Housing Supply Regulation: Local Causes and Aggregate Implications*

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Abstract

I study why some cities have strict housing supply regulation, how regulation affects the economy, and what policymakers can do to mitigate its effects. I develop and calibrate a spatial equilibrium model with heterogeneous workers, where local regulation is endogenously determined by voting. Cities with high productivity and scarce land vote for strict regulation. In a quantitative exercise, I find that regulation leads to spatial misallocation of labor and therefore reduces aggregate productivity. It also contributes to skill sorting, and wage and house price dispersion across cities. A federal policy that weakens incentives to regulate could raise productivity by 2.5%.

Key Words: housing supply regulation, productivity, spatial misallocation, wage inequality, house prices

JEL Classification: D72, E24, J31, R13, R31, R38, R52

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1 Introduction

Housing supply is highly regulated in the U.S. This is important because restrictions such as zoning laws, public opposition to new construction, and project approval delays all add significantly to housing costs. Regulation is especially stringent in highly productive metropolitan areas, such as New York, San Francisco and Los Angeles, meaning that people often choose to live not where they are most productive but where housing is affordable.[1] 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.[2]

The regulation was not always as strict as it is now. Both the level and the cross-city differences in regulation have increased in recent decades, and these changes have been accompanied by a broad pattern of spatial divergence. Since the 1980s, the differences in wages and house prices across metropolitan areas have widened. During the same period, workers have become more sorted by skill: metro areas with a larger fraction of college-educated workers in the labor force in 1980 added more college workers over the next three decades than other metro areas.

This paper makes three contributions. First, it proposes a spatial equilibrium model in which regulation in every location is determined endogenously in a political process. Second, it quantitatively evaluates how local land supply and productivity feed into housing supply regulation, and then how regulation affects aggregate productivity, skill sorting, and wage and house price dispersion across metropolitan areas. Third, it studies a federal policy that reduces incentives of local governments to regulate housing supply, and shows that this policy could lower house prices and raise aggregate productivity.

The model has a life-cycle structure and is populated by workers with heterogeneous skills. They choose where to live, and their choice depends on wages, housing costs, local amenities, and idiosyncratic location preferences. They also choose whether to own or rent a house. Individuals prefer to own, however purchasing a house requires a downpayment. Thus buying immediately may not be feasible and workers need to accumulate savings to afford a house. House prices depend on local population size, exogenous land supply and endogenous housing supply regulation.

Regulation performs two functions. First, it reduces the elasticity of housing supply, making house prices and rents higher. Second, it lowers local congestion, increasing the amenity value of cities. Indirectly, by raising housing costs, regulation also reduces local

[1] This paper uses the notions "metropolitan statistical area", "city" and "location" interchangeably.

[2] See, for example, Yglesias (2012), The Economist (2016), and White House (2016). This paper uses the notions "housing supply regulation" and "land use regulation" interchangeably.

population and therefore wages, since the latter depend on agglomeration externalities.

Regulation is determined in a political process, designed along the lines of a standard model of probabilistic voting with lobbying. Every period elections are held for local governments, and residents vote for candidates, each of which runs with a proposed level of regulation. Individuals have three main considerations when choosing regulation: congestion, agglomeration and housing costs. First, both renters and owners prefer more regulation because it alleviates congestion. Second, both groups prefer less regulation because it lowers wages via the agglomeration externality. However, renters and owners are affected differently by housing costs. Renters prefer less regulation because this decreases rents, as well as house prices, thereby lowering the downpayment they need to pay in case they decide to buy. Homeowners, on the other hand, prefer more regulation as it increases the value of their houses.[3] Therefore, all else equal, owners vote for higher regulation than renters. Owners finance the candidates' campaigns with monetary contributions, and the size of the required contribution is increasing in the proposed level of regulation.

Given that regulation is costly, the incentive of owners to support stricter regulation depends on the sensitivity of prices to changes in regulation which is higher in cities with scarce land. Besides, highly productive cities attract more workers, hence congestion concerns in these cities are higher. Therefore, in equilibrium, denser and more productive locations are more regulated, and thus have higher house prices. Note that, because of lower land supply and stronger housing demand, denser and more productive places would have higher house prices even if they had the same level of regulation as other places. This means that political decisions amplify the effects of differences in land and productivity on house prices and, as a result, on the distribution of economic activity across space. In addition, by making the most productive cities highly regulated, local political decisions lead to misallocation of labor across space, since marginal workers choose to locate in less productive but more affordable cities.

The model parameters are disciplined by a set of moments that describe local labor and housing markets in the U.S. The quantitative model comprises 202 metropolitan areas. Regulation is measured using the Wharton Residential Land Use Regulatory Index, constructed for the year 2007 by Gyourko, Saiz and Summers (2008). While the calibration only targets three moments of the observed distribution of regulation, the political economy model predicts a significant portion of the observed distribution.

Then the model is used to run a series of quantitative exercises. First, I evaluate the effects of exogenous differences in land and productivity across cities. Absent these

[3]The idea that homeowners favor stricter regulation due to their concern for the value of their property was proposed by Fischel (2001) and called the "homevoter hypothesis."

differences, regulation would be lower on average. In addition, aggregate productivity would be 0.6% larger, there would be less skill sorting, and house price and wage dispersion across cities would be smaller.

Then, in several counterfactual experiments, I show that lowering regulation weakens the spatial misallocation, as well as raises aggregate productivity by about 3.5-3.8% and welfare by about 19%. It also diminishes skill sorting and reduces wage dispersion by 4-10%. On top of that, lowering regulation decreases average house prices by 20-30%, as well as reduces the dispersion of prices across cities by 14-24%. Interestingly, a complete elimination of regulation has a minor effect on productivity and welfare. This is because, in the absence of regulation, congestion effects in large productive cities become very strong and these cities become unattractive to potential residents.

The main reason why regulation has a negative effect on aggregate productivity is that local governments choose regulation independently from each other and thus disregard the implications of their decisions on the rest of the economy. This means that a national-level policy that internalizes the aggregate effects of local decisions might improve aggregate outcomes. I design a Pigouvian tax policy and quantitatively evaluate it using the model. According to this policy, the federal government taxes highly regulated cities and provides transfers to cities with low regulation. This policy raises output by 2.5% and welfare by about 15%. It also reduces average house prices by 36% and the price dispersion by 16%. However, it has a minimal effect on skill sorting and thus does not diminish wage inequality across cities.

This paper joins the recent literature on macroeconomic effects of land use regulation.[4] Like Hsieh and Moretti (2018), and Herkenhoff, Ohanian and Prescott (2018), it also studies aggregate implications of reducing regulation, however in those papers regulation is exogenous. In this paper, I present a model in which regulation is endogenously determined by voting. Therefore, in addition to evaluating the effects of regulation on aggregate productivity, I can also study *why* some cities are more regulated and evaluate policy interventions that reduce *incentives* of local governments to regulate, as compared to only studying counterfactual experiments in which regulation is reduced to an arbitrarily lower level. Even though the model in this paper is different, it finds aggregate effects comparable to those found in the two above-mentioned papers. Hsieh and Moretti (2018) finds that with lower regulation productivity would be 3.7%-8.9% higher.[5] Herkenhoff, Ohanian and Prescott (2018) find

[4]Gyourko and Molloy (2015) provide an excellent review of the literature on land use regulation and its effects on local housing and labor markets, as well as the national economy.

[5]These results are obtained by setting regulation in the New York, San Francisco and San Jose metropolitan areas to the median U.S. level. The magnitude of the productivity effect in that paper is lower when labor mobility across cities is assumed to be constrained.

that lowering regulation in California and New York to the level of 1980 would raise U.S. productivity by about 7%.[6] By comparison, this paper finds that with lower regulation aggregate productivity would be 3.5%-3.8% larger. Unlike this paper, Herkenhoff, Ohanian and Prescott (2018) use their model to back up regulation back from 1950, and therefore can study dynamic effects of regulation.[7] This paper uses the observed regulation – the Wharton Index – and therefore it can only study static effects of regulation.[8]

Bunten (2017) proposes a model with endogenous regulation in which current residents restrict housing supply as a defense against congestion inflicted by potential newcomers. As a result, attractive cities undersupply housing, relative to the social optimum at the national level. In a quantitative exercise, it finds that a social planner's solution results in a 1.4% higher productivity. However, unlike this paper, which offers a specific policy, Bunten (2017) does not explain how the planner's solution may be achieved. It also assumes that the only reason why local residents regulate housing supply is congestion, while previous literature suggested that the desire of owners to preserve or raise the value of their houses plays a central role.[9] In contrast, the model in this paper features both homeowners and renters, and therefore allows both congestion and house values to affect voting. In addition, unlike all papers mentioned above, this paper features heterogeneous labor which allows studying implications of regulation for income inequality.[10]

The political economy model of this paper builds upon the extensive, largely theoretical, literature on the political economy of regulation. The two most closely related papers are 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, thereby formalizing the "homevoter hypothesis" of Fischel (2001).[11]

[6] Herkenhoff, Ohanian and Prescott (2018) build a general equilibrium model with seven locations: California, New York, and other states grouped into five locations. In their model, land use regulation limits the amount of land available for housing and commercial activities.

[7] Another study of dynamic effects of regulation is Ganong and Shoag (2017), which counted the number of cases in state appellate courts related to land use and used their fraction among all cases as a measure of stringency of land use regulation at the state level. It showed that regulation increased on average in the U.S. since 1940, with the fastest increase during 1970-1990. Regulation became more different across states, and contributed to the slowdown of income convergence across states.

[8] 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.

[9] The idea that homeowners favor stricter regulation due to their concern for the value of their property was proposed by Fischel (2001) and called the "homevoter hypothesis."

[10] To the best of my knowledge, the only other paper that studies the interaction between inequality and regulation is Truffa (2017). It finds that expanding housing supply in constrained cities would raise aggregate productivity by 0.2-0.4%, and that this effect is dampened by spatial skill sorting.

[11] Earlier work on the political economy of land use regulation includes Brueckner (1995), Helsley and Strange (1995), Calabrese, Epple and Romano (2007), and Solé-Ollé and Viladecans-Marsal (2012).

In addition, this paper joins the literature on the recent rise in house price dispersion across locations.[12] It also contributes to a large body of work on the causes of the escalation in income inequality in recent decades, and emphasizes the geographic channel of inequality.[13] More broadly, this paper relates to the literature which studies how various local and national policies result in spatial misallocation.[14] Finally, this paper contributes to the large literature on the effects of homeownership on the economy.[15]

This paper is organized as follows. Section 2 describes the theoretical framework. Section 3 discusses the values of model parameters and describes the benchmark calibrated economy. Section 4 studies the importance of land and productivity for the observed regulation, and evaluates the effects of regulation on aggregate productivity, wage inequality and house prices. Section 5 describes a policy experiment that discourages local regulation and studies its effect on the economy. Section 6 concludes.

2 Environment

2.1 Cities, Workers and Markets

Cities. The economy comprises J locations (cities), indexed by $j \in \{1, ..., J\} \equiv \mathcal{J}$. A city is an "island" with no internal structure, as in Lucas and Prescott (1974). Exogenous features of a city include the supply of land available for residential use (Λ_j) and consumption amenities (α_j). Land supply is normalized such that $\Lambda_j \in (0, 1)$. A city is populated by an endogenously determined measure N_j of workers. Population of a city affects how productive and how congested it is: productivity increases with city size thanks to agglomeration externalities, however utility declines with population density due to congestion externalities.

Workers. Individuals live and work for T periods, and their age is indexed by t. They are endowed with a skill level, low or high, $s \in \{L, H\}$. Skill level is fixed for lifetime. Measures of each skill in the economy are given exogenously by λ_L and λ_H. An individual must live in the same location where she works.

