more conservative effects of counterfactual experiments.

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

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

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.

Welfare comparisons between benchmark and counterfactual economies are made using a consumption equivalence approach. Since a spatial equilibrium is stationary and does not specify an initial location of renters, the correct measure of welfare for renters is the expected ex-ante welfare before the vector of utility shocks realizes. Under this measure, $\tilde{\Delta}$, the parameter which quantifies the change in consumption of renters must solve

$$\tilde{N}^0 \ln\left(\sum_{j \in \mathcal{J}} \exp\left(\frac{\tilde{v}\left(\tilde{c}_j, X_j\right)}{\sigma}\right)\right) - \tilde{N}^0 \ln\left(\sum_{j \in \mathcal{J}} \exp\left(\frac{\tilde{v}\left(\tilde{\Delta}\tilde{c}_j^0, X_j^0\right)}{\sigma}\right)\right) = 0,$$

where $\tilde{c}_j = \gamma^{\gamma}(1-\gamma)^{1-\gamma} w_j r_j^{-\gamma}$ is the composite consumption of renters.[43]

Since homeowners do not receive preference shocks in the benchmark economy, the correct measure of welfare for owners is simply their indirect utility, net of preference shocks. Also, since homeowners cannot move in the benchmark economy, in order to isolate welfare effects due to changes in consumption and amenities from those due to reallocation, I only consider welfare of owners who did not move. Under this approach, $\bar{\Delta}$ must solve

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

where $\bar{c}_j = \left(w_j + T_{jj}\right)^{1-\gamma} \bar{h}_j^{\gamma}$ is the composite consumption of owners. Therefore, the change in aggregate welfare is the weighted average of welfare changes for renters and owners:

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

[43]See Aguirregabiria and Mira (2010) for a discussion of the ex-ante utility and De Palma and Kilani (2011) for a discussion of welfare measurement in logit models.

4.2 Effects of Deregulation

To study aggregate effects of land use regulation, I perform a set of counterfactual experiments in which land use constraints are relaxed. The results of these deregulation experiments are summarized in Tables 3 and 4.

In the first experiment, all differences in regulation across cities are eliminated by fixing it at the average level everywhere, that is setting $z_j = 1$ everywhere. The results are shown in column (1) of Table 3. Because highly regulated locations tend to be more productive, lowering z_j in those places reallocates some workers there and increases aggregate output by 2.2%. However, deregulation implies that homeowners lose land rents. As a result, homeowners' welfare falls by 2.5%. Renters' welfare goes up by 4.1%, however since around 70% of the population are owners, aggregate welfare slightly declines. The variance of the city size distribution increases as large cities become larger and small cities shrink. Under this experiment, average wages go up but their dispersion across space increases too – while land use deregulation increases the size of the economic pie, it also reallocates more workers into highly productive areas thereby increasing wage inequality across locations.[44] 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 by the level observed in Houston.[45] If city j has $z_j \leq z_{\text{Houston}} = 0.896$, then z_j remains at the observed level. Otherwise, z_j is lowered to the level z_{Houston}. The results of this experiment are reported in column (2) of Table 3. The effects on productivity, wages, rents and city size distribution are similar to the results of the first experiment, however because Houston's regulation is below average, rents fall more and renters' welfare gain is even greater. As a result, overall welfare improves marginally.

The previous two deregulation experiments deal with 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.[46] I take 50 largest metropolitan areas and rank them by (1) the level of regulation, (2) wages and (3) rents, and then select 10 top areas in the combined ranking. The "superstar" cities are

[44] Truffa (2017) also studies effects of housing supply constraints. Using a model with heterogeneous skills, it finds that expanding housing supply in constrained cities would increase income inequality because of larger skill sorting across areas.

[45] Houston, TX is often mentioned as an example of a large city with a minimal level of land use regulation. Notably, 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 how land can be used. The value of z_j in Houston is equal to 0.896, only slightly below the national mean of 1.

[46] The term "superstar" cities was first coined by Gyourko, Mayer and Sinai (2013).

Boston, San Francisco, New York, San Jose, Seattle, Baltimore, Philadelphia, San Diego, Washington and Los Angeles. All of these cities, with possible exceptions of Baltimore and Philadelphia, are frequently characterized as highly productive and innovative but unaffordable. Table A.4 shows the ranking of the "superstars".

In the third experiment, I repeat the exercise of capping regulation at the level of Houston, but only in the ten "superstar" cities. Results are reported in column (3) of Table 3. This experiment produces a larger productivity gain than applying the same kind of deregulation to all cities. This is because other, non-"superstar", cities do not become more attractive due to deregulation and even more workers flock into the "superstars". However, welfare goes down as homeowners in the "superstars" lose land rents due to deregulation and homeowners in other cities lose the rents due to the outflow of workers. At the same time, the variance of the city size distribution and wage inequality do not increase as much as in the previous two experiments.

Table 3: Effects of Deregulation

	Benchmark	(1) All cities have mean z_j	(2) All cities have $z_j \leq z_{\text{Houston}}$	(3) Superstar cities have $z_j \leq z_{\text{Houston}}$
Labor productivity	100.0	102.2	102.3	102.7
Welfare	100.0	99.4	100.1	99.5
owners	100.0	97.5	97.7	97.5
renters	100.0	104.1	106.1	104.5
Var of log city size	1.178	1.440	1.429	1.389
Mean wages	100.0	102.2	102.3	102.7
Mean rents	100.0	85.0	78.7	83.6
Var of log wages	0.0088	0.0099	0.0098	0.0095
Var of log rents	0.0554	0.0364	0.0369	0.0484

Note: Aggregate labor productivity, welfare, mean wages and mean rents are normalized so that the value of each variable is equal to 100 in the benchmark economy with exogenous regulation. 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. See Section 4 for details.

City-level results. Table 4 shows the city-level effects of the third experiment, i.e. cap regulation at the level of Houston in the "superstar" cities. Not surprisingly, deregulation raises local employment in all "superstars", however magnitudes vary by city. While labor supply goes up by more than 60% in Los Angeles and New York and by more than 40% in San Francisco and Boston, it only increases by 23% in San Jose and barely changes in Philadelphia and Washington, DC. These disparities arise for the following reasons. First, the observed level of regulation is smaller in San Jose and Washington than in Los Angeles, New York, San Francisco or Boston. Hence, a deregulation to the level of Houston results in a smaller change in z_j in San Jose and Washington. Second, San Jose has less land and therefore it is more difficult to supply additional housing there. At the same time, while Washington has relatively abundant land, its exogenous productivity is lower than in San Jose, hence it attracts less workers following a deregulation. In a similar vein, Philadelphia has a higher original level of regulation and larger land supply than San Jose, however it only experiences a 4% increase in employment due to its relatively low exogenous productivity.

As a result of deregulation, real incomes in the "superstars" go up. First, the increase in labor supply leads to higher wages thanks to the agglomeration externalities. Second, lower regulation significantly reduces the land share which lowers rents even despite larger housing demand.[47] Notably, land prices in Los Angeles and New York do not change. The effect of deregulation on the land share is offset by much larger demand for land as developers need to build housing for the newcomers. In addition, the "superstars" now offer poorer amenities due to higher levels of congestion.[48]

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

$$\frac{Y_j^1 - Y_j^0}{\sum_{k \in \mathcal{J}} \left(Y_k^1 - Y_k^0 \right)}. \tag{4.2}$$

Table 4 shows that most of the aggregate productivity gains from deregulation in the "superstars" come from New York and Los Angeles, followed by Boston and San Francisco. The contributions of the rest of the "superstars" are much smaller.

[47] Aura and Davidoff (2008) argue that only coordinated deregulation, such as the one conducted in this paper, can lead to substantial rent reductions. When cities deregulate individually, general equilibrium effects prevent local rents from falling.

[48] It is also possible that, when a city expands, an increase in the congestion disamenity is compensated by an endogenous increase in consumption amenities, as in Diamond (2016).

