On the origins of land use regulations: Theory and evidence from US metro areas

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First submission: October 24, 2011
Revised version: September 24, 2012
Accepted: October 11, 2012

Abstract. We model residential land use constraints as the outcome of a political economy game between owners of developed and owners of undeveloped land. Land use constraints benefit the former group via increasing property prices but hurt the latter via increasing development costs. In this setting, more desirable locations are more developed and, as a consequence of political economy forces, more regulated. These predictions are consistent with the patterns we uncover at the US metropolitan area level.

JEL classification: H7, Q15, R52. **Keywords:** Land use regulations, zoning, land ownership, housing supply

Forthcoming in

Journal of Urban Economics

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1. Introduction

Land use regulations vary tremendously in shape and scope across space and have become more widespread and stringent over time. They can, in principle, raise welfare by correcting market failures. Recent evidence, however, casts doubt on this proposition: land use regulations impose – via increasing housing costs – an enormous gross cost on households that is unlikely to be matched by welfare gains arising from correcting market failures. Understanding the causes of these regulations is thus of primary economic policy importance. Yet, perhaps because a large part of the regulatory costs are indirect and the underlying political-economy processes such as lobbying are difficult to observe empirically, this area of research remains relatively underexplored.

In this paper we propose a political economy model of landowner influence in which land use regulations are the outcome of redistribution motives only. In the model, owners of developed residential land favor additional land use constraints as this raises the price of their land; owners of undeveloped land oppose such tightening because it increases the cost of development. Mobile households evaluate heterogeneous local amenities and housing costs and pick locations accordingly. The model leads to two key equilibrium relationships: first, places with desirable amenities are more populated and their land is more developed than that of less desirable places; second, places that are more developed adopt tighter land use regulations. We find that both theoretical predictions are consistent with patterns we uncover in a cross-section of US Metropolitan Statistical Areas ('MSAs' or 'cities' henceforth). We also quantify these effects and find them to be economically meaningful.

The spreading adoption of land use regulations is a phenomenon that seems to accompany the rise of urbanization. In the early 20th century, when only about a quarter of the world population lived in urbanized areas, virtually no city had any zoning laws. San Francisco in 1880 and New York City in 1916 were early exceptions. Now that over half of the world population lives in cities, land use regulations are ubiquitous in all developed and most developing countries. Our model and our data are cross-sectional, but the logic of the model suggests that land use regulations are a by-product of urban development.

Formally, we design a theory that complements extant political economy models of land use regulation by showing how development leads to regulation. Specifically, we construct a discrete choice model in which a given population of mobile households has heterogeneous preferences over a set of cities. Some cities are endowed with more desirable amenities than others and such cities have a higher equilibrium population and are more developed. Each city comprises several local jurisdictions, each of which has a local planning board. Each planning board chooses land use regulations that are subsumed in a 'regulatory tax' (Glaeser *et al*., 2005a,b) in a non-cooperative fashion as in Brueckner (1995), Helsley and Strange (1995), and Schone *et al.* (2011).

The working of the model rests on three main features. First, a regulatory tax raises the price of developed land and increases the conversion cost of undeveloped land, putting the owners of developed land (i.e., homeowners and landlords who rent out their properties) against the owners of undeveloped land. Landowners lobby the planning board and the equilibrium degree of regulation reflects these 'land based interests' (Molotch, 1976). The marginal (net) value of land use regulations increases with the size of the regulatory tax base of a jurisdiction at the political economy equilibrium, that is, the marginal value of a regulatory tax is increasing in the share of developed residential land (*SDL* henceforth) of the jurisdiction. This relationship is upward sloping in the *SDL*-regulatory tax space of a jurisdiction and we refer to it as the 'political economy response curve' in Figure 1. Second, a regulatory tax also increases the cost of living. This effect decreases the equilibrium population and the *SDL* of heavily regulated jurisdictions relative to the laisser-faire. This relationship is downward sloping in the *SDL*-regulatory tax space of a jurisdiction and we refer to it as the 'market response curve' in Figure 1. Third, more desirable cities attract more households, all else equal; greater desirability shifts the market response curve to the right, as illustrated by the arrow in Figure 1. Putting all three features together, desirable jurisdictions are more developed and they charge a higher regulatory tax at equilibrium than less desirable jurisdictions.

The main theoretical contributions of our paper are to (i) develop a formal model of landowner influences that predicts a link between urban development and regulatory stringency and (ii) propose a combination of a discrete choice model for across-city (macro) location decisions and of a standard monocentric city model for within-city (micro) location decisions. This combination provides a useful generalization of the currently available extreme versions of the monocentric city model, whereby each city is either fully isolated or fully open and small (Brueckner, 1987). In our model, both the population size and average utility levels vary across cities and are determined endogenously.

The main empirical contribution of our paper is to establish the robustness of the positive correlation between *SDL* in 1992 against the Wharton Residential Land Use Regulation Index (*WRLURI*) in 2005 for our reference sample of the 93 largest US MSAs. Figure 2 (panel a) plots this relationship; the unconditional correlation between these variables, ρ = 0.31, is statistically larger than zero. Figure 2 (panel b) suggests that this pattern was already visible in earlier data from the late 1970s, with ρ = 0.34. We show that the positive relationship between *SDL* and regulatory stringency is robust to the inclusion of a battery of control variables, region fixed effects, and some instrumental variation of the *SDL*.

In what follows, Section 2 reviews related work. Section 3 presents the model. Section 4 describes the data, provides baseline results, and discusses a number of robustness checks. Section 5 concludes.

2. Related literature

Evenson and Wheaton (2003) and Glaeser and Ward (2009) regress measures of various types of land use regulations on historical and other characteristics of Massachusetts towns. Whereas Evenson and Wheaton (2003: 223) conclude that zoning seems to follow the current market, Glaeser and Ward (2009: 266) find that 'the bulk of these rules seem moderately random and unrelated to the most obvious explanatory variables'. Our analysis shows that looking at aggregated measures of regulation across the major US MSAs reveals systematic patterns. The most closely related study to ours is Saiz (2010) and the papers complement each other in important ways. For each MSA in his sample, Saiz builds a measure of *developable land* and regresses the *WRLURI* on this measure. His findings suggest that cities with a relatively small fraction of developable land are more regulated. By contrast, we create a measure of *developed land* that has developable land at the denominator.[1] Therefore, we take the physical constraints to expanding human settlements in existing MSAs as given and, guided by our theory, we aim to understand how the fraction of land *actually developed* influences regulation, emphasizing political economy mechanisms. Our model also suggests that the most desirable places should indirectly be the most regulated. This accords well with Glaeser *et al.* (2005a), who find that the regulatory tax is highest in Manhattan and in the Bay area (exceeding 50% of house values), while they find no evidence for a regulatory tax in places such as Pittsburgh or Detroit. Recent evidence for the US and the UK suggest that regulation is suboptimal (Cheshire and Hilber, 2008; Cheshire and Sheppard, 2002; Glaeser *et al.*, 2005a; Turner *et al.*, 2011).

[1] Saiz (2010) excludes water bodies, wetlands and slopes of 15% or more to construct his measure of developable land. We use a comparable dataset, except that we base our definition of non-developable land on land cover data. See also Burchfield *et al.* (2006), Hilber (2010) and Hilber and Mayer (2009).

The idea that landowner influence matters for land use regulation outcomes goes back to Fischel (1973) at least. Fischel notes that bribes to local officials for zoning variances in the US are sometimes notorious. The conviction of former Baltimore mayor Sheila Dixon for taking bribes from developers in 2009 suggests that such behavior is still prevalent. Solé-Ollé and Viladecans-Marsal (2011) and Schone *et al.* (2011) provide indirect empirical evidence for the relevance of lobbying by land developers in Spain and in France, respectively (our evidence is also indirect).