Workers consume a homogeneous consumption good and one unit of housing. Since

[12] See Glaeser, Gyourko and Saks (2005b), Albouy and Ehrlich (2016), Gyourko, Mayer and Sinai (2013) and Van Nieuwerburgh and Weill (2010).

[13] The geographic channel is studied in Moretti (2013), Baum-Snow and Pavan (2013) and Diamond (2016).

[14] Also see Albouy (2009), Şahin, Song, Topa and Violante (2014), Eeckhout and Guner (2017), Fajgelbaum, Morales, Suárez Serrato and Zidar (2018), and Parkhomenko (2016)

[15] See Ferreira, Gyourko and Tracy (2010), Schulhofer-Wohl (2011), Head and Lloyd-Ellis (2012), and Karahan and Rhee (2014), among others.

housing consumption is fixed, the share of housing in expenditures falls with income.[16] Housing can be rented or owned. In the first period of the life cycle all workers rent, however later in life they may buy a house. Ownership provides additional utility γ.[17] The utility of consumption is given by

$$u(c,h) = \ln c + \mathbb{I}_{h\geq 1}\gamma,$$

where $h \in \{0, ..., T-1\}$ indicates how long the worker has owned the house, and $h = 0$ means that the worker rents. Future utility is discounted with factor β. Individuals can save a part of their income and receive return i_k on their assets next period. Borrowing is not allowed, except for taking out a mortgage to purchase a house.

Besides consumption, workers also obtain utility from local amenities α_j and disamenities (i.e. congestion). Congestion disutility is modeled as $\frac{\phi}{1+z_j}\left(\frac{N_j}{\Lambda_j}\right)^{\delta}$, where ϕ is a parameter that accounts for the strength of the congestion effect and δ represents the elasticity of congestion with respect to population density. Parameter z_j represents land use regulation. Stricter regulation reduces the congestion externality for a given density level. This assumption is based on the idea that regulation potentially makes cities more organized and that some types of regulation, such as zoning, were created in order to separate land use and therefore reduce negative externalities brought about by congestion.[18] The overall net amenity value of city j is thus defined as

$$a_j = \alpha_j - \frac{\phi}{1+z_j}\left(\frac{N_j}{\Lambda_j}\right)^{\delta} \tag{2.1}$$

Labor markets. In every city, there is a representative firm that uses labor to produce a homogeneous consumption good. The good is a numeraire, traded across cities at zero cost. The production technology is given by

$$Y_j = A_j \tilde{N}_j, \tag{2.2}$$

where A_j is local total factor productivity (TFP), and $\tilde{N}_j \equiv \sum_{s\in\{L,H\}}\sum_{t=1}^{T}\eta_{jst}N_{jst}$ is labor supply in efficiency units. The parameter η_{jst} denotes the productivity of an s-skill worker

[16] Ganong and Shoag (2017) finds that the share of income spent on housing is decreasing with income, though an earlier study by Piazzesi, Schneider and Tuzel (2007) finds that the housing expenditure share varies very little with real income.

[17] Besides the "warm glow" interpretation, this assumption may also capture the fact that owner-occupied houses are larger in size, as argued in Garriga and Hedlund (2017).

[18] Duranton and Puga (2015) review literature that studies the emergence of land use regulation in response to negative local externalities.

of age t in city j, while N_{jst} denotes the number of such workers.[19] Local TFP is determined as

$$A_j = \bar{A}_j N_j^{\rho}, \tag{2.3}$$

where $\bar{A}_j$ is the exogenous part of the TFP, while $\rho > 0$ is the agglomeration externality which captures the idea that productivity increases with city size.[20] The equilibrium wage of an s-skill worker of age t in city j is then

$$w_{jst} = \eta_{jst} \bar{A}_j N_j^{\rho}. \tag{2.4}$$

Housing markets. There are two types of housing: rental and owner-occupied. Every individual must either rent or own one unit of housing in the city where he works. Rent in city j is given by

$$r_j = \chi_j^R N_j^{\zeta_j^R}, \tag{2.5}$$

and the price of an owner-occupied house in city j is

$$p_j = \chi_j^O N_j^{\zeta_j^O}, \tag{2.6}$$

where χ_j^m is the city-specific term for housing of type $m \in \{R, O\}$ and ζ_j^m is the inverse elasticity of housing supply.[21] The inverse elasticity of housing supply is given by

$$\zeta_j^m \equiv \bar{\zeta}^m + \zeta_{\text{land}}^m (1 - \Lambda_j) + \zeta_{\text{reg}}^m z_j, \tag{2.7}$$

where $\bar{\zeta}^m$ is the baseline level of elasticity common for all cities, ζ_{land}^m represents the effect of land scarcity, $(1 - \Lambda_j)$, on the elasticity, while ζ_{reg}^m is the effect of housing supply regulation, z_j, on the elasticity.[22] That is, both land scarcity and housing supply regulation reduce the elasticity of housing supply, consistent with the findings of Saiz (2010) which uses a similar

[19]Since η_{jst} varies by location and age, the model can accommodate cross-city differences in age-income profiles, which tend to be steeper in large cities, as documented in De la Roca and Puga (2017).

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

[21]The same expressions for rents and prices can be microfounded using a standard Rosen-Roback model with a representative construction firm (see Rosen (1979) and Roback (1982)). Glaeser (2008) describes such a model and arrives at a similar expression for rents using a perfectly competitive construction section. Perfect competition is a common assumption in the literature, however recent evidence documented by Cosman and Quintero (2018) suggests that market concentration in the homebuilding industry has increased since 2005.

[22]Extensive literature finds that stricter regulation 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). 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).

specification of housing supply elasticity.

The equilibrium price-rent ratio is

$$\frac{p_j}{r_j} = \frac{\chi_j^O}{\chi_j^R} N_j^{\zeta_j^O - \zeta_j^R}.$$

The ratio accounts for possible differences in city-specific terms χ which could, for instance, represent differences in construction costs for each type of housing. The ratio also accounts for potential differences in supply elasticities of each type of housing. If the supply of owner-occupied housing is less elastic – a pattern documented by the empirical analysis of this paper – then larger cities have a higher price-rent ratio.

Homeownership. All individuals have access to a mortgage facility which allows extending payments for the house over κ periods. If a renter decides to buy a house in period t, he must pay dp_{jt} where $d \in (0, 1)$ is the downpayment rate. In each period $t + 1, ..., t + \kappa$ the worker pays $q(i_h, \kappa)(1 - d)p_{jt}$, where $q(i_h, \kappa) \equiv i_h / \left(1 - (1 + i_h)^{-\kappa}\right)$ and i_h is the mortgage interest rate. The market house price may change, but the worker always repays mortgage based on the purchase price p_{jt}. Starting from period $t + \kappa + 1$, the worker fully owns the house. An individual who has owned a house for h periods can sell it any time at current market price $p_{j,t+h}$. If the mortgage was not fully paid, the proceeds from the sale are equal to the current price of the house minus the amount owed to the lender: $p_{j,t+h} - (1 - f_h)p_{jt}$, where $f_h \in [0, 1]$ is fraction of the loan which has already been repaid after owning the house for h periods.[23]

A measure zero of absentee competitive real estate managers (REMs) own rental housing and issue mortgages. Buyers of owner-occupied houses pay the downpayment to the REM immediately and mortgage payments over the next κ periods. I assume that the cost of default is large enough that buyers always fulfil their debt obligations to REMs. REMs bear all the risks associated with price changes: upside risks if the equilibrium price falls and incoming mortgage payments exceed loans to new homeowners, and downside risks in the opposite case. These risks are uninsurable. However, in a stationary environment there would be no price risk, and hence the REMs would not charge a risk premium.

[23] The fraction f_h is determined recursively. Right after the downpayment was paid in the period when the homebuyer still rents, $f_0 = dp_{jt}$. Next period, $f_1 = f_0 + (q(i_h, \kappa) - i_h(1 - f_0))p_{j,t-1}$. In the following period, $f_2 = f_1 + (q(i_h, \kappa) - i_h(1 - f_1))p_{j,t-2}$, and so on.

2.2 Workers' Decisions

Choice of location. At the very beginning of the first period, an individual must choose the location of residence j. This decision is irreversible – it is not possible to move to another location later in life. The location choice is affected by three factors. First, at the moment of birth an individual receives a $J \times 1$ vector of *i.i.d.* utility shocks ε which are associated with living in each of the cities in the economy. This shock should be interpreted as the idiosyncratic utility cost or benefit of living in a given city. Second, individuals take into account the amenity value of each location, a_j. Finally, workers compare the attractiveness of labor and housing markets in different cities: they take into account the lifetime wage profile $\{w_{jst}\}_{t=1}^{T}$ each city j offers to workers of their skill group s, and the costs of renting and buying a house: r_j and p_j. When choosing a city, workers not only consider the level of housing costs but also the price-rent ratio, since it determines whether they can afford the downpayment and purchase a house soon enough in the life cycle. This is because, all else equal, owning is preferred to renting. First, it brings additional utility γ. Second, a house is an asset that can be sold, and the proceeds from the sale can be consumed.

Timing and value functions. Every period an individual works and receives wage w_{jst}. Then he decides (1) how much to consume, (2) how much to save, and (3) whether to rent or own a house, in order to maximize the expected discounted lifetime utility. Renters pay rent r_j. Owners pay mortgage payments, $q(i_h, \kappa)(1-d)p_{j,t-h}$, on a house bought h periods ago. A renter may decide to buy a house at any age, just as an owner may decide to sell the house and become a renter. The transactions involved in changes in the homeownership status occur in the current period, but the actual changes in the status are effective next period. In the last period T, an owner pays the mortgage (if it has not been paid off), sells the house and consumes the proceeds.

There is no aggregate uncertainty, and the only source of individual uncertainty are the location-specific utility shocks in the first period. The individual state is $x = (j, s, t, k, h)$. Skill level s is fixed for life. Residence j is chosen in the first period and remains fixed thereafter, while age t, savings k, and the length of ownership h change every period. The aggregate state is described by the distribution of workers across individual states $\Phi : \mathcal{X} \to \mathbb{R}_+$, where $\mathcal{X} \equiv \mathcal{J} \times \{L, H\} \times \{1, ..., T\} \times [0, \infty) \times \{0, ..., T-1\}$ is the space of individual states. This paper focuses on a stationary environment, hence t indexes both age and time.

The value function of a renter in period $1 \leq t < T$ describes the decision between becoming a homeowner and remaining a renter, and the decision on the next period's savings. Wages $w_{jst}(\Phi)$, rents $r_{jt}(\Phi)$, house prices $p_{jt}(\Phi)$, and amenities $a_{jt}(\Phi)$ depend on the distribution of population across individual states Φ. When making decisions, individuals take wages, rents, prices and amenities as given. There is a tradeoff between becoming an owner and remaining a renter. On the one hand, ownership may provide a higher expected future utility $\mathrm{E}\left[V^{O}\right]$. On the other hand, in addition to the rent, renter must pay downpayment $dp_{jt}(\Phi)$ in the current period. The value function of a renter is given by

$$\begin{aligned} V^{R}\left(j,s,t,k,h=0;\Phi\right) \;=&& (2.8) \\ \max_{\{\text{own,rent}\}}\Bigg\{ \max_{k'\geq 0}\Bigg\{ & \ln\left[w_{jst}(\Phi)-r_{jt}(\Phi)-dp_{jt}(\Phi)-k'+(1+i_k)k\right] \\ & + a_{jt}(\Phi)+\beta\mathrm{E}\left[V^{O}\left(j,s,t+1,k',1;\Phi'\right)\right]\Bigg\}, \\ \max_{k'\geq 0}\Bigg\{ & \ln\left[w_{jst}(\Phi)-r_{jt}(\Phi)-k'+(1+i_k)k\right] \\ & + a_{jt}(\Phi)+\beta\mathrm{E}\left[V^{R}\left(j,s,t+1,k',0;\Phi'\right)\right]\Bigg\}\Bigg\}, \end{aligned}$$

where the expectation is over the distribution of population next period, Φ'. However, in a stationary economy the distribution is time-invariant, and a rational agent is aware of this, hence in a stationary economy the expectation operator is redundant. The expressions in logs incorporate the individual budget constraint and represent the disposable income used for consumption, that is wage earnings after housing expenses and saving.