Table 4: Effects of Deregulating "Superstar" Cities to the level of Houston

MSA	Regul'n, BM	Regul'n, CF	Empl't, % chg	Wages % chg	Rents % chg	Land px, % chg	Contrib'n growth, %
Baltimore, MD	1.493	0.896	26	0.9	-34	-45	13
Boston, MA-NH	1.515	0.896	41	1.4	-32	-38	35
Los Angeles, CA	1.207	0.896	68	2.1	-18	2	161
New York, NY-NJ	1.253	0.896	69	2.1	-22	-1	266
Philadelphia, PA	1.380	0.896	4	0.2	-33	-51	4
San Diego, CA	1.197	0.896	39	1.3	-18	-19	21
San Francisco, CA	1.256	0.896	47	1.5	-24	-19	50
San Jose, CA	1.117	0.896	23	0.8	-20	-25	10
Seattle, WA	1.327	0.896	30	1.0	-28	-35	17
Washington, DC	1.150	0.896	4	0.2	-22	-39	5

Note: This table shows the benchmark level of regulation in each of the "superstar" cities and its level in the counterfactual experiment where regulation in these cities is lowered to the level of Houston. It also shows percentage changes in employment (N_j), wages (w_j), rents (r_j), land prices (l_j) and the contribution of each city to aggregate growth (equation 4.2) following the deregulation. See Section 4 for details.

Role of land supply. An alternative way to reduce the aggregate inefficiency due to strict land use regulation in productive cities is to increase the amount of land. The amount of land that a city can use for development is not only limited by geography but also by infrastructure. Improvements in transportation, such as high-speed rail, could allow residential development outside the current boundaries of metro areas, effectively expanding the relevant land supply.[49]

In order to understand how limited land supply affects the economy, I perform counterfactual experiments in which local land supply is expanded. In the first experiment, land supply is doubled in all cities. In the second experiment, land supply is only doubled in the ten "superstar" cities. The level of land use regulation in each location remains at the benchmark level. The results of these experiments are summarized in Table 5.

The expansion of land supply in all areas leads to a 1.3% increase in productivity and a small welfare gain. The expansion of land supply in "superstar" cities leads to a larger productivity gain of 2.1% but lowers welfare by 0.5%, as renters' welfare gains are limited to the "superstars". As in the deregulation experiments, counterfactual exercises in the "superstars" produce larger productivity gains because they are targeted at areas where land scarcity is especially acute. These results suggest that infrastructure improve-

[49]Hsieh and Moretti (2019) suggested that developing transportation to connect expensive and productive labor markets with more affordable areas could increase aggregate output.

ments that expand the effective area of a local labor market may help increase aggregate productivity, but the effects would be larger if these improvements are combined with a relaxation of land use constraints.

Table 5: Effects of Increasing Land Supply

	Benchmark	(1) All cities have $2 \times \Lambda_j$	(2) Superstars have $2 \times \Lambda_j$
Labor productivity	100.0	101.3	102.1
Welfare	100.0	100.3	99.5
owners	100.0	97.8	97.8
renters	100.0	106.5	103.6
Var of log city size	1.178	1.332	1.356
Mean wages	100.0	101.3	102.1
Mean rents	100.0	76.5	86.4
Var of log wages	0.0088	0.0094	0.0094
Var of log rents	0.0554	0.0455	0.0494

Note: Aggregate productivity, mean wages and mean rents are normalized so that the value of each variable is equal to 100 in the benchmark economy. Column 1 shows results of the experiment in which land supply is doubled in all cities. Column 2 contains results of the experiment in which land supply is doubled in the ten "superstar" cities. See Section 4 for details.

Comparison to previous studies. Two other papers, Hsieh and Moretti (2019) and Herkenhoff, Ohanian and Prescott (2018), have also studied how lowering land use restrictions would affect the economy. In the next two experiments, I use my model to repeat 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 6. Lowering regulation in these three cities to the median results in a 1.7% improvement in labor productivity and a 1% decline in welfare. This productivity growth is somewhat lower than the one found in Hsieh and Moretti (2019) – 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 somewhat smaller welfare gain.[50]

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 $z_j \leq z_{\text{TX}}$,

[50]Hsieh and Moretti (2019) also study deregulation in a model without location preferences and find much larger aggregate effects.

then z_j is kept at the observed level. Otherwise, z_j is lowered 50% toward z_{TX}, i.e. set at the level $z_j - 0.5(z_j - z_{\text{TX}})$. The results of this experiment are in column (3) of Table 6. 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%, this paper finds that, under the same experiment, labor productivy would increase by much less, 1.6%, and welfare would fall. The model in this paper generates much smaller productivity gains than Herkenhoff, Ohanian and Prescott (2018) 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 stringency of land use restrictions in Texas is several times higher than in coastal regions. This paper uses the observed level of regulation, i.e. the Wharton Index, according to which the average regulation in Texas is 0.9332, only 0.25 standard deviations below the national mean.

Table 6: Effects of Deregulation. Comparison to Other Studies

	Bench-mark	(1) Superstar cities have $z_j \leq z_{\text{Houston}}$	(2) Hsieh & Moretti exper't	(3) Herken-hoff et al exper't
Labor productivity	100.0	102.7	101.7	101.6
Welfare	100.0	99.5	99.0	99.4
owners	100.0	97.5	97.7	97.8
renters	100.0	104.5	102.4	103.4
Var of log city size	1.178	1.389	1.309	1.345
Mean wages	100.0	102.7	101.7	101.6
Mean rents	100.0	83.6	90.4	86.9
Var of log wages	0.0088	0.0095	0.0092	0.0095
Var of log rents	0.0554	0.0484	0.0532	0.0458

Note: Aggregate labor productivity, welfare, mean wages and mean rents are normalized so that the value of each variable is equal to 100 in the benchmark economy. Column 1 shows results of the experiment where regulation is capped at the level of Houston in ten "superstar" cities and reproduces column 3 from Table 3. 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). See Section 4 for details.

In order to confirm that my findings of smaller productivity gains from deregulation hinge on strong location preferences and the congestion externality, I recalibrate the model with $\sigma = 0.05$ and set $\theta = 0$.[51] As a result, the long-run elasticity of employment with respect to a productivity shock increases from 4.16 to 8.03. Column (1) of Table A.5 shows that with weaker idiosyncratic preferences for locations and without congestion effects, a deregulation to the level of Houston results in a much larger, 5.4% productivity gain.

Notably, this paper finds negative effects of deregulation on the welfare of homeowners and, as a result, deregulation does not bring aggregate welfare gains, unlike in Hsieh and Moretti (2019) and Herkenhoff, Ohanian and Prescott (2018). The models of the two aforementioned papers only consider renters and therefore may overstate benefits of deregulating land use.[52]

5 Political Economy of Land Use Regulation

While the counterfactual experiments in Section 4 help us understand aggregate implications of land use regulation, they ignore the important fact that regulation is endogenous and chosen by cities themselves. In this section, I augment the model of Section 2 by allowing incumbent residents to determine the level of regulation in their cities.

5.1 A Model of Local Voting

Before renters choose location, incumbent homeowners in each city decide how strictly to regulate land use, that is choose the level of z_j.[53] Their collective decision is modeled using a standard voting model with lobbying. 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 with respect to 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.[54] The lobbying cost may be interpreted as time

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

[52] Another difference between this paper and Herkenhoff, Ohanian and Prescott (2018) is that the latter only contains 8 locations: California, New York, Texas and other states grouped into 5 areas.

[53] The model assumes that renters do not vote. While this is not exactly correct, previous research has shown that turnout in local elections is higher for homeowners than for renters. See DiPascuale and Glaeser (1999), Manturuk, Lindblad and Quercia (2009), and Hall and Yoder (2019), among others. Hall and Yoder (2019) shows that the difference between owners' and renters' turnouts is especially large during votes on issues regarding zoning.