In the US, land use regulations are largely determined by local planning boards whose members are elected by local residents. Accordingly, the dominant political economics view suggests that local land use regulations correspond to the wishes of a majority of local voters (Fischel, 2001; Ortalo-Magné and Prat, 2007). Available evidence is strongly suggestive that 'homevoters' (and conservationists) are influential in regulating land use *locally* (e.g. Dehring *et al.*, 2008).

3. The model

The set of players and the timing of the game are as follows. In stage 1, the planning boards of a set of local jurisdictions (which differ in exogenously given characteristics) simultaneously choose a zoning policy, taking the other planning boards' choices as given. Each jurisdiction belongs to exactly one MSA and the set of MSAs is a partition of the set of jurisdictions. In stage 2, households make location decisions of two kinds. They first choose a jurisdiction where to live; a bidding process for land then allocates households within each jurisdiction. Finally, payoffs are realized. The equilibrium concept is a (subgame perfect) Nash equilibrium in zoning policies: all agents are rational and forward-looking.[2] We now formally describe the set of players, their strategy sets and their payoff functions. Appendix A and a guide to calculations in Appendix B (not intended for publication) collect the proofs of propositions and some algebraic details, respectively.

3.1. Households' location choice

In stage 1, a continuum of H households indexed by $h \in [0, H]$ allocate themselves to a number $J > 1$ of jurisdictions indexed by $j \in \Im \equiv \{1, ..., J\}$. Households established in

[2] As in all papers in which interest groups lobby the executive power in order to raise their rent, we assume away entry of developers as entry erodes rents. Baldwin and Robert-Nicoud (2007) show how both ingredients can be simultaneously included in a dynamic stochastic model. This issue is beyond the scope of this paper so we omit it for simplicity.

jurisdiction j derive utility u_j and households pick the jurisdiction that brings them the highest utility. Following the *Random Utility Theory*, which finds its origins in psychology (Thurstone, 1927), we assume that u_j is a random variable and we model the fraction f_j of households that choose to live in jurisdiction j as

$$f_j = \Pr\left\{u_j = \max_{k\in\Im} u_k\right\}. \tag{1}$$

Specifically, the household-specific realization of u_j, denoted as $u_j(h)$, has a common component V_j and an idiosyncratic, random households-specific component $\varepsilon_j(h)$ with cumulative density G. These components add up as follows:

$$u_j(h) = \ln V_j + \varepsilon_j(h), \qquad \varepsilon_j(h) \sim \text{i.i.d.}\, G(\cdot). \tag{2}$$

The common component V_j is deterministic and summarizes the costs and benefits from living in jurisdiction j, expressed in monetary units; we refer to it as the deterministic utility or real income. The idiosyncratic component $\varepsilon_j(h)$ is random (Anderson *et al.*, 1992; Manski, 1977) and summarizes the idiosyncratic utility that household h derives from consuming local amenities. Households are heterogeneous in their appreciation of these amenities. In order to get simple, explicit solutions, we assume that the ε_j's are iid distributed according to the double exponential distribution with mean zero (so that the average and median households are a-priory indifferent about where to live) and variance $\sigma^2\pi^2/6$. The resulting location choice corresponds to a standard multinomial logit model (Anderson *et al.*, 1992). The degree of household heterogeneity σ, which governs the sensitivity of f_j with respect to the utility differentials, is not observable in the data and we therefore normalize it to unity in order to simplify the equilibrium expressions. As a result of these assumptions and of (2) (see Appendix B.1 for details), the location choice probabilities in (1) are equal to

$$f_j = \frac{1}{J}\frac{V_j}{\overline{V}} \tag{3}$$

where $\overline{V} \equiv \sum_{k\in\Im} V_k / J$ (throughout the paper, we use 'upper bars' to denote averages across jurisdictions). Note that $f_j = 0$ or $f_j = 1$ in an obvious manner if the right-hand-side (RHS) of (3) falls outside the unit interval. An implication of (3) is that jurisdictions that command a higher-than-average deterministic utility V_j attract more households than the average jurisdiction (i.e. $V_j > \overline{V} \Rightarrow f_j > 1/J$).

We assume that the common, deterministic component V_j is a function of economic and non-economic variables pertaining to jurisdiction j: let

$$V_j = a_j + w - c_j - t_j, \qquad (4)$$

where a_j is a measure of the observable *quality* of local amenities (converted in monetary units), w denotes the household's income, c_j captures the monetary costs of living associated with j (henceforth 'urban costs') and t_j is a local 'regulatory tax' levied on residents (more on this below). Household h's global appreciation of jurisdiction j's amenities is thus equal to $a_j + \varepsilon_j(h)$. a_j summarizes the attributes of local amenities that can be ranked across the average population (hence the term 'quality').[3]

In this paper, the land market outcomes play the central role, so we treat a_j and w as parameters but we endogenize the urban cost as follows; we show in Appendix B.2 how the qualitative properties of the model are unaffected by relaxing the parameterization of a_j and w to allow for agglomeration and other external (dis)economies. Assume that jurisdiction j is a linear monocentric city (Alonso 1964), in which the per-unit-distance commuting cost is equal to τ. Then, if H_j households live in j, c_j is equal to $H_j\tau$.[4] Substituting this expression for c_j in (4) yields:

$$V_j = \omega_j - H_j\tau - t_j; \qquad \omega_j \equiv a_j + w, \qquad (5)$$

where ω_j summarizes the 'fundamental' (parametric) determinants of welfare in jurisdiction j. We say that a jurisdiction characterized by a high ω_j is a 'desirable' location *ex ante* (or that it is *fundamentally desirable*). The urban cost τH_j and the regulatory cost t_j are endogenous to the model. The former rises with jurisdiction size; the latter is the outcome of the political economy game of section 3.2 below. Plugging (5) into (3) establishes that the fraction f_j of

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[3] Consider the following examples to fix ideas. Within the metro area of Los Angeles, people-watchers prefer to live in Venice Beach and recreation and golf lovers in Bel Air, ceteris paribus. Similarly, at the more aggregate level, skiers prefer local jurisdictions in the Boulder MSA, whereas windsurfers prefer locations in the San Francisco MSA. Let us now compare a representative jurisdiction in the Boulder MSA to a representative jurisdiction in the San Francisco MSA ($j = B, SF$). Ranking access to mountain slopes versus access to the ocean is clearly a mater of individual taste but most people prefer mild to very cold winter temperatures: the latter implies $a_{SF} > a_B$. Put differently, the distribution of $a_{SF} + \varepsilon_{SF}$ stochastically dominates the distribution of $a_B + \varepsilon_B$.

[4] To see this, assume that all city dwellers consume one unit of land and that the central business district (CBD) is located at $d = 0$, so that a city of size H_j stretches out from 0 to H_j. Without loss of generality, we assume that the opportunity cost of land at the urban fringe is zero. Each city dweller commutes to the CBD at a constant per unit distance cost $\tau > 0$. The city residential land market is at an equilibrium when the sum of commuting costs and land rents are identical across city locations (a no arbitrage condition), thus the equilibrium bid rent schedule is $r(d) = (H_j - d)\,\tau$. As a result, the urban cost is $c_j = H_j\tau$, the aggregate land rent is equal to $H^2\tau/2$ and $\omega_j = a_j + w$, as in (5).

households wishing to live in jurisdiction j is decreasing in the regulatory tax it levies, decreasing in its level of congestion and increasing in the desirability of jurisdiction j, which includes amenities and wages.