An owner in period $2\leq t<T$ decides on savings, and whether to keep the house or sell it and become a renter, taking wages and house prices as given. Here the tradeoff is between a higher expected future utility of ownership, $\mathrm{E}\left[V^{O}\right]$, and a higher current consumption financed by revenues from selling the house. The owner's value function is given by

$$\begin{aligned} V^{O}\left(j,s,t,k,h;\Phi\right) \;=&& (2.9) \\ \max_{\{\text{own,rent}\}}\Bigg\{ \max_{k'\geq 0}\Bigg\{ & \ln\left[w_{jst}(\Phi)-\mathbb{I}_{h\leq\kappa}q(i_h,\kappa)(1-d)p_{j,t-h}-k'+(1+i_k)k\right] \\ & + a_{jt}(\Phi)+\gamma+\beta\mathrm{E}\left[V^{O}\left(j,s,t+1,k',h+1;\Phi'\right)\right]\Bigg\}, \\ \max_{k'\geq 0}\Bigg\{ & \ln\left[w_{jst}(\Phi)-\mathbb{I}_{h\leq\kappa}q(i_h,\kappa)(1-d)p_{j,t-h}+p_{jt}(\Phi)-(1-f_h)p_{j,t-h}-k'+(1+i_k)k\right] \\ & + a_{jt}(\Phi)+\gamma+\beta\mathrm{E}\left[V^{R}\left(j,s,t+1,k',0;\Phi'\right)\right]\Bigg\}\Bigg\}. \end{aligned}$$

In the last period, the value functions are equal to the value of current consumption. For a renter it is equal to

$$V^{R}\left(j,s,T,k,0;\Phi\right)=\ln\left[w_{jst}(\Phi)-r_{jt}(\Phi)+(1+i_k)k\right]+a_{jt}(\Phi),$$

and for an owner it is given by

$$V^O(j,s,T,k,h;\Phi) = \ln\big[w_{jst}(\Phi) - \mathbb{I}_{h\le\kappa} q(i_h,\kappa)(1-d)p_{j,t-h} + p_{jt}(\Phi) - (1-f_h)p_{j,t-h} + (1+i_k)k\big] + a_{jt}(\Phi) + \gamma.$$

The expected lifetime utility of an s-skilled worker who chooses to spend life in location j is

$$V(j|s,\varepsilon;\Phi) = V^R(j,s,t=1,k=0,h=0;\Phi) + \varepsilon(j),$$

and the optimal location choice of this worker satisfies

$$j = \underset{j'\in\mathcal{J}}{\operatorname{argmax}}\left\{V(j'|s,\varepsilon;\Phi)\right\}.$$

2.3 Political Economy of Housing Supply Regulation

Housing supply regulation performs two functions. First, it reduces the elasticity of housing supply and consequently raises rents and prices (equations 2.5, 2.6 and 2.7). Second, regulation increases the amenity value of a city by reducing congestion (equation 2.1).[24]

The individual costs and benefits of regulation depend on whether a person is a renter or an owner. On the one hand, both onwers and renters would like to have *more* regulation in order to enjoy better amenities, since regulation reduces congestion, and *less* regulation to be able to earn higher wages, since regulation weakens agglomeration effects by making cities smaller. On the other hand, while owners prefer a higher level of regulation, since it raises the values of their houses, renters favor a lower level, since it reduces rents and also makes buying a house more affordable.[25]

The level of regulation is determined in a model of probabilistic voting with lobbying.[26] In every city there is a regulatory board, and every period there is an election of local government which appoints members of the board.[27] Two parties, A and B, run for the government and each party proposes a level of residential land use regulation: z_A and z_B.

[24] In practice, different types of regulation may affect supply and prices though different channels. Yet Mayer and Somerville (2000) find that uncertainty associated with obtaining zoning approvals and building permits constrains new development much more than other types of regulation, such as development and impact fees. Paciorek (2013) finds a strong effect of regulation on the supply elasticity.

[25] Dubin, Kiewiet and Noussair (1992) show that in a 1988 election in San Diego, precincts with a larger fraction of owners had a larger proportion of votes cast in favor of growth control measures. Hankinson (2017) runs a nationwide survey and finds that, while homeowners exhibit an aversion toward new construction, renters on average express high support for new housing.

[26] The model of probabilistic voting with lobbying is described in Persson and Tabellini (2002), and is based on Lindbeck and Weibull (1987) and Baron (1994).

[27] In the U.S., municipalities have a Planning and Zoning Commission charged with city planning and recommending to the local government boundaries of zoning districts and regulations to be enforced therein.

The only objective of a party is to be elected and, if elected, it must implement the proposed level. At the end of each period, all residents aged $t \in \{1, ..., T-1\}$ vote, and the level proposed by the winning party is effective next period.[28] Residents have two considerations when deciding which party to vote for: the utility of the proposed regulation level and their idiosyncratic taste for each party.

1. *Utility of regulation.* If party $l \in \{A, B\}$ is elected, then regulation level z_l will be implemented, and a worker in state $x = (j, s, t, k, h)$ will choose to be in state $x'(z_l) = (j, s, t+1, k'_l, h'_l)$ next period. In addition, the worker knows that, if city j chooses a different level of regulation, the distribution of population in the economy will change to Φ'_l, leading to adjustments in wages and housing prices. Thus, changes in individual and aggregate states will lead to changes in the utility of regulation.

2. *Ideology.* Worker i has an idiosyncratic taste for party A, which can be interpreted as ideological bias. This taste shock is denoted by ξ_i and is distributed uniformly across workers on $\left[-\frac{1}{2\nu}, \frac{1}{2\nu}\right]$. Parameter ν measures how consolidated opinions on regulation are among the voters. If $\nu \to \infty$, all voters have the same preference for regulation. If $\nu = 0$, voters completely disagree.

Local elections are financed via campaign contributions. Party $l \in \{A, B\}$ receives C_l from each homeowner who votes for it.[29] The contributions are needed to enact the level of regulation proposed by the party, and their size depends on the proposed level:[30]

$$C_l = \omega_0 z_l^{\omega_1}.$$

The contributions enter the budget constraints and become a part of homeowner's expenses. Taking into account all factors that influence a vote, an individual i with ownership status $m \in \{R, O\}$ votes for party A if

$$V^m\left(x'(z_A); \Phi'(z_A) | x, \Phi\right) + \xi_i - \mathbb{I}_{m=O} C(z_A) \geq V^m\left(x'(z_B); \Phi'(z_B) | x, \Phi\right) - \mathbb{I}_{m=O} C(z_B),$$

[28] Members of the oldest generation do not vote, since they will not be around next period to live with the results of the vote and hence would be indifferent between the two levels of regulation.

[29] Alternatively, renters could be allowed to lobby for less regulation. However, this would incite owners to contribute even more and lead to a contributions "arms race", without changing the equilibrium regulation.

[30] This approach is close in spirit to Glaeser, Gyourko and Saks (2005a), where homeowners spend time out of work to affect the decisions of the zoning authority, and to Hilber and Robert-Nicoud (2013), where regulation is a function of monetary contributions from landowners and developers to the planning board. While there is no data on how much money is spent on campaigning for or against residential development, anecdotal evidence suggests that such actions involve substantial resources. 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.

and for party B otherwise.[31] The value $V^m(x'(z), \Phi'(z)|x, \Phi)$ is the next-period value function of a worker in individual state x and aggregate state Φ, if the chosen regulation is z.

In the unique Nash equilibrium, the electoral competition between the two parties makes them converge to announcing the same policy, and the equilibrium level of regulation maximizes the weighted welfare of local residents,

$$W_j(z) = \nu \int \left[\frac{N_j^O(x)}{N_j} \left(V^O\left(x'(z); \Phi'(z)|x, \Phi\right) - C(z) \right) + \frac{N_j^R(x)}{N_j} V^R\left(x'(z); \Phi'(z)|x, \Phi\right) \right] \mathrm{d}x, \tag{2.10}$$

where integration is performed over all residents of age $a \in \{1, ..., T-1\}$. Therefore the elected level of regulation in city j is

$$z_j = \underset{z \in \mathbb{R}_+}{\operatorname{argmax}} \left\{ W_j(z) \right\}. \tag{2.11}$$

All else equal, homeowners benefit from a higher z_j since it makes the value of their houses higher.[32] Fischel (2001) describes reasons why homeowners might want stricter residential land use regulation, but argues that most of the restrictions capitalize into higher house values. In practice this makes it difficult to distinguish the actions of owners that are explicitly driven by their willingness to increase or maintain house values from those that are aimed at improving local public goods and services. Nonetheless, a model in which the main reason why owners prefer strict regulation is because it raises house values, such as the model in this paper, can be interpreted more generally, since the house value motivation contains many other reasons for preferring stringent regulation.

2.4 Equilibrium

Distribution of labor across locations. Utility shocks ε follow the extreme value type 1 distribution with parameters μ_ε and σ_ε, and zero mean.[33] Consider a worker with skill s. Before the vector of utility shocks ε is known to the worker, her value of choosing to

[31] The future distribution of votes in a city also influences the value of locating in the city. However it is completely described by the value functions and the future distribution of labor $\Phi'(z_l)$, and thus does not have to enter the value functions separately.

[32] An increase in regulation may actually reduce prices if the resulting outflow of labor to other locations is large, as in Chatterjee and Eyigungor (2017). In the current paper, the outflows are small due to individual location preferences and the inability to move after the first period.

[33] The extreme value type 1 distribution is widely used in discrete-choice models. The density of the distribution with parameters μ_ε and σ_ε is $f(x) = \exp(-\exp(-(x - \mu_\varepsilon)/\sigma_\varepsilon))$. The mean is $\mu_\varepsilon + \sigma_\varepsilon \bar{\gamma}$, where $\bar{\gamma} \approx 0.5772$ is the Euler-Mascheroni constant, and the variance is $\sigma_\varepsilon^2 \pi^2/6$. The utility shock has zero mean if $\mu_\varepsilon = -\sigma_\varepsilon \bar{\gamma}$.

spend life in location j is[34]

$$\tilde{V}(j|s,\Phi) \equiv V^R(j,s;t=1,k=0,h=0;\Phi).$$

Let $\Pi(j|s,\Phi)$ be a conditional choice probability (CCP), the probability that, after observing ε, an s-skilled worker chooses to live in j. The distributional assumption on ε allows to derive a closed-form expression for the CCP:[35]

$$\Pi(j|s,\Phi) = \frac{\exp\left(\tilde{V}(j|s,\Phi)\right)^{\frac{1}{\sigma_\varepsilon}}}{\sum_{j'\in\mathcal{J}}\exp\left(\tilde{V}(j'|s,\Phi)\right)^{\frac{1}{\sigma_\varepsilon}}} \tag{2.12}$$

Since workers can only migrate once in lifetime, the CCPs translate directly into the city size distribution. The equilibrium supply of age-1 s-skilled workers in location j is given by

$$N_{js1} = \Pi(j|s,\Phi)\lambda_s,$$

where λ_s is the exogenous fraction of s-skilled workers. Then the total supply of s-skilled workers is $N_{js} = TN_{js1}$, and the total population in the location is $N_j = N_{jL} + N_{jH}$.