[54] 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

and effort required to understand local land use regulation issues and vote appropriately. In a unique political equilibrium, all candidates run with the same level z_j.[55]

Note that the indirect utility of homeowners (equation 2.1) 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. Homeowners 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

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

which coincides with a solution of a planner's problem where the planner maximizes the weighted utilitarian welfare of local homeowners subject to the lobbying cost. Therefore, the equilibrium regulation chosen by voting is characterized by the first-order condition,

$$\frac{1-\gamma}{w_j + T_j} \left(\frac{dw_j}{dz_j} + \frac{dT_j}{dz_j} \right) + \frac{1}{X_j} \frac{dX_j}{dz_j} = \kappa'(z_j), \tag{5.1}$$

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

Condition (5.1) highlights three main considerations that owners have when choosing regulation – agglomeration, land rents and amenities – all of which are affected by the level of z_j. Given that regulation lowers local employment (part (a) of Proposition 2.1), higher regulation implies lower wages and greater amenities.[56] Under certain conditions, it also increases land rents (part (c) of Proposition 2.1). The choice of regulation depends on relative magnitudes of these three effects.

Spatial equilibrium with endogenous regulation and fundamental determinants of regulation. Definition 5.1 generalizes the notion of equilibrium described in Section 2.5 by including endogenously determined land use regulation.

Definition 5.1. 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 (2.3), (2.4), (2.5), (2.7), (2.8), (2.9), (2.10) and (5.1) are satisfied.

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a function of monetary contributions from landowners and developers to the planning board. 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. For example, Los Angeles Times (2017) estimates that more than \$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 which requires a change in zoning.

[55]See Persson and Tabellini (2002) for more details on the model.

[56]To see this note that $\frac{dw}{dz} = \frac{\rho w}{N} \frac{d\tilde{N}}{dz}$ and $\frac{dX}{dz} = -\frac{\theta X}{N} \frac{d\tilde{N}}{dz}$.

Proposition 5.1 describes how exogenous and endogenous characteristics of a city affect the equilibrium level of regulation. In particular, it shows that, under certain parametric restrictions, highly productive cities with attractive amenities vote for more stringent regulation. As Figure 1 demonstrates, these are exactly the locations which tend to have high levels of regulation in the data.

Proposition 5.1. Let the parameters of the model satisfy the following conditions[57]

(1) $\sigma > \Big((1-\gamma\eta(z_j))\rho - \theta\Big)\hat{n}_j - \gamma\eta(z_j)$ and $\eta(z_j) > 0$;

(2) $\eta'(z_j)/\eta(z_j) > -\mathcal{E}(\tilde{N}_j, z_j)$ and $\eta'(z_j)/\eta(z_j) > -\mathcal{E}_z(\tilde{N}_j, z_j)$;

(3) the lobbying cost is convex, i.e. $\kappa''(z) > 0$;

(4) parameters γ, θ and ρ, and the land share $\eta(z_j)$ are such that

$$\frac{\eta'(z_j)\gamma(1+\rho\hat{n}_j)}{(1-\hat{n}_j)\hat{n}_j\mathcal{E}(\tilde{N}_j, z_j)} < (1-\gamma\eta(z_j))\rho - \theta < -\frac{(1-\gamma)\gamma\eta(z_j)}{1-(1-\eta(z_j)\gamma)\hat{n}_j};$$

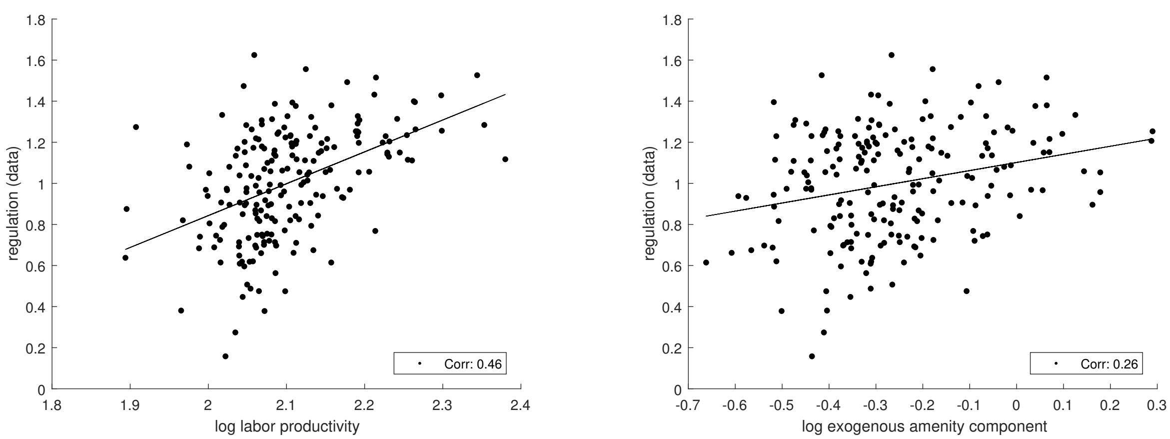
and let $N_j > 0$ and $\tilde{N}_j > 0$. Then, equilibrium regulation z_j is

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

(b) increasing in the exogenous amenity term α_j

The proof is in Appendix A.1.2.

Figure 1: Correlates of Regulation



Note: These figures show the relationship between the log of the estimated exogenous labor productivity ($\bar{A}_j$), the log of the calibrated exogenous amenity term (α_j), and the normalized Wharton Index.

[57]Condition (1) is a slightly stronger variant of the condition for Proposition 2.1. The first part of condition (2) is a weaker variant of the condition for part (c) of Proposition 2.1. All four conditions hold in the quantitative model.

Discussion of the lobbying cost function. Given that rents increase in the level of regulation (Proposition 2.1), the voting model implies that homeowners in pricier cities are willing to pay a higher lobbying cost. Hall and Yoder (2019) provides empirical evidence for this result. Using rich administrative panel data that links voters and properties in Ohio and North Carolina, it demonstrates that homeowners who buy more expensive properties are more likely to participate in local elections than buyers of cheaper homes. This finding may also be viewed as empirical support for Fischel (2001)'s "homevoter hypothesis" which 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.

Note that if there were no lobbying cost, i.e. $\kappa(z) = 0$, nothing would prevent owners from setting regulation as high or as low 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 to regulate would not depend on the two fundamental features of a city described above. Then the model would also be unable to predict the observed regulation.

5.2 Calibration and Model Performance

The lobbying cost function is parameterized as a quadratic function of the level of regulation, $\kappa(z) = \kappa_0 + \kappa_1 z + \frac{\kappa_2}{2} z^2$, so that the the marginal private cost of regulation is equal to

$$\kappa'(z) = \kappa_1 + \kappa_2 z.$$

Parameters κ_1 and κ_2 are calibrated to the mean and the standard deviation of the normalized Wharton Index (see Table 7).[58] Note that the calibrated value of κ_2 implies that the marginal cost of regulation is convex, as required by Proposition 5.1. The rest of the model parameters are the same as in the benchmark calibration described in Section 3.

Table 7: Parameters of the lobbying cost function

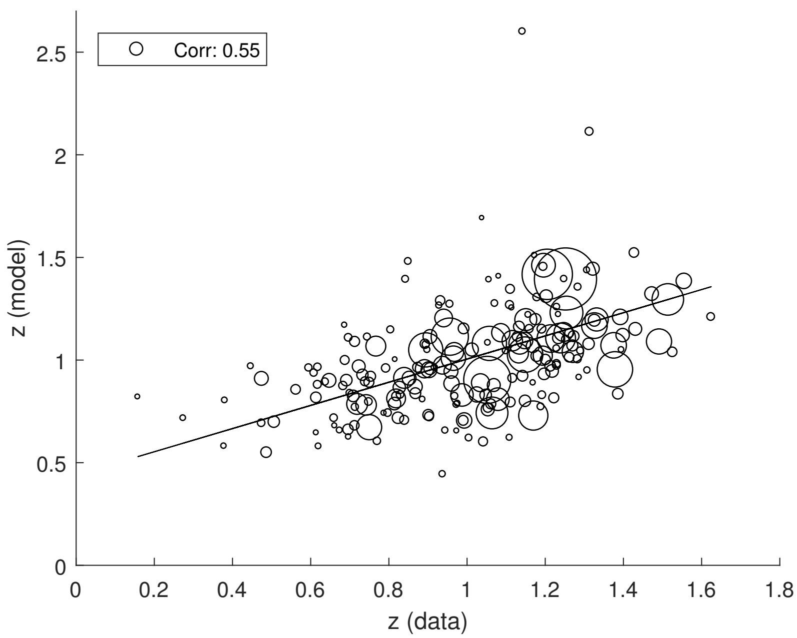
Parameter	Value	Target	Moment	
			Model	Data
κ_1	3.52×10^{-3}	Normalized Wharton Index, mean	1.000	1.000
κ_2	6.45×10^{-3}	Normalized Wharton Index, s.d.	0.266	0.266

Note: This table reports the calibrated lobbying cost function parameters. See Section 5 for details.