Define the vectors $\mathbf{t} \equiv [t_1,...,t_J]'$ and $\mathbf{H} \equiv [H_1,...,H_J]'$. Households treat $\mathbf{t}$ and $\mathbf{H}\tau$ as parameters. We define as a *spatial equilibrium* for **H** a situation in which, given the induced equilibrium values of (3) and (5), no household wishes to relocate to another jurisdiction. Formally, the actual fraction of households living in j, H_j/H, must be equal to f_j. Using (5) and (3), this is equivalent to writing

$$\frac{H_j}{H} = \frac{1}{J}\frac{\omega_j - t_j - H_j\tau}{\bar{\omega} - \bar{t} - \bar{H}\tau} \tag{6}$$

$\forall j \in \Im_+$. That is, the fraction of people living in j is increasing in the local well-being net of the regulatory tax and urban costs and decreasing in the well-being net of regulatory tax and urban costs of other jurisdictions. Since households directly consume one unit of land for housing purposes in the linear monocentric city model, the equilibrium H_j is perfectly positively correlated with the equilibrium fraction of developed land in jurisdiction j. (We thus use the phrases 'more populated' and 'more developed' interchangeably but in the empirical section we will disentangle population size from our measure of interest, *SDL*.) We readily obtain the following:

Proposition 1 (existence and uniqueness of the spatial equilibrium). Assume that the fraction of households that wish to live in jurisdiction j is given by (3) and that the observable real income is given by (5). Then the spatial equilibrium defined in (6) exists and is unique.

Proof . See Appendix A.

Figure 3 illustrates the spatial equilibrium concept. The downward-sloping schedule illustrates the fact that as jurisdictions get more populated they get more congested and thus less desirable, ceteris paribus. A higher ω_j and/or a lower t_j shift this schedule upwards. Thus, at equilibrium more desirable locations have more households and are consequently more developed. To see this formally, solve (6) explicitly for H_j:

$$\frac{H_j}{H} = \frac{1}{J}\left[1 + \frac{(\omega_j - \bar{\omega}) - (t_j - \bar{t})}{\bar{\omega} - \bar{t}}\right]. \tag{7}$$

Together, (5) and (7) imply

$$V_j = (\omega_j - t_j)\left[1 - \frac{H\tau}{J(\bar{\omega} - \bar{t})}\right]. \tag{8}$$

For now, we assume $t_j < \omega_j$ for all j (this will be true at equilibrium) and we impose $H\tau < J(\bar{\omega} - \bar{t})$ so that utility and development are strictly positive, i.e. $V_j > 0$ and $H_j \in (0, H)$ for all j.[5] Several aspects of the spatial equilibrium characterized by (7) and (8) are noteworthy. First, jurisdictions that receive more households than the average $\bar{H}$ either have a low regulatory tax or are fundamentally desirable, or both, relative to the average jurisdiction. The former characteristic is illustrated by the market response curve of Figure 1; the latter shifts it to the right. Second, precisely because such desirable places end up being more congested in equilibrium, households obtain a real income that is only a fraction of the local fundamental desirability net of regulatory taxes. Third, *all jurisdictions yield about the same welfare ex post*: congestion and labor mobility between jurisdictions together ensure that in each jurisdiction the marginal household is indifferent between staying put and living in its next best alternative. All infra-marginal households are strictly better off in the jurisdiction of their choosing. To get a sense of this, consider (3) at the limit $\sigma \to 0$ (homogeneous population). In this deterministic case, $f_j > 0$ if and only if $V_j = \max_k V_k$. That is, all jurisdictions with a strictly positive equilibrium population yield the same (deterministic) utility. By contrast, for $\sigma > 0$ households do not enjoy exactly the same real wage everywhere at the spatial equilibrium because they are willing to forego some economic benefits to live in jurisdictions that offer the non-economic amenities that they value.

3.2. Planning boards choose regulation

We assume that each jurisdiction j has a planning board that regulates the use of land. Land use restrictions can take many forms. To simplify the analysis, we assume that the main effect of such regulations is to increase the individual cost of living in the jurisdiction of each household by t_j. We interpret t_j as a 'regulatory tax' (Glaeser *et al.*, 2005a, b) and assume that it is capitalized into the price of developed land (e.g., Oates, 1969; Palmon and Smith, 1998). This capitalization effect captures in a parsimonious way the fact that land use regulations

[5] The former technical condition assumes away corner solutions and is for simplicity. The latter require aggregate urban costs and aggregate taxes to be smaller than aggregate well-being so that equilibrium consumption is positive; these are needed for (3) to be well-defined. These conditions are implied by (14) below when the t_j's are endogenous.

reallocate the local demand for land away from potential new developments to existing ones, keeping total demand for land constant. In addition to this *direct* effect that benefits owners of developed land at the expense of owners of undeveloped land, a higher regulatory tax in j decreases the desirability of j as per (5), which in turn reduces the equilibrium population size and equilibrium amount of developed land in jurisdiction j as per (6); the former effect reduces the average land rent in the jurisdiction. Thus, the overall *indirect* effect of regulation tends to hurt all landowners.

In what follows, we depart from the standard literature by assuming that the planning board caters to the landowners' interests. We assume that the owners of undeveloped land (or land developers) and the owners of developed land form two competing lobbies that influence the planning board by way of lobbying contributions in the wake of Bernheim and Whinston (1986) and Dixit *et al.* (1997). The literal interpretation of this working hypothesis is that stakeholders bribe the planning boards in order to sway its decisions. We may also understand the word 'influence' in a broader and more benign sense, such as pressure groups acting as experts and conveying useful information to the executives. By using legal contributions so as to buy access to executives (Austen-Smith, 1995; Lohmann, 1995), pressure groups provide credible and valuable information to legislators.[6] In this setting, the owners of developed land are offering a contribution schedule that is increasing in the degree of regulation whilst land developers' contributions are decreasing in t_j. Appendix B.2 (not intended for publication) provides the details of the lobbying game. At equilibrium, the planning board maximizes total land rents plus the regulatory tax revenue:

$$\begin{aligned} R_j(\mathbf{t}) &\equiv \int_0^{H_j} \tau\left[H_j(\mathbf{t}) - x\right] \mathrm{d}\,x + t_j H_j(\mathbf{t}) \\ &= \frac{\tau}{2}\left[H_j(\mathbf{t})\right]^2 + t_j H_j(\mathbf{t}), \end{aligned} \tag{9}$$

where $H_j(\mathbf{t})$ is given by (7). Two aspects of the program $\max_{t_j} R_j(\mathbf{t})$ are noteworthy. First, the planning board gives equal weight to the cost and benefit to landowners of raising the local regulatory tax t_j; that is, the lobbying game is a 'one-dollar-one-vote' system. Second, maximizing only the first component of $R_j(\mathbf{t})$ above and ignoring strategic interactions among

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[6] The non-partisan research group Center for Responsive Politics (CPR) reports that the National Association of Realtors topped the CPR's top-20 list of Political Action Committees contributing to federal candidates both in 2005/6 and 2007/8. The National Association of Home Builders ranked 4th and 12th, respectively.

jurisdictions would lead planning boards to choose the first best policy by the Henry George theorem; this would be $t_j = 0$ for all j since there is no market failure in the model.