I focus on stationary spatial equilibria. By doing this, I restrict attention to long-term effects of regulation.[36]

Definition 2.1. A *stationary spatial equilibrium* consists of value functions V^O and V^R and the associated decision rules that determine optimal location, ownership status and savings; prices $w_{jst}(\Phi)$, $p_j(\Phi)$ and $r_j(\Phi)$; levels of regulation z_j; conditional choice probabilities Π; distribution of labor Φ; and a transition function $F:\mathcal{X}\to\mathcal{X}$, such that: (1) the value functions maximize expected utility and the decision rules attain the value functions; (2) wages, house prices and rents clear markets in every city; (3) the social welfare function (2.10) is maximized in every city via the probabilistic voting mechanism; (4) the distribution of labor is stationary: $F(\Phi) = \Phi$.

Computing an equilibrium. An advantage of focusing on stationary equilibria is that rational agents learn that they are in a stationary environment and know that next

[34]In the discrete-choice literature these functions are called *conditional value functions*.

[35]The possibility of obtaining closed-form solutions for conditional choice probabilities in models with extreme value type 1 shocks was first discovered by McFadden (1973).

[36]Elasticity of housing supply also matters for the ability of a city to withstand short-term fluctuations: Arias, Gascon and Rapach (2016) find that areas with less elastic supply experience more severe recessions, while Huang and Tang (2012) and Paciorek (2013) find that in locations with restricted supply house prices are more volatile.

period the distribution of workers across individual states will be the same as in the current period. Moreover, in a stationary equilibrium political parties run with the same proposed level of regulation every period. They know that the composition of population in the city is exactly the same as in the previous period, and therefore the announced level of regulation that maximizes their probability of winning is the same as one period before. Workers, in turn, know that the parties will offer the same level of regulation next period and embed this knowledge in their value functions. All these features greatly simplify the computation.

However, even in a stationary environment, the political economy part of the equilibrium poses a significant computational challenge for two reasons. First, maximization of the social welfare function (equation 2.10) requires evaluating workers' value functions at different non-equilibrium regulation levels. To do that, one needs to know an entire dynamic path of regulation in every city starting from any level of regulation. Second, when voting on regulation, individuals must know how every elected level of regulation would affect labor supply in a city. In other words, they must fully know the shape of the aggregate transition function F. Yet F is a high-dimensional object and its computation is difficult. In order to deal with these two issues during computation of an equilibrium, I make two simplifying assumptions. Appendix A.3 discusses these assumptions and other computational details.

2.5 Regulation and Amplification

As discussed earlier, housing supply regulation has two direct effects: on the one hand, it alleviates congestion, on the other hand, it raises house prices and rents. Residents vote on regulation taking into account these two effects. The fundamental determinants of regulation are local land supply, productivity and amenities. Lower supply of land implies higher density and therefore stronger congestion, which increases the demand for regulation. Higher productivity and amenities attract more workers, also making congestion higher and encouraging residents to strengthen regulation. At the same time, lower land supply, higher productivity and better amenities will all increase house prices by simultaneously reducing the supply and raising the demand for housing. In places like these, real estate is a more important part of individual portfolios, hence owners are more interested in voting for higher regulation in order to preserve or increase the value of their asset.[37]

Indeed, in line with the predictions of the model, data shows that, even after controlling for the city size, metropolitan areas with scarce land, high wages, and high house prices tend

[37]This is because in places with scarce land, prices are more sensitive to changes in regulation. To see this, note that the derivative of the equilibrium house price (equation 2.6) with respect to regulation and land scarcity, $\frac{\partial^2 p_j}{\partial z_j \partial (1-\Lambda_j)} = \chi_j^O \zeta_{\text{land}}^O \zeta_{\text{reg}}^O \left(\ln N_j\right)^2 \times N_j^{\bar{\zeta}^O + \zeta_{\text{land}}^O (1-\Lambda_j) + \zeta_{\text{reg}}^O z_j}$, is positive as long as $\zeta_{\text{land}}^O > 0$ and $\zeta_{\text{reg}}^O > 0$, which is indeed what the empirical analysis of this paper finds (see Section 3).

to be the most regulated (Figures A.5, A.6 and A.7). At the same time, highly regulated areas have less homeowners (Figure A.8).[38]

To illustrate the *main mechanism* of the model, suppose that location j experiences an increase in its exogenous TFP $\bar{A}_j$. This attracts workers to the city, and the demand for housing goes up. As a consequence, prices increase and the inflow of labor slows down. However, the inflow of high-skilled workers is not affected as much as that of the low-skilled, since the former earn higher wages and therefore spend a smaller share of income on housing. As a result, the share of high-skilled workers in the city grows. If the cities experiencing faster productivity growth are those with initially high fraction of skilled labor, then *skill sorting* ensues. This is exactly what we see in the data since 1980 (Figure A.1).[39] Skill sorting, in turn, leads to larger *wage differences* across locations.[40] Similarly to skill sorting, there has been a rise in wage dispersion across cities since 1980 (Figure A.2). Finally, if areas where productivity grows faster were the areas where housing was more expensive to begin with, then the model produces an increase in house price dispersion, another phenomenon observed in the data (Figure A.3).

What role does regulation play? In response to stronger congestion and higher house prices, local residents, especially homeowners, vote to increase the level of regulation. This raises prices even more, especially in land-scarce cities, and makes labor inflows smaller. As a result, labor increasingly locates in more affordable but less productive places, which causes *spatial misallocation* of labor and reduces aggregate productivity. However, the effect of house prices on the inflow of low-skilled workers is stronger than on the high-skilled, and therefore skill sorting is more intense and wage inequality grows by more. Therefore, the endogenous regulation mechanism *amplifies* the effect of exogenous differences in productivity and land supply on (1) aggregate productivity, (2) skill sorting, (3) wage inequality across locations, and (4) house price dispersion across locations.

Rise in Housing Supply Regulation One notable fact about regulation is that it has become much more stringent since the 1970s and also more different across locations.[41]

[38]The model does not unambiguously predict what the relationship between regulation and homeownership should be. On the one hand, higher ownership rates should lead to more regulation as owners are likely to be interested in restricting new construction. On the other hand, high regulation leads to higher house prices and makes ownership unaffordable for a larger share of population. The observed negative correlation between ownership and regulation suggests that the second effect dominates in the data.

[39]The increase in skill sorting since the 1980s across MSAs was studied by Moretti (2004), Berry and Glaeser (2005), Shapiro (2006), Diamond (2016) and Giannone (2018).

[40]That the increase in skill sorting leads to the increase in mean wage differences cannot be shown analytically. However, it is the case for the model parameters and the observed skill shares at the MSA level.

[41]Regulation is hard to quantify, hence it is challenging to document its rise. Yet, using various approaches, a number of studies show that regulation has became stringent over the last few decades. See McLaughlin (2012), Morrow (2013), Gyourko and Molloy (2015), Jackson (2016), and Ganong and Shoag (2017).

Glaeser, Gyourko and Saks (2005a) examine several explanations for the rise of regulation and assert that the most likely reasons are that residents' groups have become more politically influential and that the ability of developers to affect decisions of local planning boards using legal and illegal payments has diminished. Fischel (2001) argues that homeowners would support any measure that raises the value of their property, strict land use regulation being one of them, and since the 1970s they have been more able to incite local governments to adopt regulation that favors their interests.

The political economy model of regulation proposed here can accommodate these forces and can generate the rise of regulation and the increasing differences across cities.[42] As house prices increased, real estate became more important in the portfolios of homeowners, which made them more willing to undertake actions that preserve or increase the values of their houses. In the context of the model of this paper, this increased the willingness of owners to pay campaign contributions toward more stringent regulation, which could be interpreted as an increase in owners' influence on local governments. However, because productivity and house prices increased faster in some places than in others, regulation became very stringent in highly productive expensive cities, while it didn't increase much elsewhere.

3 Parameter Values and Benchmark Economy

The quantitative model has 202 locations, which correspond to the 202 MSAs in the sample (see Appendix A.2 for more details).[43] Model parameters are set so as to reproduce some central facts about local labor and housing markets, migration, and residential land use regulation in the U.S. during 2005-2007. I focus on these years, since the data on regulation is only available for the year 2007. Parameter values are summarized in Table A.2.

3.1 Parameter Values

3.1.1 Parameters Calibrated outside the Model

Land supply Λ_j is taken from Saiz (2010) and represents the fraction of territory within a 50km radius from the population centroid of a metropolitan area that is not occupied by

[42]I have conducted an exercise in which all observables, besides regulation, were changed to the level of 1980 and some parameters recalibrated to match the 1980 moments. In this experiment, regulation becomes smaller on average and less different across cities, consistent with Ganong and Shoag (2017) and other studies. However, given that there is no time series index of regulation, it is not clear whether the magnitude of the increase in regulation between 1980 and 2007 generated by the model is similar to the actual increase.

[43]Some MSAs, typically small ones, had to be dropped due to the lack of data on land supply or regulation.

water or slopes steeper than 15%.[44] The degree of congestion δ is set to 0.25, following Albouy et al (2017).[45]

A worker's life cycle consists of $T = 8$ periods, each five years long. These periods correspond to ages 25-29, 30-34, ..., 60-64 in the data. The fraction of high-skilled workers in the economy is $\lambda_H = 0.365$, which is the share of observations with a college degree in the sample. The time discount factor is $\beta = 0.96$. The parameter that governs the variance of the location preference shocks, σ_ε, is set to 0.3, following Hsieh and Moretti (2018).[46]

The parameter that determines the variance of the ideological taste shocks, ν, is normalized to 1. The expression for local welfare (equation 2.10) illustrates that ν scales the total welfare but does not affect the welfare-maximizing choice of regulation, therefore the value of ν is irrelevant for the calibration. The savings interest rate is $i_k = 4.30\%$, the average rate on 5-year CDs in 2005-2007, according to the National Credit Union Administration.[47]

The parameters that characterize mortgage contracts are taken from the data. According to the American Housing Survey in 2013, the average downpayment rate was 16.1% (excluding homes bought outright) and 25.1% (including homes bought outright). In practice, a common downpayment in mortgage contracts is 20%. Hence $d = 0.2$. As much as 80% of outstanding mortgages had a 30-year period, thus the mortgage term in the model is set to $\kappa = 6$ periods, which corresponds to 30 years. Finally, the interest rate on the mortgage is $i_h = 6.21\%$, the average rate in 2005-2007, as reported by Freddie Mac.[48]

3.1.2 Labor Demand

Taking log of equation (2.4), we obtain the following labor demand specification:

$$\ln w_{jst} = \ln \bar{A}_j + \rho \ln N_j + \ln \eta_{jst}. \tag{3.1}$$

To estimate $\bar{A}_j$, ρ and η_{jst}, I must first solve the problem of reverse causality between w_{jst} and N_j. I use the Bartik (1991) labor demand shocks as an instrument for labor supply of each type N_{jst}. Bartik shocks have been extensively used for identification in labor and urban economics, and are obtained by interacting cross-MSA differences in industrial composition in year y with changes in industrial composition at the national level between years $y-1$ and y. The identifying assumption is that changes in industrial composition in all cities but

[44] This implies that potential land area of an MSA only depends on geographic characteristics and not on population size or regulation.

[45] There is no consensus on the value of δ in the literature, and values from 0.1 to 0.5 have been used.

[46] Hsieh and Moretti (2018) uses the type 2 extreme value distribution, while this paper uses the type 1 extreme value distribution. However, the value of σ_ε is the same across the two distribution types.