[58] The value of κ_0 is irrelevant in the quantitative model.

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.[59] Yet, the model produces a fairly accurate prediction of the level of regulation in each location. The population-weighted correlation between the Wharton index and the regulation predicted by the model is 0.55 (Figure 2). That is, the model accounts for 30% of the observed variation in the Wharton index.[60]

Figure 2: 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. See Section 5.2 for details.

[59]Since the Wharton Index does not have a cardinal interpretation, it would be meaningless to design a quantitative model not calibrated to any moments of the observed distribution of the Wharton Index. 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.

[60]Note that there are many other important reasons why regulation differs across locations and which are outside the scope of the model. These include historical land use patterns (Glaeser and Ward, 2009) and political ideology of local voters (Kahn (2011)). 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.

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 8 shows, the correlations between each of these two variables and the level of regulation itself are similar 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 the positive relationship between regulation and city size. As expressions (A.15) and (A.16) in Appendix demonstrate, the incentives of homeowners to regulate land use in the model do not directly depend on city size and density.

Table 8: Correlations

Correlation	**Model**	**Data**
Regulation (z_j) and log exogenous productivity ($\ln \bar{A}_j$)	0.31	0.46
Regulation (z_j) and log exogenous amenity level ($\ln \alpha_j$)	0.19	0.26
Regulation (z_j) and log wages ($\ln w_j$)	0.28	0.50
Regulation (z_j) and log land prices ($\ln l_j$)	0.34	0.47
Regulation (z_j) and log land supply per worker ($\ln(\Lambda_j/N_j)$)	0.12	-0.28
Regulation (z_j) and log rents ($\ln r_j$)	0.52	0.59
Regulation (z_j) and log city size ($\ln N_j$)	0.05	0.25
Regulation (z_j) and log number of incumbents ($\ln \bar{N}_j$)	0.00	0.23

Note: The table reports unweighted correlations between regulation and several variables of interest, both in the model and the data. See Section 5.2 for details.

6 Policy Interventions

Land use regulation in the U.S. is decided by municipal governments, and direct federal involvement in land use issues would be unconstitutional, though some state governments have certain power over municipal decisions.[61] In the model of Section 5, likewise local governments choose regulation independently, only considering local welfare and disregarding possible nationwide effects of their decisions. However, as experiments of Section 4 illustrate, the freedom of cities to set their preferred level of regulation results in aggregate productivity and welfare losses. This suggests that there is a room for a national policy that discourages regulation in productive cities.

[61]See Gyourko and Molloy (2015).

While experiments in Section 4, as well as those in other studies, suggest substantial aggregate benefits of deregulation, it is not clear which policy could achieve such deregulation and how feasible it may be. The benefit of having a model which explains how cities determine land use regulation, such as the model in Section 5, is that one can study how changing local incentives to regulate land use could affect local regulation, as well as other variables of interest, such as local employment, productivity, rents, etc. This is useful because, even though the federal government cannot force cities to reduce regulation, it can introduce policies that lower incentives of local governments to regulate. The model can then be used in order to quantitatively study local and aggregate effects of various policy incentives.

In the rest of the section, I study three policies. The first two, federal infrastructure subsidies conditional on regulation and a land tax, endogenously discourage local land use regulation. The third policy, rent control, is studied in a setting with exogenous regulation.

6.1 Policy 1: Infrastructure Subsidies

In the United States, the federal government provides sizable transfers to municipal governments.[62] One of the common uses of the transfers is to build or improve infrastructure. I propose a policy in which a national benevolent planner can affect the city-specific commuting efficiency.[63] 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:

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

[62] National League of Cities estimates that about 5% of municipal revenues are transfers from the federal government and 20-25% are transfer from state governments. However, according to the Tax Policy Center, 30% of state revenues come from federal transfers, hence the transfers from the states to the municipalities also implicitly 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.

[63] I thank Will Wilkinson for suggesting this hypothetical policy.

where $\mathcal{J}^*$ is the set of ten "superstar" cities (see Section 4). 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 receving the subsidy, the "superstars" must pay an even larger tax which 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 $(1 + \tau^0 - \tau^1 z_j)\xi_j$. For simplicity, I assume that the federal government can costlessly transfer infrastructure from one city to another. The policy is revenue-neutral at the aggregate level:

$$\sum_{j \in \mathcal{J}} \tau(z_j)\xi_j N_j = 0. \tag{6.1}$$

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 is illustrated by the first order condition

$$\frac{1-\gamma}{w_j + T_j}\left(\frac{dw_j}{dz_j} + \frac{dT_j}{dz_j}\right) + \frac{1}{X_j}\frac{dX_j}{dz_j} = \kappa'(z_j) + \frac{\tau'(z_j)}{1-\tau'(z_j)}, \tag{6.2}$$

which is identical to the condition (5.1), except the additional term $\tau'(z_j)/(1-\tau'(z_j))$.[64] This term is positive in "superstar" cities which, for a given value of the marginal benefit of regulation, 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.

Effects of the policy. The planner chooses τ^0 and τ^1 in order to maximize aggregate welfare subject to the constraint (6.1). The welfare-maximizing policy sets $\tau^0 = 0.0011$ and $\tau^1 = 0.0609$. Any $\tau^1 > 0.0609$ would be sufficient to make each of the ten "superstar" cities choose minimal regulation.[65] As column (1) of Table 9 shows, this kind of deregulation would boost labor productivity by as much as 8.1% and welfare by 3.5%. The effects are so large because minimal regulation implies a zero land share.[66]

Since a zero land share may be unrealistic, I also study aggregate effects of setting

[64]Note that functional forms of $\frac{dw_j}{dz_j}$, $\frac{dT_j}{dz_j}$ and $\frac{dX_j}{dz_j}$ also change.

[65]Since the land share $\eta(z_j)$ cannot be negative, z_j must satisfy $\bar{\eta} + \hat{\eta} z_j \geq 0$. Under the values of $\bar{\eta}$ and $\hat{\eta}$, this implies that the minimal level of regulation is 0.0511.

[66]One could imagine cities where all residential structures are tall skyscrapers and each dwelling uses very little land. Rents in these cities could drop dramatically at the same time as their populations double or triple. However, it is not clear if such cities are feasible from the engineering point of view.

τ^1 so that the productivity gain due to the policy is identical to the productivity gain in the third experiment in Section 4 where regulation in the "superstars" is lowered to the level of Houston. 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 9. Under this policy, welfare goes up by 0.6%, compared to a 0.5% loss in the ad-hoc deregulation. However, the increase in wage inequality is larger than in the ad-hoc experiment. These results suggest that, for a given targeted productivity gain, the system of federal infrastructure transfers conditional on regulation could deliver welfare gains, albeit at a cost of higher wage inequality, as compared to an ad-hoc deregulation.