3.3. Subgame perfect equilibrium

We solve for a Nash subgame perfect equilibrium (SPE henceforth) in regulatory taxes. Thus, j's planning board chooses $t_j \in \Re_+$ so as to maximize (9) subject to (7) taking the SPE vector $\mathbf{t}^{\mathbf{0}}_{\mathbf{-j}}$ of all other jurisdictions as given (the superscript '0' pertains to equilibrium values). Then the first order condition for this program may be written as

$$\frac{\mathrm{d}}{\mathrm{d}t_j} R_j(t_j, \mathbf{t}^{\mathbf{0}}_{\mathbf{-j}})\bigg|_{t_j = t_j^0} = H_j^0 + \left(H_j^0 \tau + t_j^0\right) \frac{\mathrm{d}}{\mathrm{d}t_j} H_j(t_j, \mathbf{t}^{\mathbf{0}}_{\mathbf{-j}})\bigg|_{t_j = t_j^0} \leq 0, \qquad t_j^0 \geq 0, \tag{10}$$

with complementary slackness; H_j^0 is the equilibrium jurisdiction size, namely (7) evaluated at the Nash tax vector $\mathbf{t}^{\mathbf{0}} \equiv [t_1^0, ..., t_J^0]'$ (also $\mathbf{H}^{\mathbf{0}} \equiv [H_1^0, ..., H_J^0]'$). The first term on the RHS of (10) is the marginal benefit associated with increasing the regulatory tax; it is equal to the regulatory tax base. The second term on the RHS is the marginal cost of raising t_j: by reducing *SDL*, doing so reduces the regulatory tax and the land rent bases. At an interior equilibrium, the cost and benefits of raising t_j are equal at the margin. In terms of Figure 1, the first term in the RHS is the political economy response curve, its second term is the market response curve, and the dot is the political economy equilibrium, that is, the combination of t_j and H_j such that the marginal cost and benefit of raising t_j are equal, and all markets clear.

Let

$$f_j^0 \equiv \frac{1}{J} \frac{\omega_j - t_j^0}{\overline{\omega} - \overline{t}^0} \in [0,1] \tag{11}$$

be the equilibrium fraction of people settling in jurisdiction j. Then, using (7) and (11) and assuming that the parameters of the model are such that the resulting H_j^0's in (10) are all interior (precise conditions to follow in equation (14)), we may develop the first order condition (10) to get an equilibrium relationship between population size $f_j^0 H$ and the regulatory tax t_j^0:

$$t_j^0 = \kappa_j^0 \omega_j - \left(1 - \kappa_j^0\right) f_j^0 H \tau, \qquad 1 > \kappa_j^0 \equiv \frac{1}{2 - f_j^0} > \frac{1}{2}. \tag{12}$$

That is, the equilibrium regulatory tax absorbs part, but only part, of the jurisdiction's desirability ω_j and of its urban cost $f_j^0 H\tau$. Plugging (11) into (12) yields a system of J third-order polynomials in the components of $\mathbf{t^0}$. Plugging (12) into (5) yields an expression for equilibrium deterministic utility:

$$V_j^0 = \left(1-\kappa_j^0\right)\omega_j + \kappa_j^0\left(-f_j^0 H\tau\right). \tag{13}$$

That is to say, V_j^0 is a weighted sum of the fundamental desirability and the urban costs pertaining to j.

All the properties of the spatial equilibrium continue to hold at the SPE that (11) and (12) characterize. Three additional properties resulting from strategic interactions are noteworthy (formal proofs follow). First, the equilibrium regulatory tax increases in own desirability and decreases in the desirability of other jurisdictions. Second, this effect is stronger, the lower the urban costs τH. This cross-effect arises because, when urban costs are large, cross-jurisdiction differences along other dimensions matter relatively less for households' location choices. Finally, places that are more desirable are more developed at equilibrium, *despite being more regulated*. That is, endogenous regulation does not change the ranking of jurisdictions according to their ω_j.

The second derivative of R_j with respect to t_j is negative for *any* $\mathbf{t}$; so we may write:

Proposition 2 (existence of a SPE in the tax setting game). The subgame perfect equilibrium characterized by (11) and (12) exists.

Proof. See Appendix A.

We can also formally establish the subgame perfect equilibrium properties of our model:

Proposition 3 (properties of the SPE). Assume:

$$\min_{k\in\Im}\omega_k > \frac{H\tau}{J-1}. \tag{14}$$

Then (11) and (12) imply the following properties for any SPE:

(i) Places that are fundamentally more desirable are more *developed*: $\omega_j > \omega_k \Rightarrow H_j^0 > H_k^0$;

(ii) Places that are more developed are more *regulated*: $H_j^0 > H_k^0 \Rightarrow t_j^0 > t_k^0$.

Proof . See Appendix A.

These are the properties that we test in section 4: (i) is the first stage of our TSLS instrumental variable (IV) approach, whereas (ii) is the second stage. The equilibrium properties of the model that we do not directly test include:

Corollary 3.1 (further properties of the SPE). Assume that (14) holds. Then:

(iii) The fundamental amenities of a jurisdiction are not fully capitalized into the regulatory tax: $\omega_j > \omega_k \Rightarrow \omega_j - t_j^0 > \omega_k - t_k^0$;

(iv) Despite being more developed and more regulated, fundamentally more desirable places command a larger deterministic utility: $\omega_j > \omega_k \Rightarrow V_j^0 > V_k^0$.

Proof. See Appendix A.

The parameter restriction (14) ensures that all jurisdictions have positive population and regulation in equilibrium. We make this assumption for analytical convenience only. Relaxing it would require us to replace the strict inequalities in Proposition 3 by weak inequalities.

3.4. Cross-Metro Area theoretical predictions

As we shall see in the immediate sequel, our data is a cross-section of MSAs. Yet, in the US regulatory decisions are taken at the local level. Also, the theory so far has cross-sectional implications for jurisdictions. These implications tend to hold across MSAs, too. To fix ideas, assume that there is a number $M < J$ of MSAs in the economy indexed by $m \in \{1,...,M\}$; the set of MSAs is a partition of $\Im$. In other words, each MSA is comprised of at least one jurisdiction and each jurisdiction belongs to exactly one MSA; we use $\Im_m$ to denote the subset of jurisdictions that belong to MSA *m*. Consider an arbitrary MSA *m*; then we can define any average variable pertaining to MSA *m* as $x_m \equiv |\Im_m|^{-1} \sum_{j \in \Im_m} x_j$, $x_j \in \{\omega_j, H_j, t_j\}$.

The relationships we want to test below – between amenities and land development, on the one hand, and land development and local regulation, on the other – are both monotonic; so they also tend to hold across MSAs. Yet, the relationships between H_j^0 and ω_j, on the one hand, and between t_j^0 and H_j^0, on the other, are non-linear, so aggregating over MSAs and using ω_m, H_m^0 and t_m^0 instead yields some measurement error. There are two ways to deal with this issue. Since we use linear regressions in the empirical section, the first solution is to do nothing more about it: such regressions can be seen as estimating a linear approximation of the model. The second way is to instrument for H_j^0, which we also do.

4. Empirical Analysis

The main purpose of our empirical analysis is to explore whether the unconditional positive correlation between physical residential development and regulatory restrictiveness at the MSA-level – illustrated in Figure 2 – is robust to adding other potential explanatory variables, estimating alternative specifications, using variant proxy measures, and applying some instrumental variation of the share developed land measure in an attempt to account for the endogeneity of residential development to the regulatory environment.

4.1. Description of data

We derive our data from various sources and geographical levels of aggregation. We match all data to the MSA level using GIS. Table 1 provides summary statistics and sources for all variables. Our dependent variable in the core analysis is the Wharton Residential Land Use Regulation Index (*WRLURI*), the counterpart in the data to the regulatory tax t_m in the model. The *WRLURI* is a measure of differences in the local land use regulatory climate across more than 2600 communities across the US based on a 2005 survey and a separate study of state executive, legislative, and court activities. It is arguably the most comprehensive survey to date. See Gyourko *et al.* (2008) for details on the compilation. Saiz (2010) reports *WRLURI* values for 95 MSAs (our sample consists of 93 MSAs; we lose two observations for lack of data on 1880 population density). A *WRLURI* value of 1 implies that the measure is one standard deviation above the national mean. The *WRLURI* measure is positively correlated with other measures of regulatory stringency that are derived using either a different methodology or a different time period. Appendix Table A1 reports regulatory tax estimates for 21 MSAs for 1998 (Glaeser *et al.*, 2005a) along with the corresponding *WRLURI* and a comprehensive index of housing supply regulation for the second half of the 1970s and the 1980s (Saks, 2008).