[47] https://www.ncua.gov/DataApps/Documents/CUBNK200320042005.pdf

[48] http://www.freddiemac.com/pmms/pmms30.htm

j are uncorrelated with labor supply shocks in j. The Bartik instrument is defined as the change in labor supply of type (s,t) in city j as predicted by changes in the supply of this type of labor in each of the industries $i \in \mathcal{I}$ in the rest of the economy:

$$B_{jst,y} = \sum_{i \in \mathcal{I}} \left(\ln \left(\sum_{j' \neq j} N_{ij'st,y} \right) - \ln \left(\sum_{j' \neq j} N_{ij'st,y-1} \right) \right) \frac{N_{ijst,y-1}}{N_{jst,y-1}}.$$

To construct the instruments, I use 13 industry groups in the Census classification.[49] Since the instrument depends on the industrial composition of city j in year $y-1$ and the change in labor supply to each industry between years $y-1$ and y in all cities but j, it is exogenous to current productivity levels in city j. The predicted supply of labor of each type is $\ln \hat{N}_{jst,y} = \ln N_{jst,y-1} + B_{jst,y}$, and the estimating labor demand equation is given by

$$\ln w_{jst,y} = \ln \bar{A}_{jy} + \rho \ln \left(\sum_{s \in \{L,H\}} \sum_{t=1}^{T} \hat{N}_{jst,y} \right) + \ln \eta_{jst,y}. \tag{3.2}$$

Labor demand parameters are estimated using data from 1970, 1980, 1990 and 2000 Censuses and the 2005-2007 three-year American Community Survey sample. Parameters $\bar{A}_{jy}$ and $\eta_{jst,y}$ cannot be identified separately, but this is not needed, given that local wages depend on the product of the two parameters. The value $\ln \bar{A}_{jy} + \ln \eta_{jst,y}$ is equal to the estimated residual plus the year fixed effect and the constant in regression (3.2). The estimated agglomeration effect ρ is 0.041, consistent with the estimates obtained in the literature.[50]

3.1.3 Housing Supply

Taking logs of equations (2.5) and (2.6), and plugging in equation (2.7), we obtain the following expressions for rents

$$\ln r_j = \ln \chi_j^R + \left(\bar{\zeta}^R + \zeta_{\text{land}}^R (1 - \Lambda_j) + \zeta_{\text{reg}}^R z_j \right) \ln N_j, \tag{3.3}$$

and house prices

$$\ln p_j = \ln \chi_j^O + \left(\bar{\zeta}^O + \zeta_{\text{land}}^O (1 - \Lambda_j) + \zeta_{\text{reg}}^O z_j \right) \ln N_j. \tag{3.4}$$

[49] The industry groups are: (1) agriculture, forestry, and fisheries; (2) mining; (3) construction; (4) manufacturing of nondurable goods; (5) manufacturing of durable goods; (6) transportation, communications, and other public utilities; (7) wholesale trade; (8) retail trade; (9) finance, insurance, and real estate; (10) business and repair services; (11) personal services; (12) entertainment and recreation activities; (13) professional and related services.

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

Estimation of the housing market parameters faces the same issue as the estimation of labor demand: there is reverse causality between labor supply N_j and prices or rents. This issue is solved by instrumenting for labor supply using the Bartik (1991) labor demand shocks, similar to those described above. The Bartik instrument is defined as the change in the supply of labor of type (s,t) with ownership status $m \in \{R, O\}$ in city j, as predicted by the changes in the supply of this type of labor in each of the industries $i \in \mathcal{I}$ in the rest of the economy between years $y-1$ and y. The instrument is given by

$$B^m_{jst,y} = \sum_{i\in\mathcal{I}} \left(\ln\left(\sum_{j'\neq j} N^m_{ij'st,y} \right) - \ln\left(\sum_{j'\neq j} N^m_{ij'st,y-1} \right) \right) \frac{N^m_{ijst,y-1}}{N^m_{jst,y-1}},$$

and the predicted supply of labor of each type is $\ln \hat{N}^m_{jst} = \ln N^m_{jst,y-1} + B^m_{jst,y}$.

Rents, originally reported at monthly frequency, are converted to 5-year rates to be consistent with the model period. The values r_j and p_j are average rents and prices for a given metropolitan area, controlled 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.[51]

Since the land use regulation data is only available for 2007, housing supply is estimated using individual-level data from the 2005-2007 ACS three-year sample. To convert the Wharton index of regulation into units suitable for the housing supply specification in this paper, I take the log of the Wharton index and add 3.[52]

The estimating equations are then

$$\begin{aligned} \ln r_j &= \ln \chi^R_j + \left(\bar{\zeta}^R + \zeta^R_{\text{land}}(1-\Lambda_j) + \zeta^R_{\text{reg}} z_j\right) \ln \hat{N}_j, \\ \ln p_j &= \ln \chi^O_j + \left(\bar{\zeta}^O + \zeta^O_{\text{land}}(1-\Lambda_j) + \zeta^O_{\text{reg}} z_j\right) \ln \hat{N}_j. \end{aligned} \tag{3.5}$$

Parameters $\ln \chi^R_j$ and $\ln \chi^R_j$ correspond to residuals in the regressions above. In all but one metropolitan areas, the estimated elasticity of supply $(1/\zeta^m_j)$ is lower for owner-occupied housing than for rental (See Table A.2).

3.1.4 Parameters Calibrated within the Model

The utility of homeownership γ is calibrated to the observed homeownership rate. The two parameters of the campaign contribution function, ω_0 and ω_1, and the strength of the congestion effect ϕ are calibrated to the following three moments of the distribution of the

[51] I follow the hedonic regression approach used in Eeckhout, Pinheiro and Schmidheiny (2014).

[52] This transformation is used in Saiz (2010) in order to ensure positive levels of regulation in the estimation, as the Wharton Index is built such that it has mean of zero and standard deviation of one. That paper claims that adding a positive constant to the log of the original index does not change the results.

Wharton index: the mean, the standard deviation, and the ratio between average regulation in the 20% of cities with least land and the 20% of cities with most land. The rationale for using the latter moment is that the congestion effects, and thus the incentives to regulate, are larger in cities with less land. Finally, the vector of exogenous amenity parameters α_j is calibrated so as to match the observed distribution of population across MSAs.

3.2 Benchmark Economy

Table 1 compares the empirical targets for the calibrated parameters and the corresponding moments produced by the model. The model reproduces very well the five targeted moments, and the distribution of population is matched nearly exactly to the one observed in the data.

Table 1: Model Fit (targeted moments)

	Model	**Data**
Homeownership rate	0.693	0.692
Regulation, mean	1.056	1.058
Regulation, s.d.	0.244	0.251
Regulation, bottom 20% land / top 20% land	1.270	1.274
Population (distance: data vs model)	0.85%	

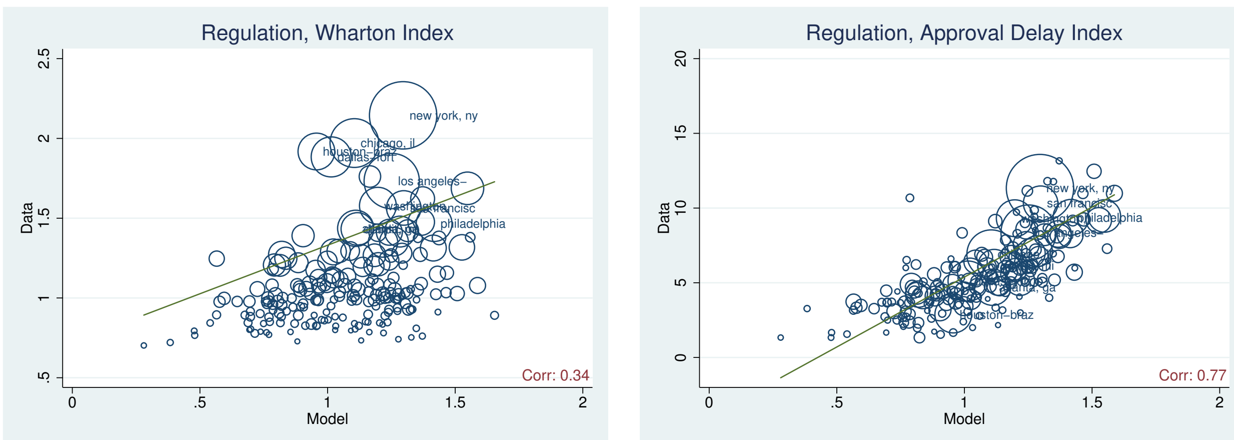
Table A.3 shows the performance of the model relative to a set of non-targeted moments. The dispersion of average wages and college shares across cities produced by the model is higher than that observed in the data.[53] At the same time, house price dispersion is very similar to the one observed in the data. In addition, the correlations between regulation and wages, house prices, homeownership and land scarcity have the same sign and similar magnitude in the model as in the data. Even though not targeted, aggregate expenditures on housing in the model are equal to 24% of wage income, the same number as found by Davis and Ortalo-Magné (2011).

Most importantly, the model produces a fairly accurate prediction of the level of regulation in each location, even though I only target three moments of the distribution of the Wharton index. The correlation between the Wharton index and the regulation predicted by the model is 0.34 (Figure 1). However, in practice regulation affects land use and prices through many channels, while the channel emphasized in the model is the elasticity of supply. The correlation between the regulation predicted by the model and the Approval Delay

[53]The age-skill specific wages are matched nearly exactly, since they depend on exogenous productivities η_{jst}. However, the skill shares are not targeted, and therefore are not reproduced exactly. As a result, average wages at the city level are also not matched exactly.

Index (ADI), a subindex of the Wharton Index most related to the supply elasticity, is 0.77 (Figure 1).[54] Taking into account that many reasons why regulation differs across locations are outside the scope of the model, these correlations are fairly high.[55] If we interpret these correlations as the R^2 in the regressions of the model-predicted regulation on the Wharton index and the ADI, we can say that the model explains 12% of the variation in the Wharton index and 59% of the variation in the ADI.

Figure 1: Regulation: model vs data



4 Causes and Implications of Regulation

How do exogenous local land and productivity differences affect productivity and economic outcomes? What is the effect of levels and cross-city differences in regulation on aggregate productivity, wage inequality, house prices and other variables? In this section, I perform two sets of experiments to answer these questions.

4.1 Causes of Regulation

As Section 2.5 argues, residents of highly productive cities with little land are inclined to choose strict regulation, hence regulation amplifies the effects of exogenous differences

[54] The Approval Delay Index takes into account the average duration of the review of a building permit, the typical amount of time between application for rezoning and issuance of a building permit for hypothetical projects, and the typical amount of time between application for sub-division approval and the issuance of a building permit conditional on proper zoning being in place. Therefore, a higher value of the ADI should indicate a lower housing supply elasticity.

[55] Some of the reasons include historical land use patterns (Glaeser and Ward, 2009) and political ideology of local voters (Kahn, 2011).

in land and productivity across cities. In order to understand how large the effects of land and productivity are, I conduct the following counterfactual experiments. First, land endowments are set to the mean level in every city which allows isolating the effect of land differences. Second, skill-age specific productivities are set to the mean level in every city which allows studying the effect of exogenous productivity differences.[56] This equalizes exogenous productivity parameters (η_{jst}) across cities, though local TFPs still differ due to agglomeration effects. Finally, both land and productivity levels are equalized across cities.

Endowing all cities with the same amount of land leads to an overall fall in regulation and an increase in productivity. However the effect on skill sorting is very small, and therefore there is no effect on wage inequality across locations.[57] In addition, even though the differences in prices across cities fall, the average prices are 5.5% higher. This is because many metropolitan areas with low prices see their land endowment shrink and hence prices there go up.