Table 9: Effects of Infrastructure Subsidies

	Benchmark	(1) Optimal policy	(2) Same as lower to Houston
τ^0	0	0.0011	0.0021
τ^1	0	0.0609	0.0089
mean z	1.000	0.524	0.868
s.d. of z	0.266	0.247	0.249
Labor productivity	100.0	108.1	102.7
Welfare	100.0	103.5	100.6
owners	100.0	96.9	98.4
renters	100.0	119.6	106.1
Var of log city size	1.178	1.787	1.455
Mean wages	100.0	108.1	102.7
Mean rents	100.0	46.9	77.2
Var of log wages	0.0088	0.0110	0.0098
Var of log rents	0.0554	0.0375	0.0454

Note: Aggregate labor productivity, welfare, mean wages and mean rents are normalized so that the value of each variable is equal to 100 in the benchmark economy with endogenous regulation. Note that this benchmark economy is somewhat different from the benchmark economy with exogenous regulation described in Section 3. Column 1 reports effects of introducing optimal federal subsidy policy. Column 2 reports effects of introducing a federal subsidy policy that yields the same output gain as the counterfactual experiment where regulation in "superstar" cities is lowered to the level of Houston. See Section 6.1 for details.

Table A.6 shows how the federal policy affects each of the ten "superstar" cities. As a result of the policy, all "superstars" vote for lower regulation and become larger. However, notice that, 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 happens because homeowners in places with the most expensive land, such as the four abovementioned areas, are not so eager to abandon regulation as the share of land transfers in their disposable incomes is larger than that of homeowners in other cities. This suggests that any federal policy that encourages local deregulation may be less successful in places where real estate ownership is particularly important sources of income and wealth.

6.2 Policy 2: Land Tax

Next, I study implications of introducing a tax on land rents earned by homeowners. A tax on land was first proposed and popularized by George (1879). Under this policy, net transfer earnings of owners become $(1-\lambda_j)T_{kj}$. The tax rate is specified as follows:

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

In order to make the policy comparable to the previous policy, land rents in non-"superstar" cities are not taxed. Tax revenues are equally distributed among all individuals in the economy. Since, as long as the condition of part (c) of Proposition 2.1 hold, land rents are increasing in regulation, the land tax discourages homeowners from voting for high regulation. This effect is illustrated by the first-order condition for equilibrium regulation:

$$\frac{1-\gamma}{w_j + (1-\lambda_j)T_j}\left(\frac{dw_j}{dz_j} + (1-\lambda_j)\frac{dT_j}{dz_j}\right) + \frac{1}{X_j}\frac{dX_j}{dz_j} = \kappa'(z_j). \tag{6.3}$$

Effects of the policy. The goal of the national planner is to find λ that maximizes aggregate welfare. The welfare-maximizing land tax rate is 66%. At this level, homeowners in "superstar" cities 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 homeowners in the "superstars" lose 2/3 of their land rent income, the society as a whole benefits. When λ is high, as equation (6.3) demonstrates, owners pay more attention to the effect of regulation on wages and amenities. Hence, regulation in "superstar" cities falls. As column (1) of Table 10 shows, introduction of an optimal land tax yields the same productivity and welfare gains as the system of infrastructure subsidies discussed above.

To study a more conservative policy, I also run an experiment in which the land tax is set at the level needed to obtain the same productivity gain as in the 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 25%. The results of this experiment are shown in column (2) of Table 10. Welfare goes up by 0.3%, while in the ad-hoc deregulation experiment welfare fell by 0.5%. However, as under the policy of infrastructure subsidies, the increase in wage inequality is larger than in the ad-hoc experiment. Table A.7 reports the results of the experiment in each of the ten "superstar" cities.

Table 10: Effects of a Land Tax

	Benchmark	(1) Optimal policy	(2) Same as lower to Houston
λ	0	0.663	0.250
mean z	1.000	0.518	0.879
s.d. of z	0.266	0.246	0.248
Labor productivity	100.0	108.2	102.7
Welfare	100.0	103.5	100.3
owners	100.0	96.9	98.2
renters	100.0	119.8	105.6
Var of log city size	1.178	1.795	1.450
Mean wages	100.0	108.2	102.7
Mean rents	100.0	46.7	79.2
Var of log wages	0.0088	0.0110	0.0098
Var of log rents	0.0554	0.0372	0.0462

Note: Aggregate labor productivity, welfare, mean wages and mean rents are normalized so that the value of each variable is equal to 100 in the benchmark economy. Column 1 reports effects of introducing an optimal land tax. Column 1 reports effects of introducing a land tax that yields the same output gain as the counterfactual experiment where regulation in "superstar" cities is lowered to the level of Houston.. See Section 6.2 for details.

6.3 Policy 3: Rent Control

In response to declining housing affordability, some U.S. cities resorted to controls on rent.[67] In this policy experiment, I study the response of the economy to a limit on rents

[67]Rent control is present in certain cities in only five U.S. states and the District of Columbia. However, in some of the most important "superstar" cities, such as New York, San Francisco and Los Angeles, a large fraction of rental housing stock is rent-controlled.

in “superstar” cities at the level observed in the counterfactual experiment where these cities were deregulated to the level of Houston (see Table 4). That is, instead of relaxing land use restrictions, I cap rents at the level that such a relaxation would bring.

From equation (2.10) it is evident that, under rent control, housing markets do not clear, since developers are not willing to build as much housing as demanded by potential renters.[68] To make the results of the policy experiment more conservative, I assume that lower rents due to rent control do not allow renters to consume larger units than in the benchmark economy. Therefore, rent control results in an exogenous limit on population of renters equal to

$$\tilde{N}_j^{RC} = \frac{H_j^{RC}}{h_j^{BM}}.$$

Stricter rent control implies lower values of H_j^{RC} and, therefore, lower values of $\tilde{N}_j^{RC}$. Since the demand for being a renter in a rent-controlled city j exceeds the supply of available rental housing, access to the city is rationed via a lottery. Parameter δ_j is the probability that an individual who chooses to live in a rent-controlled city j finds a unit for rent in the city. The equlibrium supply of renters in a rent-controlled city is

$$\tilde{N}_j^{RC} = \delta_j \left(\tilde{\pi}_j \tilde{N} + \sum_{k \neq j} \bar{\pi}_{kj} \bar{N}_k^0 \right).$$

Effects of the policy. Table 11 summarizes the results of the rent control experiment. While rent control improves affordability in the “superstar” cities, it drastically reduces the supply of rental housing. As a result, the most productive cities shrink (see Table A.8 for city-level results) as labor reallocates to less productive areas without rent control. In response, rents in those areas, as well as average rents in the country, go up, while aggregate output and welfare fall. Ironically, even though the stated goal of rent control is to help renters, welfare of renters falls more than that of owners. This happens because rents in other locations increase and because, due to rationing, rent control forces many renters to reside outside their favorite location. At the same time, rent control substantially reduces income inequality in the country as a whole.

[68]This result consistent with previous studies of rent control. Diamond, McQuade and Qian (2019) and Favilukis, Mabille and Van Nieuwerburgh (2019) find that rent control reduces the supply of rental housing.

Table 11: Effects of Rent Control

	Benchmark	(1) Rent control
Labor productivity	100.0	97.1
Welfare	100.0	94.5
owners	100.0	97.8
renters	100.0	86.5
Var of log city size	1.178	1.006
Mean wages	100.0	97.1
Mean rents	100.0	130.1
Var of log wages	0.0088	0.0074
Var of log rents	0.0554	0.0797

Note: Aggregate labor productivity, welfare, mean wages and mean rents are normalized so that the value of each variable is equal to 100 in the benchmark economy. See Section 6.3 for details.

7 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 the distributions of local employment, wages and rents across cities are determined endogenously, and land use regulation is optimally chosen by local homeowners in a political setting. In equilibrium, productive cities with attractive amenities tend to choose excessive regulation. These choices lead to spatial misallocation of labor and, as a result, reduce aggregate productivity. I argue that hypothetical federal policies that discourage local regulation, such as infrastructure subsidies conditional on the level of regulation or a land tax, could partly mitigate the negative effects of regulation and yield aggregate productivity and welfare gains. At the same time, policies that curb housing costs instead of increasing the supply of housing, such as rent control, make the most productive areas smaller and reduce productivity and welfare.