There is considerable variation in the degree of land use regulation across US MSAs. Gyourko *et al.* (2008) report that there is more variation across than within MSAs. Other empirically motivated reasons also lead us to run our regressions at the MSA level. In many MSAs only few municipalities responded to the surveys that are the foundation of the *WRLURI* measure and many potentially important controls are available only at the MSA- or state-level. See also Gyourko *et al.* (2008) and Saiz (2010) on the merits of using MSA aggregates. Our decision to use *aggregate* indices – rather than various measures of different types of land use regulation – allows us to capture the overall regulatory environment, while avoiding the loss of statistical clarity associated with trying to look at the effects of various types of regulations simultaneously (Glaeser and Ward, 2009).

The land use data, which we use in our core analysis, is derived from satellite images from the National Land Cover Data 1992 (NLCD 92) as in Burchfield *et al.* (2006). We define the share developed residential land in an MSA, *SDL*, as

$$SDL = \frac{developed\ residential\ land\ area}{developable\ residential\ land\ area}, \tag{15}$$

where the 'developable residential land area' is the total land area minus the surface area that is covered by industrial land or 'non-developable' land uses (i.e., soil that does not sufficiently support permanent structures and/or is extremely costly to develop: barren, water, ice, wetlands, and shrubland). Appendix Table A1 reports the *SDL* for 1992 and for 1976 for the 21 MSAs for which Glaeser *et al.* (2005a) report a regulatory tax. The *SDL* for 1976 is derived from aerial photos from the Land Use and Land Cover GIRAS Spatial Data. A comparison of the various measures of MSA-level (i) regulatory stringency and (ii) physical development suggests that the positive correlation between (i) and (ii) is persistent over time.

The data for the additional explanatory variables that may drive the stringency of regulation at the MSA-level and the various instruments we use in an attempt to identify the political economy response curve come from various sources listed in the note to Table 1 and are discussed below.

4.2. Baseline empirical specification and results using OLS

Our objective in this section is to test the predictions of our model as directly as possible. The key prediction from our model, stated in Proposition 3 (ii), follows from (12): cities that are more developed are more regulated, i.e. $\partial t_m^0 / \partial H_m^0 > 0$. In the theoretical model, H captures the political influence of owners of developed land relative to the influence of owners of undeveloped land. Moreover, in the model, H and *SDL* are interchangeable (population size and *SDL* are perfectly correlated in any version of the monocentric city model in which the technologies used to convert land into housing and to commute are the same across cities). Formally, in a jurisdiction that has a greater population H and hence a higher *SDL*, more is at stake for the owners of developed land relative to the owners of undeveloped land. The best proxy empirically available that captures this idea is *SDL*. Empirically, *SDL* and MSA population size (*POP*) are positively albeit imperfectly correlated (in our sample of 93 MSAs the correlation coefficient is +0.34). This fact allows us to empirically disentangle the effect of *POP* from land based interests as proxied by *SDL*. Controlling for *POP* also ensures that what *SDL* is capturing empirically is not a mechanism related to the size of the metro area (larger cities may require more regulation) but rather a mechanism that relates to land based interests.

In order to capture other factors that may explain spatial differences in regulatory restrictiveness and to limit potential omitted variable bias, we add a number of additional control variables. To begin with, we control for the *homeownership rate* (*HOR*) in the MSA to capture the distinct political-economy impact homeowners ('homevoters') may have on regulatory outcomes at the city level. The welfare economics view suggests that regulation corrects for market failures in the urban economy (e.g. 'externality zoning'). We use the *population density in the developed residential area* (*POPD*) as a proxy for the intensity of these market failures. The motivation for including this proxy is that urban economic theories predict that externalities that are conductive to urban costs and agglomeration economies are sensitive to distance (Arzaghi and Henderson, 2008; Rosenthal and Strange, 2008): denser places generate more non-market interactions and pecuniary externalities, both conductive to urban growth (e.g. knowledge spillovers, labor market matching) and to urban costs (e.g. noise). Residents in densely populated MSAs may impose more stringent regulation in an attempt to internalize such externalities. In a similar vein, we control for the *total open land* (*TOL*) *in an MSA*. This measure captures the prospect that residents protect open land more rigorously if the MSA has less of it. Finally, we add the *share democratic votes* (i.e., the state share of votes that went for the Democratic candidate in the 1988 and the 1992 presidential elections), *average household wage* and *US region dummies* to capture the possibilities that spatial differences in the regulatory environment may be driven by political ideology, income sorting or other regional-specific unobservable characteristics. We thus write our empirical base line specification as follows:

$$\begin{aligned} WRLURI_m = \quad & \beta_0 + \beta_1\left(\boldsymbol{SDL_m}\right) + \beta_2\left(HOR_m\right) + \beta_3\left(POPD_m\right) + \beta_4\left(TOL_m\right) \\ & + \beta_5\left(POP_m\right) + \beta_6\left(other\ controls_m\right) + \varepsilon_m \end{aligned}, \tag{16}$$

where *WRLURI* is our measure for the restrictiveness of regulation and ε_m is the error term with the standard assumed properties. Our model predicts $\beta_1 > 0$. The *SDL* variable (in bold) is arguably endogenously determined: more regulated places should be less developed, all else equal, as per the market response curve. Putting this issue aside for now, we start by running (16) using OLS. Columns (1) and (2) of Table 2 report the estimation results of specifications that include region dummies only and all controls, respectively.[7] The adjusted R^2 of 0.35 and 0.45 are reasonably high. Our coefficient of interest β_1 has the expected sign and is statistically highly significant in both specifications. The coefficient on *SDL* increases when we add further explanatory variables. Turning our attention to the controls, we find that MSAs in Democrat-leaning states are more regulated. Our interpretation is that liberal voters (in North American parlance) are ideologically more sympathetic to regulation than conservative ones. MSAs with *less* open land are also more regulated, consistent with the view that lack of open space encourages tighter controls. Region dummies reveal that broad geographic patterns emerge, with the West being the most regulated region and the Midwest (the omitted category) the least regulated one. All other explanatory variables, including the homeownership rate and contemporaneous population density, are not statistically significantly related to the *WRLURI*.

4.3. Results for TSLS-specifications

Figure 1 in the introduction illustrates the workings of our theoretical model. The figure resembles a demand-supply framework with *SDL* as the 'quantity' and the regulatory tax (proxied by *WRLURI*) as the 'price'. Using this analogy, the *market response curve* can be interpreted as a 'demand curve': regulation works as an impediment to development by (7), thereby increasing the cost of living. This reduces the demand for land in the area, resulting in less developed places (negative slope). By the same token, we can interpret the *political economy response curve* as a 'supply curve': owners of developed land are more politically influential in more developed places and such owners prefer tighter controls. As a result, the marginal (political economy) cost of converting new land is increasing in *SDL* (positive slope).

Our empirical aim is to identify the slope of the political economy response curve. We expect to obtain a downward biased estimate of the slope of the political economy response curve if we estimate β_1 in (16) via OLS. Proper identification of this 'supply curve' is challenging for it requires assuming that the 'demand shifters' (illustrated in Figure 1) do not affect 'supply'.

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[7] Throughout the empirical analysis we cluster the standard errors by state because the *share of democratic votes* is state-specific.

Establishing the validity of any one instrument is particularly challenging in an empirical setting with a single cross-section of MSAs such as ours.