Equalizing productivities across locations does not change the average level of regulation. At the same time, the experiment produces a dramatic fall in wage inequality and skill sorting, however the effect is largely mechanical since a substantial fraction of wage inequality in the benchmark arises from differences in exogenous productivities. In this experiment, house prices and their differences across locations become smaller.

Finally, elimination of land and productivity differences at the same time allows evaluating their joint effect. In this experiment, average regulation falls and productivity increases slightly, by 0.6%. Wage differences and skill sorting across cities fall significantly. House prices and house price dispersion drop as well. Table 2 summarizes the results of all three experiments.

Table 2: Effects of land and productivity differences

	Benchmark	Same land	Same productivity	Same land & productivity
Mean regulation	1.056	1.009	1.056	1.008
S.d. regulation	0.244	0.254	0.285	0.285
Output	1.000	1.012	1.000	1.006
Skill sorting	0.206	0.195	0.180	0.162
Variance of log wages	0.042	0.043	0.024	0.023
Mean house prices	1.000	1.055	0.832	0.935
Variance of log house prices	0.233	0.203	0.181	0.157

[56]That is, in every city a skill-s age-t worker has access to productivity $\bar{\eta}_{st} = \frac{1}{J}\sum_{j\in\mathcal{J}} \eta_{jst}$. Parameters $\bar{\eta}_{st}$ are normalized such that aggregate output is the same as in the benchmark calibration.

[57]Skill sorting is measured as the standard deviation of college shares across MSAs.

4.2 Implications of Regulation

In order to study the effects of regulation on the economy, I conduct three quantitative experiments.

First, I introduce a one-size-fits-all policy by setting regulation at the national average level in all cities. In this case, highly regulated cities are forced to reduce regulation, while cities with low regulation levels have to increase regulation. As a result of this experiment, aggregate productivity increases by 3.8%. Average house prices fall by 20% relative to the benchmark, while house price dispersion, measured as the variance of log prices, drops by 24%. The large effect on house prices is not surprising, since regulation is a key component of house prices in the model, and is consistent with Glaeser, Gyourko and Saks (2005b) and Saiz (2010), which found that a major part of the variation in house prices across metro areas in the U.S. can be attributed to differences in residential land use regulation. With house prices being more similar across locations, skill sorting, measured as the standard deviation of college shares across metro areas, falls by nearly 20% and, as a result, wage inequality across cities, measured as the variance of log wages, falls by about 10%.

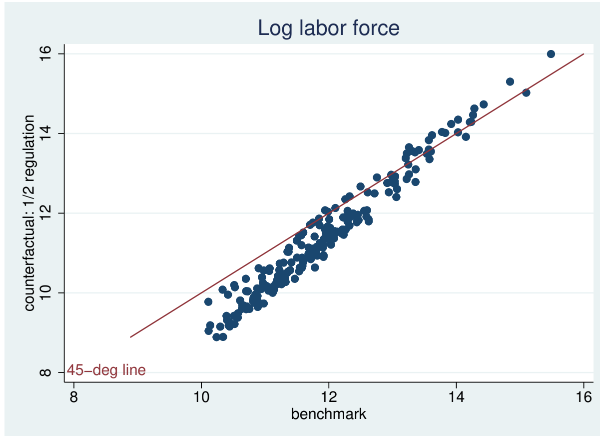
Second, I set regulation in every city to 1/2 of the benchmark level. In this scenario, the relative differences in regulation across cities are preserved, however regulation becomes lower everywhere. Because large productive cities become cheaper to live in, they experience an inflow of workers. As a result, aggregate productivity goes up by 3.5% and average house prices drop by 30%. Since cities still differ in regulation in this experiment, house price dispersion only decreases by 14% relative to the benchmark. A smaller effect on house price differences, relative to the previous experiment, also implies a smaller effect on skill sorting and wage inequality. The standard deviation of college shares across cities falls by 13%, while the variance of log wages across cities declines by 4%.

The effects in these experiments arise because highly productive areas are more regulated, and therefore have higher house prices. As a result, labor is misallocated as marginal workers choose to reside not where they are most productive but where housing is affordable.[58] Figure 2 shows that the counterfactual city size distribution in the experiment with half regulation is less compressed than the benchmark distribution: cities large in the benchmark become even larger, while small cities become even smaller.[59]

[58]The results of the experiments in this paper are comparable to the results of Hsieh and Moretti (2018), which finds that reducing regulation in only three highly productive metro areas – New York, San Francisco and San Jose – to the median U.S. level would raise aggregate productivity by 3.7% (with imperfect mobility of workers) to 8.9% (with perfect mobility of workers).

[59]Given the functional form of agglomeration externalities, reallocation of workers across cities alone does not change aggregate productivity – agglomeration makes productivity higher in large cities but lower in small cities. The productivity effect arises because workers move to the *exogenously* more productive cities.

Figure 2: City size: benchmark vs half regulation



In the third experiment, I eliminate regulation everywhere, i.e. set $z_j = 0$ in all cities. In this experiment, aggregate productivity only increases by 1.2%. Why does a complete elimination of regulation lead to a much smaller effect on productivity? On the one hand, housing supply becomes much more elastic making the most productive cities much more affordable – on average prices fall by 57%. On the other hand, congestion effects become much stronger making big cities unpleasant locations to live. As a result, the city size distribution becomes more compressed and aggregate productivity does not increase much. Elimination of regulation also does not lead to a reduction in skill sorting and wage inequality.

The results of the three experiments are summarized in Table 3.

Table 3: Counterfactual experiments

	Benchmark	Mean reg	Half reg	Zero reg
Mean regulation	1.056	1.056	0.528	0
S.d. regulation	0.244	0	0.122	0
Output	1.000	1.038	1.035	1.012
Welfare (consumption equivalence)	1.000	1.193	1.189	1.027
Skill sorting	0.206	0.167	0.179	0.205
Variance of log wages	0.042	0.038	0.040	0.041
Mean house prices	1.000	0.794	0.700	0.429
Variance of log house prices	0.233	0.177	0.200	0.161
Homeownership rate	0.69	0.82	0.85	0.87

How large are welfare gains under each of the experiments? In order to answer this question, I use a consumption-equivalent measure of a change in welfare. Under this measure,

Δ, the parameter which measures the increase in consumption, must solve

$$\int \left(\ln\left(c^1(x)\right) + \mathbb{I}_{x:h\geq 1}\gamma + a^1(x)\right) \mathrm{d}\Phi^1(x) = \int \left(\ln\left(c^0(x) + \Delta\right) + \mathbb{I}_{x:h\geq 1}\gamma + a^0(x)\right) \mathrm{d}\Phi^0(x),$$

where the 0-superscript indicates values and distributions in the benchmark economy, the 1-superscript indicates values and distributions in the counterfactual economy, and $x = (j, s, t, k, h)$ is individual state. I find that the the consumption-equivalent measure of welfare would increase by 19.3% when regulation is set to the mean level, by 18.9% when regulation is halved, and only by 2.7% when regulation is set to zero.[60] Welfare gains are much bigger than output gains in the first two experiments largely thanks to a much larger homeownership rate and lower housing costs. In the third experiment, the benefits of higher homeownership are trumped by a much lower amenity value of cities due to a larger congestion effect.[61]

5 Federal Policy Interventions

In the U.S., the federal government have virtually no authority to interfere with municipal decisions on land use, though some state governments have some power over municipal decisions.[62] Land use regulation in the U.S. has always been administered by municipal governments, and direct federal involvement in land use issues would be unconstitutional.[63] In the model of this paper likewise local governments choose regulation independently, only considering local welfare and disregarding possible nationwide effects of their decisions. However, as the exercises in Section 4.2 illustrate, the freedom of cities to set their preferred level of regulation results in lower aggregate productivity. This happens because the residents of any given city, when choosing regulation independently, impose an externality on the rest of the economy.

In this section, I study an alternative political arrangement that reduces the level of regulation in those locations where homeowners have incentives to impose strict regulation. According to this policy, the federal government introduces a Pigouvian tax on cities with high regulation and uses the tax proceeds to provide transfers to cities with low regulation, therefore reducing the incentives to regulate in all cities. In practice, of course, such a tax would not be feasible. However, the federal government provides sizable transfers to

[60]Admittedly, the welfare effects may be overestimated since they do not take into account the welfare losses of the absentee real estate managers which lose from lower prices and rents.

[61]Turner, Haughwout and van der Klaauw (2014) and Albouy and Ehrlich (2016) also argue that land use regulation has negative welfare effects. Lens and Monkkonen (2016) find that regulation drives urban segregation by income, which may impose longer term welfare costs.

[62]Hirt (2014) discusses the history of land use regulation in the U.S. and compares it to other countries.

[63]See Gyourko and Molloy (2015).

municipal governments.[64] The policy proposed in this section could be viewed as a cut of federal funding to cities that restrict housing supply (i.e. cities with high housing supply regulation) and an increase in the funding of cities that do not restrict supply. In practice, such system of transfers between municipalities would not depend on the Wharton index but on a measurable indicator of supply restrictions (e.g. number of constructed units per capita during a period of time).

The tax is paid by all residents in a city and therefore reduces the disposable income. The tax rate depends on the current level of land use regulation in the city as follows:

$$\tau(z_j) = \tau_0 + \tau_1 z_j.$$

If $\tau > 0$, then residents are taxed for choosing strict regulation that leads to high real estate values. If $\tau < 0$, then residents receive a transfer as a reward for selecting lax regulation. The policy is purely redistributive, i.e. net transfers in the economy are zero:

$$\sum_{j \in \mathcal{J}} \tau(z_j) N_j = 0. \tag{5.1}$$

The goal of the federal planner is to maximize aggregate productivity. The values of the parameters which maximize aggregate productivity while satisfying the condition (5.1) are $\tau_0 = -52,061$ and $\tau_1 = 79,850$. The highest regulation taxes are incurred by the New York and Los Angeles metropolitan areas: $\tau = 20,737$ and $\tau = 10,590$, respectively. Since the period is 5 years, this is equivalent to an annual federal tax of \$4145 (New York) or \$2118 (Los Angeles) per worker.

I find that the productivity-maximizing transfer scheme would increase output by about 2.5%. Output grows thanks to lower regulation and therefore higher population in highly productive cities. This policy also reduces average house prices by as much as 36% and the variance of log house prices by 16%. In addition, the federal intervention increases the national homeownership rate from 69% to 86%. However, this policy does not help reduce wage inequality across locations, largely because the effect of the policy on skill sorting is smaller. On the one hand, housing in large productive cities becomes cheaper. On the other hand, they face higher regulation taxes. Since the taxes are lump-sum, this discourages inflows of low-skilled workers, and therefore the effect on the skill sorting is small. Table 4

[64] 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.

summarizes results of the policy intervention.

Table 4: Federal policy interventions

	Benchmark	Tax on Reg
Mean regulation	1.056	0.475
S.d. regulation	0.244	0.080
Output	1.000	1.025
Welfare (consumption equivalence)	1.000	1.155
Skill sorting	0.206	0.194
Variance of log wages	0.042	0.042
Mean house prices	1.000	0.639
Variance of log house prices	0.233	0.195
Homeownership rate	0.69	0.86

Using the consumption-equivalent measure of welfare introduced above, I find that the output-maximizing policy would increase welfare by 15.5%. What are the sources of the welfare gains? The largest gains come from lower house prices. First, thanks to lower prices homeownership increases and therefore more workers benefit from the utility of owning a house. Second, lower prices reduce housing expenditures and allow workers to consume more. Moderate gains also come from lower homeowners' expenses on regulation and the consumption value of federal transfers. Welfare gains could be even larger if lower regulation did not increase congestion and thus reduce the amenity value of cities. Table 5 summarizes the channels of the welfare gains.