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A Appendix

A.1 Proofs

A.1.1 Proof of Proposition 2.1.

Define objective function Φ. Using equation (2.2), 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

$$\frac{d\tilde{N}_j}{dz_j} = -\frac{\frac{d\Phi\left(\tilde{N}_j, z_j\right)}{dz_j}}{\frac{d\Phi\left(\tilde{N}_j, z_j\right)}{d\tilde{N}_j}}. \tag{A.1}$$

Derivative of Φ with respect to regulation. The numerator on the right-hand side of the expression (A.1) is equal to

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

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

$$\frac{d\Phi\left(\tilde{N}_j, z_j\right)}{dz_j} \approx \frac{d\tilde{N}_j}{dz_j} - \frac{\left(1-\tilde{n}_j\right)\tilde{N}_j}{\sigma}\mathcal{E}(C_j, z_j), \tag{A.2}$$

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

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

Let us consider separately each of the three elasticities above. The semi-elasticity of wages with respect to regulation is

$$\mathcal{E}(w_j, z_j) = \frac{1}{w_j}\frac{dw_j}{dz_j} = \frac{1}{w_j}\frac{\partial w_j}{\partial N_j}\frac{dN_j}{dz_j} = \frac{\rho}{N}\frac{d\tilde{N}_j}{dz_j}. \tag{A.3}$$

The semi-elasticity of amenities is given by

$$\mathcal{E}(X_j, z_j) = \frac{1}{X_j}\frac{dX_j}{dz_j} = \frac{1}{X_j}\frac{\partial X_j}{\partial N_j}\frac{dN_j}{dz_j} = -\frac{\theta}{N}\frac{d\tilde{N}_j}{dz_j}. \tag{A.4}$$

Finally, the semi-elasticity of rents is

$$\mathcal{E}(r_j, z_j) = \frac{1}{r_j}\frac{dr_j}{dz_j} = \eta'(z_j)\left(\ln\left(\frac{1-\eta(z_j)}{\eta(z_j)}\right) + \ln l_j\right) - \chi_j'(z_j) + \eta(z_j)\mathcal{E}(l_j, z_j), \tag{A.5}$$

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

$$\mathcal{E}(l_j, z_j) = \frac{1}{l_j}\frac{dl_j}{dz_j} = \frac{\eta'(z_j)}{\eta(z_j)} + \left(\frac{\rho}{N_j} + \frac{1}{\tilde{N}_j}\right)\frac{d\tilde{N}_j}{dz_j}. \tag{A.6}$$

Combining all semi-elasticities and plugging into the expression (A.2), one can write $d\Phi\left(\tilde{N}_j, z_j\right)/dz_j$ as

$$\begin{aligned}\frac{d\Phi\left(\tilde{N}_j, z_j\right)}{dz_j} \approx{}& \frac{d\tilde{N}_j}{dz_j} - \frac{\left(1-\tilde{n}_j\right)\tilde{N}_j}{\sigma}\frac{\rho-\theta}{N_j}\frac{d\tilde{N}_j}{dz_j} \\ &+ \frac{\gamma\left(1-\tilde{n}_j\right)\tilde{N}_j}{\sigma}\left[\eta'(z_j)\left(1+\ln\left(\frac{1-\eta(z_j)}{\eta(z_j)}\right)+\ln l_j\right) - \chi_j'(z_j) + \eta(z_j)\left(\frac{\rho}{N_j}+\frac{1}{\tilde{N}_j}\right)\frac{d\tilde{N}_j}{dz_j}\right] \\ ={}& \left[1 - \frac{\left(1-\tilde{n}_j\right)\tilde{N}_j}{\sigma}\left(\frac{\rho-\theta}{N_j} - \gamma\eta(z_j)\left(\frac{\rho}{N_j}+\frac{1}{\tilde{N}_j}\right)\right)\right]\frac{d\tilde{N}_j}{dz_j} \\ &+ \frac{\gamma\left(1-\tilde{n}_j\right)\tilde{N}_j}{\sigma}\left[\eta'(z_j)\left(1+\ln\left(\frac{1-\eta(z_j)}{\eta(z_j)}\right)+\ln l_j\right) - \chi_j'(z_j)\right].\end{aligned} \tag{A.7}$$

Derivative of Φ with respect to labor supply. Let us now turn to the denominator on the right-hand side of the expression (A.1). 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

$$\frac{d\Phi\left(\tilde{N}_j, z_j\right)}{d\tilde{N}_j} \approx 1 - \frac{\left(1 - \tilde{n}_j\right)\tilde{N}}{\sigma}\left[\frac{\rho - \theta}{N} - \gamma\eta(z_j)\left(\frac{\rho}{N_j} + \frac{1}{\tilde{N}_j}\right)\right]. \qquad \text{(A.8)}$$

Relationship between regulation and labor supply. Plugging in expressions (A.7) and (A.8) into (A.1), we obtain

$$\frac{d\tilde{N}_j}{dz_j} = \frac{\gamma}{2}\left(\eta'(z_j)\left(1 + \ln\left(\frac{1-\eta(z_j)}{\eta(z_j)}\right) + \ln l_j\right) - \chi_j'(z_j)\right)\left(\frac{(1-\gamma\eta(z_j))\rho - \theta}{N_j} - \frac{\gamma\eta(z_j) + \sigma/(1-\tilde{n}_j)}{\tilde{N}_j}\right)^{-1} \tag{A.9}$$

After having found functional forms of the derivatives of labor supply, rents and land prices with respect to regulation, one can proceed to finding the signs of the derivatives.

Proof of part (a) of Proposition 2.1. Let $\sigma > ((1-\gamma)\rho - \theta)\,\hat{n}_j - \gamma\eta(z_j)$. Then

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

that is the second term in the parenthesis in equation (A.9) is negative. In case if land prices are high enough, in particular

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

which is always the case in the quantitative model, the first term in the parenthesis in equation (A.9) is positive. Therefore,

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

that is the equilibrium supply of renters is decreasing in the stringency of land use regulation. ■

Proof of part (b) of Proposition 2.1. Using expressions (A.5), (A.6) and (A.9), 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 condition always holds as long as $\rho < \theta$, $\eta(z_j) \geq 0$, $N_j > 0$ and $N_j > 0$. ■

Proof of part (c) of Proposition 2.1. From expression (A.6), 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

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

A.1.2 Proof of Proposition 5.1.

Define objective function Ψ. Using expression (5.1), 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, such a derivative could be written as

$$\frac{dz_j}{dx_j} = -\frac{\frac{d\Psi(z_j)}{dx_j}}{\frac{d\Psi(z_j)}{dz_j}}. \tag{A.10}$$

For convenience, rewrite function Ψ as

$$\Psi(z_j) = (1-\gamma)\left[\left(1 + \frac{T_j}{w_j}\right)^{-1}\mathcal{E}(w_j, z_j) + \left(1 + \frac{w_j}{T_j}\right)^{-1}\mathcal{E}(T_j, z_j)\right] + \mathcal{E}(X_j, z_j) - \kappa'(z_j), \tag{A.11}$$

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 (2.9), the semi-elasticity of transfers with respect to regulation is

$$\mathcal{E}(T_j, z_j) = \frac{\eta'(z_j)}{\eta(z_j)} + \mathcal{E}(w_j, z_j) + \mathcal{E}(\tilde{N}_j, z_j). \tag{A.12}$$

Also, from expressions (A.3) and (A.4), we find that the semi-elasticities of wages and amenities are

$$\mathcal{E}(w_j, z_j) = \rho\hat{n}_j\mathcal{E}(\tilde{N}_j, z_j) \tag{A.13}$$

and

$$\mathcal{E}(X_j, z_j) = -\theta\hat{n}_j\mathcal{E}(\tilde{N}_j, z_j), \tag{A.14}$$

where $\hat{n}_j \equiv \tilde{N}_j/N_j$. Plugging in expressions (A.12), (A.13) and (A.14) into (A.11) and dividing it by $\hat{n}_j$, we can rewrite function Ψ as

$$\Psi(z_j) = \frac{(1-\gamma)\gamma}{1-(1-\eta(z_j)\gamma)\hat{n}_j}\left(\eta'(z_j) + \eta(z_j)\mathcal{E}(\tilde{N}_j, z_j)\right) + ((1-\gamma)\rho - \theta)\,\mathcal{E}(\tilde{N}_j, z_j) - \frac{\kappa'(z_j)}{\hat{n}_j}. \quad \text{(A.15)}$$