With this important caveat in mind, our strategy to circumvent this problem as much as we can is to use two completely different types of instruments; we use them both jointly and individually. Places that are endowed with desirable amenities are more developed at equilibrium in our theory. This readily suggests two sets of 'demand shifters' (instruments) in our cross section of MSAs: natural amenities and historical population density. Our two natural amenity variables are *average temperature in January* and a dummy that equals one if the MSA *has a major coastline*. The use of *historical population density* from 1880, prior to the implementation of any relevant land use regulations in the United States, as an instrument for *SDL* is consistent with a dynamic interpretation of our model: desirable locations attracted people early and were developed first, before land use regulations became part of the urban political life. These considerations lead us to run the following first stage regression by OLS:

$$\begin{aligned} SDL_j = \alpha_0 + \alpha_1\left(coast_j\right) + \alpha_2\left(temperature_j\right) + \\ +\alpha_3\left(historical\ density_j\right) + \alpha_4\left(controls_j\right) + \xi_j , \end{aligned} \tag{17}$$

where ξ_j is the error term. Our priors are α_1 ,α_2 , $\alpha_3 > 0$.

Our identifying assumption for all three instruments is that they do not influence the tightness of regulations directly. Such an assumption may be violated in practice. One particular concern with respect to the amenity instruments is that environmental considerations may induce planning boards to regulate places endowed with valuable natural amenities. To the extent this is the case, these variables also shift the 'supply curve'.

In practice, three properties of the *WRLURI* measure suggest that *major coastline* may mitigate such concerns in the context of our analysis. First, the *WRLURI* measure does not include attitudes towards regulation of coastal areas. Second, the majority of municipalities responding to the survey do not have access to the coast; this is true even for municipalities that belong to MSAs with access to the coast. Finally, federal regulations that may protect the coast are excluded from *WRLURI* by construction. In a similar vein, we assume that the January temperature has no systematic influence on a broad index of residential land use regulations. Unlike other natural amenities, warm winter temperatures are unlikely to be significantly related to environmental considerations that usually induce planning. The rationale for using *the historical density* from 1880 as an instrument is that it captures all the unobserved and time-invariant amenity and cost factors not already included in our set of amenity instruments that lead people to settle in a specific place. It also captures historic amenity and cost factors that were important a long time ago and which started a dynamic development process of cities. These factors may no longer be important nowadays, yet they remain relevant because of inertia, durable housing, or the generation of agglomeration forces.

Another endogeneity concern relates to the *homeownership rate*. The estimation of β_2 in (16) may be biased if there are omitted variables that are correlated with *HOR* or if land use regulations systematically influence the incentive to own one's home. We use the MSA's share of households that consist of married couples without children as a source of exogenous variation of *HOR* in order to improve the identification of its effect on *WRLURI*. Married couples without children tend to have higher and more stable household incomes and are able to accumulate greater wealth over time compared to married couples with children. This makes them more likely to overcome liquidity and down-payment constraints and thus eases attaining homeownership. Moreover, married couples tend to be in more stable relationships compared to their unmarried counterparts, implying a longer expected duration in their property and, consequently, greater incentives to own rather than rent.

The results of the first stage are reported in columns (3) and (4) of Table 2. Column (3) reports OLS estimates for (17). All three instruments (major coastline, January temperature and historic population density) have the expected sign and are significant either at the one or five percent level. The quantitative effects are strong: hypothetically granting a *major coastline* to a hitherto landlocked MSA increases its share of developed land by 56.5% (+7.0 percentage points); an extra standard deviation in *average January temperature* and *historical density* are respectively associated with a 47.6% (+5.9 percentage points) and a 64.5% (+8.0 percentage points) increase in *SDL*. The adjusted R^2 is high with 0.7. Column (4) reports the result of the effect of the *share households with married couples and no children* and of the other controls on the homeownership rate. As expected, the former is positive and highly statistically significant at the 1 percent level. *Historical population density* also helps us to identify the *HOR*; this finding makes sense because historically denser places have taller buildings and renting is comparably more efficient than owning in multi-unit buildings. The adjusted R^2 of 0.71 is again high. The results contained in columns (3) and (4) thus establish that our proposed instruments for *SDL* and *HOR* fulfill an important necessary condition for being valid instruments.

Column (5) of Table 2 reports the second stage regression results of (16) with *SDL* being treated as the unique endogenous variable. Our preferred specification, which treats both *SDL* and *HOR* as endogenous, is reported in column (6). The TSLS coefficient of *SDL* is positive and significant in both specifications. The point estimate of *SDL* in our preferred specification is somewhat larger than the OLS coefficient. In general, the TSLS coefficients are very similar to those of the OLS specification reported in column (2).

One advantage of having two quite different sets of instruments is that we can exclude one of them to explore whether the alternative identification strategy yields a similar coefficient on *SDL*. Columns (7) and (8) report the results of this robustness check. We drop both amenity variables from our list of instruments in column (7) and we drop historic density in column (8). Reassuringly, the coefficients on *SDL* change little. The fact that the coefficients on *SDL* in columns (6) to (8) are somewhat larger compared to the corresponding OLS estimate may be indicative of a slight downward bias induced by the endogeneity of *SDL* to regulatory restrictiveness.

We also carry out the usual battery of tests that assess the validity of the instrumental variables, including over-identification tests, Hansen-J statistics and Kleibergen-Paap rk LM statistics. None of these tests indicates a problem at the usual confidence levels. We do not report these results in order to save space. The last line of Table 2 reports Kleibergen-Paap rk Wald F-statistics, which is a test for weak instruments in the presence of robust standard errors. The test statistics in columns (5) to (7) indicate with 95 percent confidence that the maximum TSLS size is less than 10%, implying that the sets of instruments in the respective specifications taken together are reasonably strong (Stock and Yogo, 2005; Kleibergen and Paap, 2006). The only test statistic that raises concern is that in column (8), suggesting that the amenity variables alone may only weakly identify *SDL*.[8]

To sum up, all the findings reported in Table 2 are consistent with the proposition from our model that more developed places are more regulated as a consequence of political economy forces in equilibrium. Therefore, although we cannot rule out some shift of the 'supply

[8] In attempt to explore the significance of this issue, we re-estimated this specification using a Limited Information Maximum Likelihood (LIML) estimator. LIML is approximately median unbiased for over-identified models (we have three instruments and two endogenous explanatory variables) and produces a smaller bias than TSLS in finite samples. Its asymptotic properties are the same as those of the TSLS estimator. We find that the coefficients and robust standard errors are almost unchanged when we use LIML instead of TSLS (LIML yields a coefficient of 2.27 and a standard error of 1.05) and the test statistic is well above the critical value for a maximum LIML size of 15%.

curve', the results reported in Table 2 suggest that amenities shift the 'demand curve' in a way that is consistent with the predictions of our model.

In the remainder of the empirical section we briefly describe the findings of additional robustness checks and discuss the magnitude of the estimated effect.

4.4. Robustness checks

Use of alternative proxy measures of the relative influence of owners of developed land

We define *SDL* in (15) and we use this measure as a proxy for the relative influence of owners of developed land throughout our core analysis. In Appendix Table A2 we use 11 alternative proxy measures to capture the relative influence of owners of developed land at the MSA level and we report first and second stage results for our preferred specification (column 6 in Table 2) using these alternative definitions of *SDL*. Specifically, we first redefine *SDL* in various ways to include industrial land or exclude parks, or both, and to include only the land cover within a 20km radius from the center of each MSA. It turns out that 'more developed' MSAs are more developed at any radius from the center than 'less developed' MSAs (see also Burchfield *et al.*, 2006, on this). This leads us to expect our main results to be robust to this change. Next, we attribute to each MSA the *SDL* of its average or median place to immunize our results to the role of outlier places. We then calculate the share of residential land as the total residential land divided by all land in the MSA, irrespective of whether it is developable or not. Finally, we replicate the whole analysis using the aggregate property value per square meter of developable land as the proxy variable for the relative influence of owners of developed land. We report the first stage results in Panel A of Appendix Table A2; major coastline and historic population density are both highly statistically significant with the expected signs in all specifications. Average January temperature is statistically significant, with the expected sign, in 8 of 11 specifications; in the remaining three specifications the coefficient is borderline insignificant. The second stage results – reported in Panel B – unambiguously confirm the main result reported in Table 2. The coefficients on all 11 alternative proxy measures for the relative political influence of owners of developed land are statistically significant at least at the 5 percent level.