Table 5: Decomposition of welfare gains due to the federal policy interventions

Total welfare gain	15.5%
Contribution of homeownership	8.1%
Contribution of expenses on regulation	3.2%
Contribution of federal transfers	1.3%
Contribution of amenities	-8.2%
Contribution of consumption	11.1%

A federal transfer scheme which punishes cities that restrict housing supply and rewards the others could also take other forms. One other option would be to amend the personal taxation system. For instance, the federal government could lower the limit for the mortgage interest deduction and use the tax revenues to stimulate construction in highly regulated areas.[65] Also, the federal government could reform taxation of real estate capital gains. Currently, households can deduct up to $500,000 of the taxable profit from the sale of real estate, and the capital gains tax rate does not depend on the sale price.[66] Lowering the deduction limit or making the tax rate progressive in the sale price may reduce the incentives of homeowners to introduce supply restrictions that result in higher prices.

6 Conclusions

In this paper, I study the causes and implications of housing supply regulation in the United States. To this end, I build a spatial equilibrium model in which the distributions of workers, wages and housing prices across metro areas are determined endogenously, and housing supply regulation is chosen by local residents in a voting process. I argue that exogenous differences in land and productivity incite some cities to choose excessive regulation. These choices lower aggregate productivity and lead to higher house prices and price dispersion, as well as larger skill sorting and wage differences across locations.

The negative effects of regulation arise because regulation is determined locally and residents in each community do not internalize the consequences of their choices for the rest of the economy. In a policy experiment where the federal government introduces a Pigouvian tax that discourages local regulation, I find that output would be 2.5% higher, average house prices 36% lower, and welfare more than 15% higher. The policy, however, does not reduce wage inequality.

[65] This solution was originally proposed by Glaeser and Gyourko (2008). They suggested a reduction from $1,000,000 to $300,000, however the limit was already lowered to $750,000 following the Tax Cuts and Jobs Act of 2017.

[66] https://www.irs.gov/pub/irs-pdf/p523.pdf

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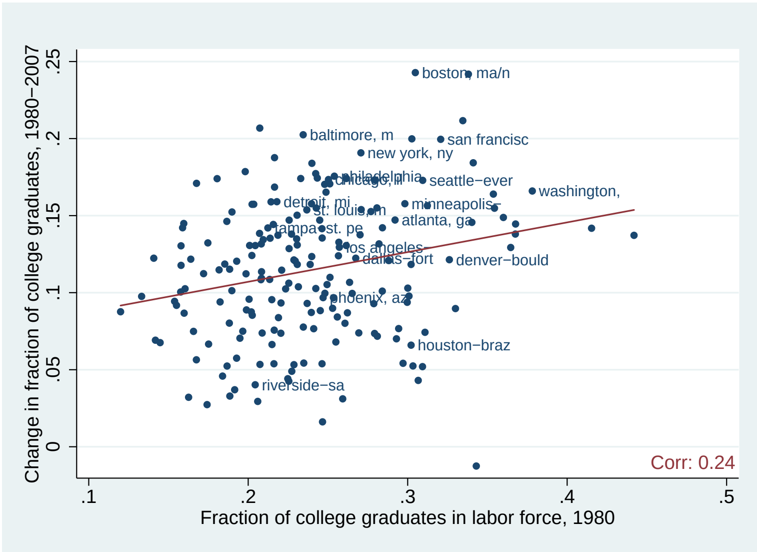
A Appendix

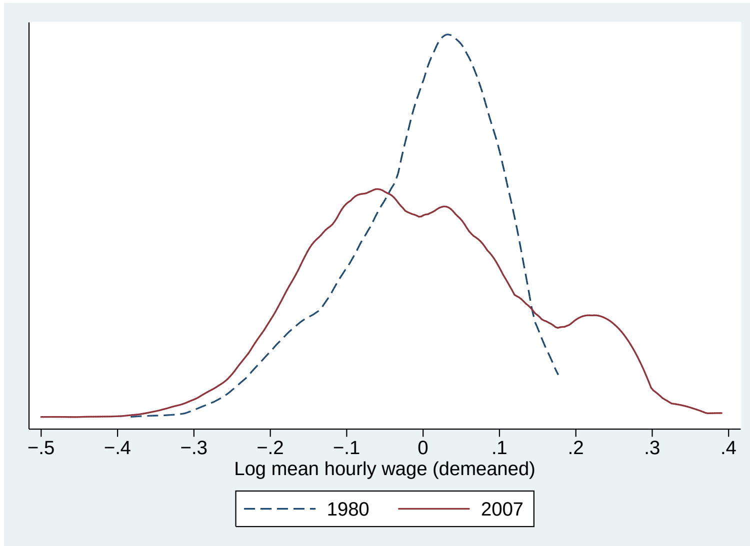
A.1 Figures and Tables

Figure A.1: Skill sorting



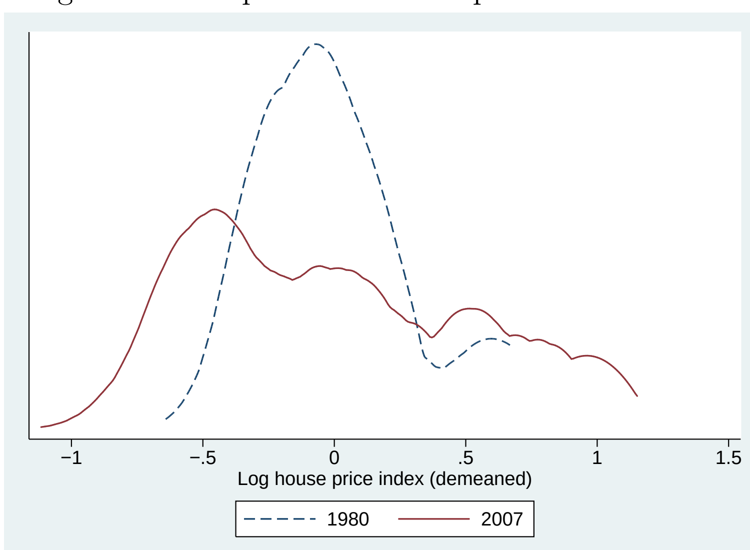
Note: The figure plots the relationship between the share of college graduates in a metro area's labor force in 1980 and the change in the share between 1980 and 2007.

Figure A.2: Dispersion of wages across MSAs



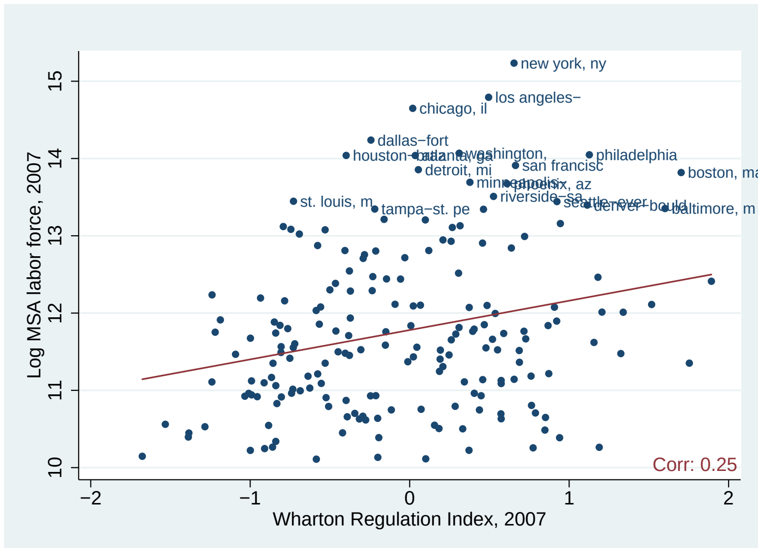
Note: The figure plots the population-weighted distribution of log average hourly wages across metropolitan areas. The distribution is smoothed using a Epanechnikov kernel.

Figure A.3: Dispersion of house prices across MSAs



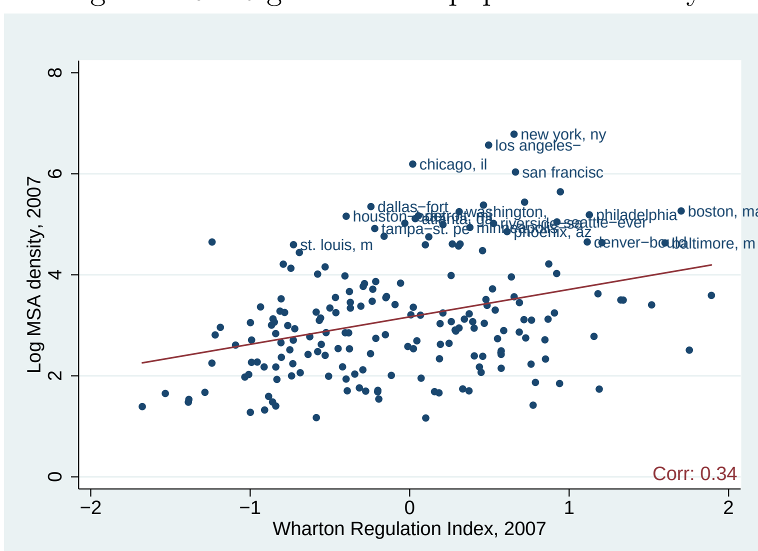
Note: The figure plots the population-weighted distribution of log quality-adjusted house prices across metropolitan areas in years 1980 and 2007. The adjustment for quality is conducted by means of a hedonic regression, as in Eeckhout, Pinheiro and Schmidheiny (2014). The distribution is smoothed using a Epanechnikov kernel.

Figure A.4: Regulation and city size



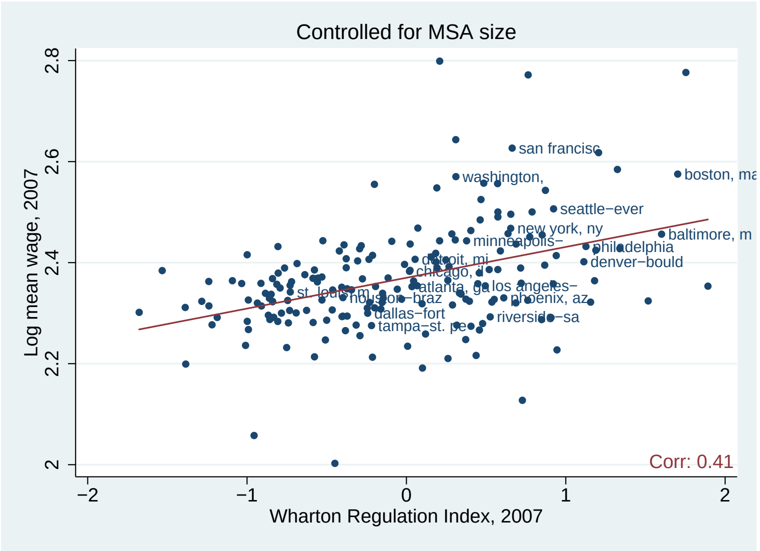
Note: The figure plots the relationship between a metro area's labor force and the Wharton Residential Land Use Regulatory Index.