Derivatives of semi-elasticities. Using expression (A.9), we can write the semi-elasticity of the supply of renters with respect to regulation as

$$\mathcal{E}(\tilde{N}_j, z_j) = \frac{\gamma}{2}\frac{\Delta_j^1}{\Delta_j^2}, \quad \text{(A.16)}$$

where

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

The derivative of $\mathcal{E}(\tilde{N}_j, z_j)$ with respect to a variable x is equal to

$$\frac{d\mathcal{E}(\tilde{N}_j, z_j)}{dx} = \mathcal{E}(\tilde{N}_j, z_j)\mathcal{E}_x(\tilde{N}_j, z_j), \quad \text{(A.17)}$$

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 (A.15) and (A.17), 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

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

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

$$\frac{d\Psi(z_j)}{dz_j} = \Psi_j^4 \mathcal{E}(\tilde{N}_j, z_j) - \frac{1}{\hat{n}_j}\kappa''(z_j). \tag{A.18}$$

where

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

Plugging in the derivatives of Ψ into the expression (A.10), 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

$$\frac{dz_j}{dx_j} = -\frac{\Psi_j^2 \mathcal{E}_x(\tilde{N}_j, z_j)\mathcal{E}(\tilde{N}_j, z_j) + \Psi_j^3 \mathcal{E}(\tilde{N}_j, x_j)}{\Psi_j^1 + \Psi_j^4 \mathcal{E}(\tilde{N}_j, z_j) - \kappa''(z_j)/\hat{n}_j}. \tag{A.19}$$

The following lemma characterizes sufficient conditions for the sign of dz_j/dx_j.

Lemma A.1. Suppose that the following conditions hold:[69]

(1) $\sigma > \Big((1-\gamma\eta(z_j))\rho - \theta\Big)\hat{n}_j - \gamma\eta(z_j)$, $\eta(z_j) > 0$, $N_j > 0$ and $\tilde{N}_j > 0$.[70]

(2) The land share and its underlying parameters are such that $\eta'(z_j)/\eta(z_j) > -\mathcal{E}_z(\tilde{N}_j, z_j)$ and $\eta'(z_j)/\eta(z_j) > -\mathcal{E}(\tilde{N}_j, z_j)$.

(3) The lobbying cost is convex, i.e. $\kappa''(z) > 0$.

(4) Parameters γ, θ and ρ, and the land share $\eta(z_j)$ are such that

$$\frac{\eta'(z_j)\gamma(1+\rho\hat{n}_j)}{(1-\hat{n}_j)\hat{n}_j\mathcal{E}(\tilde{N}_j, z_j)} < (1-\gamma\eta(z_j))\rho - \theta < -\frac{(1-\gamma)\gamma\eta(z_j)}{1-(1-\eta(z_j)\gamma)\hat{n}_j}.$$

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

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

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

[69] All these conditions indeed hold in the quantitative model in Section 5.2.

[70] It is a somewhat stronger variant of the first condition of part (a) of Proposition 2.1.

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 (1) and condition (4) (the lower bound) hold, the second ratio is positive. Hence, $\mathcal{E}_z(\tilde{N}_j, z_j) < 0$. Furthermore, as can be seen from equation (A.18), condition (2) implies that $\Psi_j^4 > 0$.

Condition (4) (the upper bound) implies that $\Psi_j^2 < 0$. Also notice that $\Psi_j^3 > 0$ and, as long as $\mathcal{E}(\tilde{N}_j, z_j) < 0$, $\Psi_j^1 < 0$.

Expression (A.19) 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 5.1. According to Lemma A.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 $\mathcal{E}(\tilde{N}_j, \bar{A}_j) > 0$.

First, consider $\mathcal{E}(\tilde{N}_j, \bar{A}_j)$. This part of the proof uses results from the proof of Proposition 2.1. From equation (2.2), 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

$$\frac{d\tilde{N}_j}{d\bar{A}_j} = -\frac{\frac{d\Phi\left(\tilde{N}_j, \bar{A}_j\right)}{d\bar{A}_j}}{\frac{d\Phi\left(\tilde{N}_j, \bar{A}_j\right)}{d\tilde{N}_j}}. \tag{A.20}$$

Using steps from the proof of Proposition 2.1, we find that the numerator is equal to

$$\frac{d\Phi\left(\tilde{N}_j, \bar{A}_j\right)}{d\bar{A}_j} = \left[1 - \frac{(1-\tilde{n}_j)\tilde{N}_j}{\sigma}\left(\frac{\rho-\theta}{N_j} - \eta(z_j)\gamma\left(\frac{\rho}{N_j} + \frac{1}{\tilde{N}_j}\right)\right)\right]\frac{d\tilde{N}_j}{d\bar{A}_j} - \frac{(1-\tilde{n}_j)\tilde{N}_j}{\sigma}\frac{1}{\bar{A}_j} \tag{A.21}$$

Similarly, the denominator is given by the expression (A.8). Plugging in expressions (A.21) and (A.8) into (A.20), 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 $\rho < \theta$, $d\tilde{N}_j/d\bar{A}_j > 0$, 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

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

Then, combining the previous two expressions, we obtain

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

Since $\Delta_j^1 > 0$, $\Delta_j^2 < 0$, $\rho < \theta$ 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 5.1. According to Lemma A.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

$$\frac{d\tilde{N}_j}{d\alpha_j} = -\frac{\frac{d\Phi(\tilde{N}_j, \alpha_j)}{d\alpha_j}}{\frac{d\Phi(\tilde{N}_j, \alpha_j)}{d\tilde{N}_j}}, \tag{A.22}$$

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

$$\frac{d\Phi\left(\tilde{N}_j, \alpha_j\right)}{d\alpha_j} = \left[1 - \frac{(1-\tilde{n}_j)\tilde{N}_j}{\sigma}\left(\frac{\rho-\theta}{N_j} - \eta(z_j)\gamma\left(\frac{\rho}{N_j} + \frac{1}{\tilde{N}_j}\right)\right)\right]\frac{d\tilde{N}_j}{d\alpha_j} - \frac{(1-\tilde{n}_j)\tilde{N}_j}{\sigma}\frac{1}{\alpha_j}, \tag{A.23}$$

and the denominator is given by the expression (A.8). Plugging in expressions (A.23) and (A.8) into (A.22), 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 $\rho < \theta$, $d\tilde{N}_j/d\alpha_j > 0$, 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

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

Since $\Delta_j^1 > 0$, $\Delta_j^2 < 0$, $\rho < \theta$ and $\mathcal{E}(\tilde{N}_j, \alpha_j) > 0$, we have $\mathcal{E}_\alpha(\tilde{N}_j, z_j) > 0$. ■

A.2 Data

Employment, wages and rents for each metropolitan area are calculated using individual level data from the 5% sample of the Census in 2000, and the 3% sample of the American Community Survey in 2005-2007 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 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 only 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, (3) the Saiz (2010) land availability measure is available, and (4) 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. 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, following the approach in Eeckhout, Pinheiro and Schmidheiny (2014).

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 eleven indices that measure different aspects of regulation, and a single index of regulation (the WRLURI) 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. While there may be variation in regulation across municipalities in an MSA, Gyourko, Saiz and Summers (2008) find that differences in regulation within metro areas are smaller than the differences across metro areas.[71]

[71] The number of municipalities in a metro area and the distribution of population between them may matter. Fischel (2008) shows that MSAs with more fragmented governments, i.e. with many small suburbs, are more likely to have stringent development restrictions. The primary reason is that in larger jurisdictions developers are more influential and homeowners find it more difficult to organize around a common goal.