Additional robustness checks and out-of-sample evidence

We carried out a large number of additional robustness checks, including re-estimating our empirical base specification for an earlier sample period (see Hilber and Robert-Nicoud, 2011, for extensive details). Reassuringly, the findings of all of these checks are consistent with the proposition that more developed places are more regulated as a consequence of political economy forces in equilibrium. We conclude that, despite the small size and the cross-sectional nature of our sample, the positive relationship between the degree of physical development in an MSA and its regulatory restrictiveness is remarkably robust to a large battery of checks.

Out-of-sample evidence from other studies suggests that this positive relationship also finds support *within* metro areas. A dynamic interpretation of our model implies that, as the city grows, land use regulations should spread from the city center to the surrounding areas. Consistent with this proposition, Fischel (2004) reports that land use regulations in the US indeed originated within larger cities and then zoning quickly spread to the suburbs and surrounding towns as the city grew. The most direct evidence that the timing and restrictiveness of zoning is tied to the distance from the central city comes from Rudel (1989) who shows that the Connecticut municipalities that located at a greater distance to New York City adopted land-use laws later than those close to the Big Apple.

Taken together, all these findings suggest that the data are consistent with the mechanism emphasized in our model and that our key estimates are robust to the reverse causation bias.

4.5. Quantitative effects

The effect is also quantitatively meaningful. To fix ideas, compare Salt Lake City to San Francisco. The former has no access to a major ocean coast, average January temperatures are 28.1°F and its historical population density is 31.4 people per square kilometer. San Francisco has a border with the Pacific Ocean, January temperatures average 48.2°F and its population density in 1880 was 239.6 people per square kilometer. The implied difference in *SDL*, as a consequence of these disparities alone, is 19.8 percentage points (1.62 standard deviations). This, in turn, based on our preferred specification reported in column (6) of Table 2, implies a 0.56 standard deviation difference (+0.393) of *WRLURI* between the two MSAs. Salt Lake City is the 56th most regulated MSA in our sample. Granting it with San Francisco's coastal access, warmer winter temperature and historical density alone hypothetically makes it the 35th most regulated MSA (SF is the 16th most regulated MSA).

5. Concluding remarks

This study contributes to the understanding of political economics considerations that shape land use restrictions. Consistent with our model of landowner influence, our empirical analysis unveils a strong positive correlation between the degree of physical development of a metro area and the regulatory restrictiveness of its residential land use. Our analysis focuses on residential land use by the nature of the regulatory data available. In practice, zoning also separates incompatible land uses and the business districts from residential areas. A second limitation of our analysis is that we were not able to test the lobbying mechanism directly for lack of available data – collecting and assembling such data is an important avenue for further research. With these caveats in mind, our results point to land-based-interests explanations. Our findings are suggestive that regulation in highly desirable and highly developed places such as New York City and San Francisco may be grossly over-restrictive. The proposition that the restrictiveness of land use regulations goes beyond welfare economics considerations is consistent with our model and the homevoter hypothesis (Fischel, 2001). It is also consistent with the empirical findings of Cheshire and Sheppard (2002) and of Turner *et al.* (2011) who assess directly the welfare effects of land use regulations in the UK and US, respectively.

Acknowledgements

We are grateful to the Editor, William Strange, to Gilles Duranton and Henry Overman for thorough discussions, detailed feedback and encouragement, and to two anonymous referees for helpful comments and suggestions. We also thank Alex Anas, John Antonakis, Jan Brueckner, Marius Brülhart, Jean Cavailhès, Paul Cheshire, Steve Gibbons, Yoshitsugu Kanemoto, Gerrit Knaap, Rafael Lalive, Tim Leunig, Jim Markusen, Florian Mayneris, Muriel Meunier, Mark Partridge, Esteban Rossi-Hansberg, Michael Storper, Jacques Thisse, Matthew Turner, Wouter Vermeulen and conference/seminar participants at various places for insightful discussions and helpful suggestions. We are grateful to Raven Saks for kindly providing regulatory index data. Alejandra Castrodad-Rodriguez, Ralph Van Doorn, Felix Weinhardt and Ben Dachis provided excellent research assistance. The remaining errors are the sole responsibility of the authors. Part of this paper was written when Frédéric Robert-Nicoud was a Peter B. Kenen visiting scholar at Princeton University; the hospitality of this institution is gratefully acknowledged.

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Summary Statistics and Regression Tables

Table 1
Summary statistics

Variable	N	Mean	Std. Dev.	Min	Max
Wharton regulatory index (*WRLURI*), 2005 [a]	93	0.117	0.702	-1.25	2.07
Developed residential land as % of developable non-industrial land ("share developed residential", *SDL*), 1992 [b]	93	0.124	0.122	0.0119	0.761
Alternative measures for robustness checks					
Share developed (incl. industrial developments), 1992 [b]	93	0.154	0.134	0.0198	0.847
Share developed, 20km radius, 1992 [b]	93	0.363	0.208	0.0580	1
Share developed residential, 20km radius, 1992 [b]	93	0.309	0.204	0.0436	1
Share developed, excluding parks, 1992 [b]	93	0.149	0.139	0.0204	1
Share developed residential, excluding parks, 1992 [b]	93	0.121	0.132	0.0124	1
Share developed of average place, 1992 [b]	93	0.462	0.164	0.0976	1
Share developed residential of average place, 1992 [b]	93	0.419	0.168	0.0822	1
Share developed of median place, 1992 [b]	93	0.463	0.188	0.0947	1
Share developed residential of median place, 1992 [b]	93	0.414	0.190	0.0793	1
Share developed residential as % of all land, 1992 [b]	93	0.085	0.067	0.0035	0.388
Aggregate property value per m^2 of developable land, 1990 [c]	93	17.9	35.4	1.3	237.5
Homeownership rate (*HOR*), 1990 [c]	93	0.628	0.070	0.325	0.739
Population density in developed res. area (per m^2) (*POPD*), 1990 [d]	93	0.00264	0.00125	0.00116	0.0107
Population (*POP*), 1990 [c]	93	1482047	1537580	383546	8853606
Total open land in MSA in thousand km^2 (*TOL*) [b]	93	9.11	12.89	0.0436	102.2
%Democratic votes in state, av. presidential elections 1988/92 [e]	93	48.8	4.9	34.4	58.8
Average household wage, 1990 [c]	93	30.0	5.2	17.0	46.5
Region = Midwest (omitted) [f]	93	0.215	0.413	0	1
Region = North East [f]	93	0.183	0.389	0	1
Region = South [f]	93	0.376	0.487	0	1
Region = West [f]	93	0.226	0.420	0	1
Metro area has major coastline [f]	93	0.247	0.434	0	1
Average temperature in January, measured between 1941-1970 [g]	93	38.2	12.5	11.8	67.2
Population density in metro area (per km^2), 1880 [h]	93	125.5	490.3	0.1	4698.6
% Households with married couples and no children, 1990 [c]	93	0.291	0.028	0.236	0.427
Saks-index of housing supply regulation (SAKS), late 1970s/80s [i]	81	0.00544	0.997	-2.399	2.211
Developed residential land as % of developable land, 1976 [j]	81	0.118	0.104	0.0119	0.501