Figure A.5: Regulation and population density



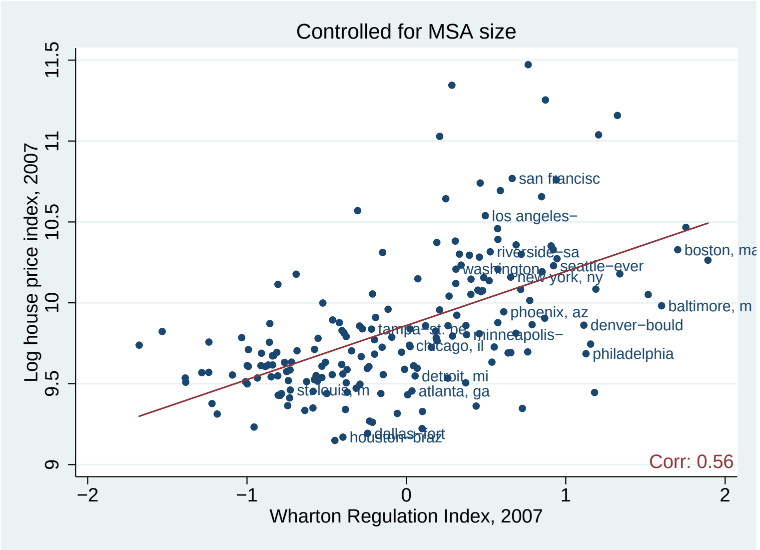
Note: The figure plots the relationship between city population density and the Wharton Residential Land Use Regulatory Index. Population density is measured as labor force per sq km of an MSA land area. The land area is the fraction of land within a 50km radius from the population centroid of a metropolitan area that is not occupied by water or slopes above 15%, taken from Saiz (2010).

Figure A.6: Regulation and wages



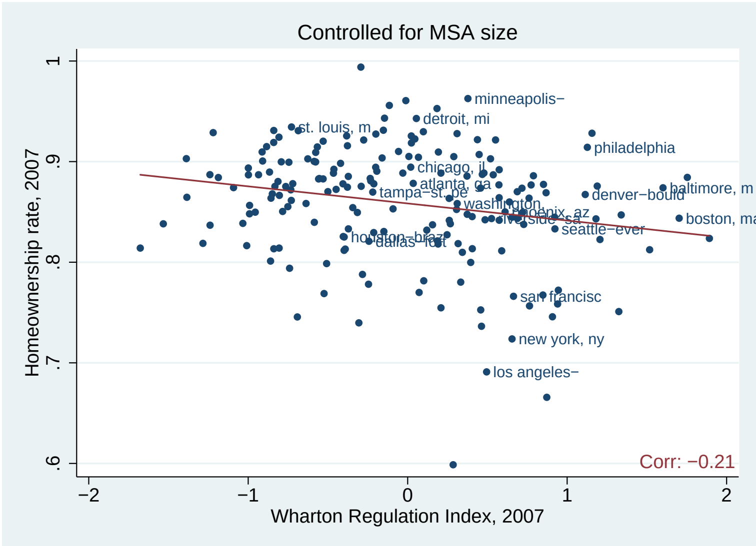
Note: The figure plots the relationship between mean hourly wage, controlled for workforce size, and the Wharton Index.

Figure A.7: Regulation and house prices



Note: The figure plots the relationship between the quality-adjusted house price index, controlled for workforce size, and the Wharton Index.

Figure A.8: Regulation and homeownership



Note: The figure plots the relationship between homeownership rate, controlled for workforce size, and the Wharton Index.

Table A.1: Predictors of Local Political Pressure Index

	LPPI
College share, 2005-2007	2.321
	(0.724)
Log mean wage, 2005-2007	-0.957
	(0.520)
Log mean house prices, 2005-2007	0.338
	(0.123)
Land availability (Saiz, 2010)	0.451
	(0.204)
Votes for democratic candidate in state, 2008	-0.423
	(0.386)
Constant	-1.937
	(1.237)
R2	0.12
N	187

Note: The table lists coefficients of a regression of the metropolitan area's Local Political Pressure Index (part of the Wharton Index) on college share, wages, house prices, land availability (from Saiz (2010)), and share of votes for the Democratic candidate in 2008 presidential elections in the state where the metro area is located. Standard errors are in parentheses.

Table A.2: Model Parameters

Parameter			**Source**
Production and Cities			
Productivity shifters	η_{jst}	multiple	Estimate labor demand equation
Exogenous city-specific TFP	$\bar{A}_j$	multiple	Estimate labor demand equation
Agglomeration externality	ρ	0.0414	Estimate labor demand equation
Congestion externality	δ	0.25	Albouy et al (2017)
Housing			
Baseline elasticity of prices	$\bar{\zeta}^O$	0.035	Estimate housing supply equation
Elasticity of prices wrt land scarcity	ζ^O_{land}	0.051	Estimate housing supply equation
Elasticity of prices wrt regulation	ζ^O_{reg}	0.042	Estimate housing supply equation
Baseline elasticity of rents	$\bar{\zeta}^R$	0.048	Estimate housing supply equation
Elasticity of rents wrt land scarcity	ζ^R_{land}	0.024	Estimate housing supply equation
Elasticity of rents wrt regulation	ζ^R_{reg}	0.031	Estimate housing supply equation
Downpayment	d	0.2	Data. 20% of house price
Mortgage term	π	6	Data. 30 years
Mortgage interest rate	i_h	6.21%	Data
Workers and preferences			
Fraction of high-skilled workers	λ_H	0.3652	Data
Exogenous amenities	α_j	multiple	Calibrate. Target: distr. of labor force
Annual discount factor	β	0.96	
Utility of homeownership	γ	0.5792	Calibrate. Target: homeownership rate
Savings interest rate	i_k	4.30%	Data
Variance of preference shock	σ_ε	0.3	Hsieh and Moretti (2018)
Regulation			
Campaign contribution function	ω_0	8300.02	Calibrate. Target: mean WRLURI
Campaign contribution function	ω_1	1.8349	Calibrate. Target: s.d. WRLURI
Congestion effect	ϕ	0.01631	Calibrate. Target: reg 20% / 80% land
Ideological taste shocks	ν	1	Normalization

Note: The table shows parameter values and whether they are estimated, calibrated, or taken from the literature. See Section 3 for details.

Table A.3: Model Fit (non-targeted moments)

	Model	**Data**
Dispersion of wages across MSAs (var of log)	0.042	0.017
Dispersion of house prices across MSAs (var of log)	0.233	0.224
Dispersion of college shares across MSAs (s.d.)	0.206	0.079
Housing share in expenditures	0.24	0.24
Correlation, mean wage vs regulation	0.84	0.44
Correlation, house price vs regulation	0.67	0.50
Correlation, homeownership vs regulation	-0.50	-0.23
Correlation, land scarcity vs regulation	0.27	0.30
Wages, correlation model vs data	0.75	
House prices, correlation model vs data	0.94	

Note: The table displays some non-targeted moments in the data and their counterparts in the model. See Section 3 for details.

A.2 Data

The number of workers, wages and housing prices for each metropolitan area are calculated using individual level data from the 5% samples of the Census in 1980, 1990 and 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 202 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 for the MSA. Thus the sample used in this paper only includes individuals residing in one of these 202 MSAs.

Observations with a college degree and above are defined as high-skilled. All others are defined as low-skilled. 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.

House prices and rents are calculated as follows. For each metro area I construct quality-adjusted owner-occupied and rental price indices using self-reported house values and rent payments.[67] 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.[68]

[67] Self-reported prices have been widely used in the literature in cases when other measures were not available. Kiel and Zabel (1999) show that, while self-reported prices are 3-8% higher than actual prices, the size of the bias does not depend on observable owners' characteristics and location. Thus, for the purposes of comparison across metro areas, self-reported prices are good proxies for market prices.

[68] 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 Solving the Model

Solving the model involves finding equilibrium objects such that the equilibrium conditions hold for given parameters of the model (equilibrium is defined in Section 2.4). A sufficient condition for stationarity is that the measure of low and high skilled workers remains constant in every location and every period. If this is the case, then wages are stationary, since they are fully determined by labor supply and exogenous productivities. The demand for housing is stationary as well, since everyone consumes one unit of housing. Then, for a given level of regulation, house prices and rents are stationary. Finally, the stationarity of prices and population implies that the incentives to regulate are unchanged from period to period, and therefore regulation is stationary as well.

The *solution algorithm* is described below.

1. Take labor supply and levels of regulation in every location from the data, and use them as an initial guess. Compute wages, house prices and rents.

2. Solve Bellman equations (2.8) and (2.9), and obtain decision rules for assets and ownership status. The Bellman equations are solved by backward induction, starting from the last period in which value functions are equal to the utility of the last period's consumption.

3. Compute the distribution of workers of each skill across locations using the value functions and the conditional choice probabilities (equation 2.12).

4. Use the value functions and the distribution of workers to compute regulation by maximizing the weighted social welfare function (equation 2.10) in every location. The social welfare function is maximized using the Nelder-Mead search algorithm.

5. Update wages using the new distribution of labor. Update house prices and rents using the new distribution of labor and the updated regulation levels.

6. Go back to step 2 and repeat steps 2 to 5 until the supply of each skill in every city converges.

All steps, except step 4, are trivial since they consist of plugging in solutions from previous steps into appropriate equations. However, finding the level of regulation that maximizes the social welfare (step 4) requires knowing value functions outside the stationary equilibrium, since changing the level of regulation may induce existing workers to change their decisions on assets and homeownership status and the newborn workers to change their location choice.

This feature makes the computation of regulation very complex for two reasons. First, when solving their Bellman equations, workers need to know the future path of regulation, given the level of regulation chosen today.[69] Second, they need to know how labor supply, and

[69]There are 1,034,240 types of workers: 202 cities, 2 skills, 8 ages, 40 asset grid points, 2 ownership statuses and, for an owner, 7 possible lengths of ownership. This is 5,120 types per city. Every type has a separate value function, and in every city the value functions have to be computed 20-40 times until the optimal regulation is found. The main complication emerges when for each of the 20-40 iterations I need to find the future path of regulation and labor supply that arise from optimal choices of agents.

therefore prices, will respond to every chosen level of regulation. In other words, workers need to know the entire shape of the aggregate transition function F. However, due to high-dimensionality of F, solving for it is difficult.

For these two reasons, the problem is computationally infeasible, and I proceed by making simplifying assumptions on the information set of individuals. The first assumption places restrictions on the beliefs of workers about the future path of regulation.

Assumption A.1. Individuals believe that the regulation elected for the next period, $z_{j,t+1}$, will persist in all subsequent periods starting from $t+1$.

The second assumption constrains agents' knowledge about the aggregate transition function F. In the spirit of Krusell and Smith (1998), I make the following assumption on the relationship between labor supply and regulation.

Assumption A.2. The effect of a change in regulation on a change in labor supply of skill s between period t and $t+1$ is described by the following linear relationship:

$$\ln N_{js,i} - \ln N_{js,i-1} = \beta_0^s + \beta_1^s \left(z_{ji} - z_{j,i-1} \right),$$

where i indexes iterations in the solution algorithm.

Due to high computational cost, I do not run numerous simulations to find β_0^s and β_1^s. Instead I use the information generated when the model is solved. At every iteration toward the solution, a location experiences changes in labor supply and regulation, and I use these changes in order to estimate the relationship between labor supply and regulation. Using estimated β_0^s and β_1^s, agents predict that, if they vote to change regulation from z to z', then the supply of s-skilled workers will change to $\ln N_{js,i} = \ln N_{js,i-1} + \beta_0^s + \beta_1^s \left(z' - z \right)$.

How reasonable are these two assumptions? Both of them imply bounded rationality of agents. The first assumption says that individuals are myopic and only think one period ahead when forming expectations about the future regulation policy path. Given that the length of the period in the quantitative model is five years, it does not seem unreasonable that, when choosing which party to vote for, residents do not incorporate their voting intentions in the elections that will take place five years from now. The second assumption says that instead of using the function F to predict labor supply in the next period, workers rely on a linear approximation. It does not seem too far-fetched that, when voting, individuals ignore information such as elections in other cities, and instead rely on a simple heuristic rule that describes the relationship between regulation and labor supply.