A.3 Additional Tables and Figures

Table A.1: Local Employment Instrument

Dependent variable:	$\ln N_j^{2005-2007}$
$\ln Pop_j^{1920}$	0.5576
	(0.0463)
Constant	5.3789
	(0.5436)
R2	0.42
N	201

Note: This table reports coefficient in the regression of log metro area employment in 2005-2007 on log metro area population in 1920. Standard errors are in parentheses. See Section 3.2 for more details.

Table A.2: Land Use Regulation Instrument

Dependent variable:	$\ln z_j$
$Share\_Rep_j^{1992}$	-1.1391
	(0.2444)
Constant	1.4506
	(0.0983)
R2	0.10
N	201

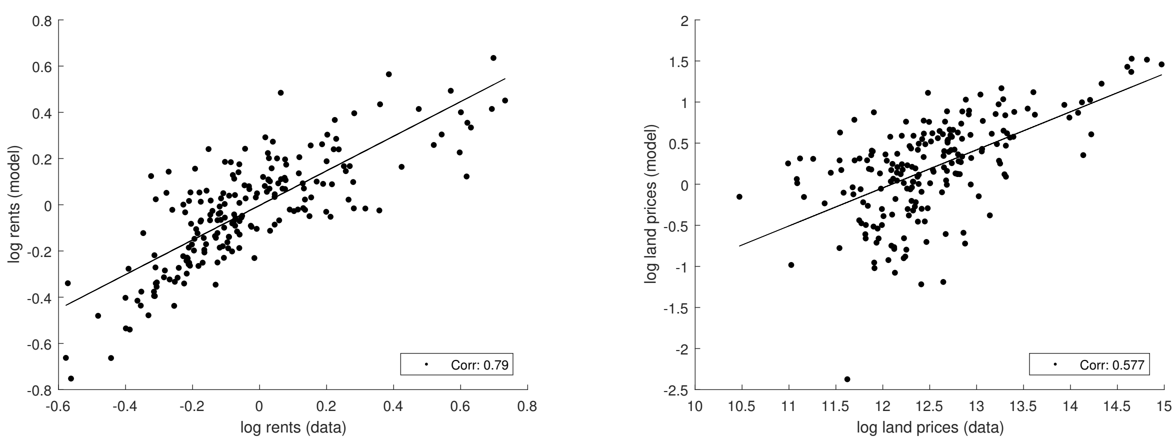
Note: This table reports coefficient in the regression of the normalized Wharton Index on the share of Republican votes in the presidential election of 1992 in each metro area. Standard errors are in parentheses. See Section 3.2 for more details.

Table A.3: Land Price Instrument

Dependent variable:	$\ln l_j$
$Land\_Unavailability_j$	1.7013
	(0.2100)
Constant	12.0756
	(0.0701)
R2	0.25
N	201

Note: This table reports coefficient in the regression of average metro area log land prices on a measure of land unavailability from Saiz (2010). Standard errors are in parentheses. See Section 3.2 for more details.

Figure A.1: Model vs Data



Note: The figure shows the relationship between the observed and model-predicted local levels of log rents and log land prices. See Section 3.2 for details.

Table A.4: "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 A.5: Effects of Deregulation. Weaker Location Preferences and No Congestion

	Benchmark	(1) Superstar cities have $z_j \leq z_{\text{Houston}}$
Labor productivity	100.0	105.4
Welfare	100.0	99.5
owners	100.0	97.3
renters	100.0	104.8
Var of log city size	1.178	1.703
Mean wages	100.0	105.4
Mean rents	100.0	86.7
Var of log wages	0.0088	0.0104
Var of log rents	0.0554	0.0517

Note: Aggregate labor productivity, welfare, mean wages and mean rents are normalized so that the value of each variable is equal to 100 in the benchmark economy. Column 1 shows results of the experiment where regulation is capped at the level of Houston in ten "superstar" cities, in a model with $\sigma = 0.05$ and $\theta = 0$.

Table A.6: Effects of Insfrastructure Subsidies. City-level Results

MSA	Regul'n, BM	Regul'n, CF	Empl't, % chg	Wages % chg	Rents % chg	Land px, % chg	Contrib'n growth, %
Baltimore, MD	1.087	0.598	40	1.3	-34	-56	22
Boston, MA-NH	1.292	0.729	40	1.4	-33	-47	37
Los Angeles, CA	1.415	0.920	56	1.8	-28	-8	123
New York, NY-NJ	1.392	0.915	54	1.7	-28	-11	198
Philadelphia, PA	0.952	0.479	29	1.0	-34	-65	31
San Diego, CA	1.459	0.845	39	1.3	-30	-30	19
San Francisco, CA	1.228	0.774	50	1.6	-31	-28	55
San Jose, CA	1.091	0.676	44	1.5	-31	-34	19
Seattle, WA	1.165	0.667	41	1.4	-33	-45	24
Washington, DC	1.023	0.553	30	1.0	-33	-53	36

Note: This table shows the level of regulation in each of the "superstar" cities predicted by the voting model and its level in the policy experiment with infrastructure subsidies. It also shows percentage changes in employment (N_j), wages (w_j), rents (r_j), land prices (l_j) and the contribution of each city to aggregate growth (equation 4.2). See Section 6.1 for details.

Table A.7: Effects of Land Tax. City-level Results

MSA	Regul'n, BM	Regul'n, CF	Empl't, % chg	Wages % chg	Rents % chg	Land px, % chg	Contrib'n growth, %
Baltimore, MD	1.087	0.676	35	1.2	-30	-51	6
Boston, MA-NH	1.292	0.806	38	1.3	-29	-42	11
Los Angeles, CA	1.415	0.967	57	1.8	-24	-2	42
New York, NY-NJ	1.392	0.962	56	1.8	-24	-4	68
Philadelphia, PA	0.952	0.568	22	0.8	-30	-59	8
San Diego, CA	1.459	0.916	38	1.3	-26	-25	6
San Francisco, CA	1.228	0.825	50	1.6	-27	-23	18
San Jose, CA	1.091	0.728	42	1.4	-28	-29	6
Seattle, WA	1.165	0.738	38	1.3	-29	-40	7
Washington, DC	1.023	0.632	25	0.9	-29	-47	10

Note: This table shows the level of regulation in each of the "superstar" cities predicted by the voting model and its level in the policy experiment with land tax. It also shows percentage changes in employment (N_j), wages (w_j), rents (r_j), land prices (l_j) and the contribution of each city to aggregate growth (equation 4.2). See Section 6.2 for details.

Table A.8: Effects of Rent Control. City-level Results

MSA	Regul'n, BM	Regul'n, CF	Empl't, % chg	Wages % chg	Rents % chg	Land px, % chg	Contrib'n growth, %
Baltimore, MD	1.493	1.493	-80	-6.1	-34	-52	-13
Boston, MA-NH	1.515	1.515	-72	-5.0	-32	-48	-20
Los Angeles, CA	1.207	1.207	-46	-2.4	-18	-38	-36
New York, NY-NJ	1.253	1.253	-43	-2.2	-22	-42	-55
Philadelphia, PA	1.380	1.380	-76	-5.5	-33	-54	-25
San Diego, CA	1.197	1.197	-66	-4.2	-18	-39	-11
San Francisco, CA	1.256	1.256	-66	-4.2	-24	-47	-23
San Jose, CA	1.117	1.117	-73	-5.1	-20	-45	-10
Seattle, WA	1.327	1.327	-75	-5.3	-28	-49	-13
Washington, DC	1.150	1.150	-69	-4.6	-22	-48	-26

Note: This table shows the level of regulation in each of the "superstar" cities in the benchmark economy and its level in the policy experiment with rent control. It also shows percentage changes in employment (N_j), wages (w_j), rents (r_j), land prices (l_j) and the contribution of each city to aggregate growth (equation 4.2). See Section 6.3 for details.