Sources: [a] Saiz (2010). [b] National Land Cover Data 1992 (NLCD 92); derived from the US Geological Survey. Non-developable land uses include barren, water, ice, wetlands, and shrubland. We do not have any land use information for the District of Columbia. We imputed *SDL* by assuming that land uses within the District are similar to those at the boundaries of the Washington, DC metro area. Since the District covers only about 1 percent of the MSA's surface area, this adjustment increases the *SDL* for the MSA by only about half a percentage point. None of the results in any of the specification changes notably if we assume that the District is either not at all or fully developed nor if we drop the observation. [c] US Census and Neighborhood Community Database (NCDB). [d] Derived from NLCD and NCDB. [e] Dave Leip's Atlas of Presidential Elections [f] Derived from ESRI's Census 2000 MSA-level shape file. [g] Natural Amenity Scale Data from the Economic Research Service, United States Department of Agriculture. [h] Interuniversity Consortium for Political and Social research (ICPSR) study #2896. Measure is based on historical MSA boundary definitions. [i] Saks (2008). [j] Land Use and Land Cover GIRAS Spatial Data 1976; derived from the U.S. Geological Survey. Non-developable land uses are: 'undefined', barren, water, ice, wetlands, shrub/brush land, dry salt flats, beaches, sandy areas, bare exposed rock, strip mines, all categories of tundra except herbaceous tundra. Missing map cells for 1976 were obtained from Diego Puga at http://diegopuga.org/data/sprawl/. Map data was unavailable for Santa Cruz, CA and a mis-projected map for Erie, Pennsylvania necessitated the removal of fourteen affected census tracts.

Table 2

Determinants of restrictiveness of land use regulations *(N=93)*

	OLS		TSLS					
			1st Stage for (6)		2nd Stage			
DEPENDENT:	*WRLURI*	*WRLURI*	*SDL*	*HOR*	*WRLURI*	*WRLURI*	*WRLURI*	*WRLURI*
Instruments:					All instr.	All instr.	Hist. density	Amenities
EXPLANTORY:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Share developed residential land	1.463**	1.791***			**1.577***	**1.981****	**1.818***	**2.262****
(*SDL*), 1992	(0.609)	(0.452)			**(0.924)**	**(0.887)**	**(1.002)**	**(1.007)**
Homeownership rate (*HOR*), 1990		0.265			0.180	**3.357**	**3.618**	**3.046**
		(0.896)			(0.788)	**(2.324)**	**(2.296)**	**(2.551)**
Population density in developed		-66.53	-23.96*	-3.324	-61.51	28.70	43.31	8.128
residential area (*POPD*), 1990		(76.22)	(12.66)	(9.154)	(79.35)	(97.69)	(96.96)	(116.3)
Population of MSA, 1990		1.43e-08	2.77e-08***	-5.61e-09	1.81e-08	2.52e-08	2.96e-08	1.82e-08
		(3.93e-08)	(5.88e-09)	(4.95e-09)	(3.71e-08)	(3.65e-08)	(3.69e-08)	(4.15e-08)
Total open land in MSA, 1992		-0.00789*	-0.00125**	-0.000409	-0.00824**	-0.00580**	-0.00588**	-0.00558**
		(0.00403)	(0.000499)	(0.000667)	(0.00402)	(0.00284)	(0.00295)	(0.00282)
Share Democratic votes in state,		0.0387*	-0.00379**	-0.000626	0.0370*	0.0413**	0.0402*	0.0434**
average 1988 and 1992		(0.0210)	(0.00184)	(0.00133)	(0.0201)	(0.0209)	(0.0210)	(0.0214)
Household wage (in thousand dollar),		0.0144	0.000522	-0.000457	0.0144	0.0201	0.0207	0.0192
1990		(0.0130)	(0.00107)	(0.00101)	(0.0121)	(0.0141)	(0.0141)	(0.0143)
Region = Northeast	0.647***	0.474*	0.0358	-0.0278	0.492**	0.519**	0.540**	0.487**
	(0.232)	(0.258)	(0.0285)	(0.0182)	(0.240)	(0.228)	(0.237)	(0.231)
Region = South	0.201	0.309*	-0.0894**	-0.00957	0.313*	0.429**	0.445**	0.407**
	(0.185)	(0.171)	(0.0341)	(0.0159)	(0.160)	(0.170)	(0.176)	(0.174)
Region = West	0.934***	0.922***	-0.0321	-0.0334*	0.927***	1.062***	1.082***	1.034***
	(0.165)	(0.201)	(0.0421)	(0.0193)	(0.192)	(0.223)	(0.220)	(0.240)
Metro area has major coastline			0.0703***	-0.0205*				
			(0.0229)	(0.0110)				
Average temperature in January, 1941-1970			0.00468**	-0.000852				
			(0.00186)	(0.000651)				
Population density in 1880			0.000163***	-4.82e-05***				
			(2.34e-05)	(1.50e-05)				
Share households with married couples			-0.0489	1.268***				
and no children in 1990			(0.297)	(0.220)				
Adj. R-squared	0.349	0.447	0.702	0.714				
Kleibergen-Paap rk Wald F-statistic					297.1	95.2	217.0	4.1

Notes: Robust standard errors in parentheses (observations are clustered by US state). *** p<0.01, ** p<0.05, * p<0.1. **Bold** coefficients are instrumented.

Appendix Tables

Appendix Table A1
MSA-level rankings of measures of regulatory restrictiveness and land scarcity

Metropolitan Area	(1) Regulatory Tax in % of House Value 1998 [i]	Rank	(2) Regulatory Index 2005 [ii]	Rank	(3) Regulatory Index late 1970s & 1980s [ii]	Rank	(4) Share Developed Land in % 1992 [iii]	Rank	(5) Share Developed Land in% 1976 [iii]	Rank
San Francisco	53.1	1	0.78	5	2.10	2	20.8	10	25.4	8
San Jose	46.9	2	0.21	10	1.65	3	19.9	12	25.2	9
Los Angeles	33.9	3	0.50	8	1.21	4	44.2	1	54.7	1
Oakland	32.1	4	0.63	7	0.10	14	26.6	5	27.6	6
Washington, D.C.	21.9	5	0.21	10	0.86	6	10.2	17	16.1	16
Newport News, VA	20.7	6	0.12	12		(-)	17.5	13	20.5	14
Boston	18.6	7	1.67	2	0.86	7	33.2	4	33.9	3
New York	12.2	8	0.67	6	2.21	1	43.9	2	50.7	2
Manhattan	>50									
Salt Lake City	11.9	9	-0.03	17	0.96	5	23.3	6	28.8	4
Chicago	5.7	10	0.01	16	-1.01	20	22.4	7	26.2	7
Baltimore	1.8	11	1.65	3	0.80	8	14.2	15	18.3	15
Birmingham	0	12	-0.24	18	-0.46	16	4.8	21	7.5	21
Cincinnati	0	12	-0.58	21	0.16	12	9.3	18	14.8	18
Detroit	0	12	0.07	14	-0.69	19	22.3	8	22.9	11
Houston	0	12	-0.30	20	-0.52	17	14.8	14	12.3	19
Minneapolis	0	12	0.38	9	-0.16	15	11.1	16	9.4	20
Philadelphia	0	12	1.13	4	0.47	9	21.1	9	27.8	5
Pittsburgh	0	12	0.08	13	0.26	11	8.5	19	15.4	17
Providence	0	12	2.07	1	0.35	10	20.6	11	22.2	12
Rochester	0	12	0.04	15	-0.68	18	5.3	20	21.8	13
Tampa	0	12	-0.24	18	0.16	13	35.6	3	24.2	10

Pair:	Correlation	Rank Correlation	Pair:	Correlation	Rank Correlation
(1), (2)	0.12	0.37	(2), (4)	0.28	0.31
(1), (3)	0.68	0.65	(2), (5)	0.29	0.43
(1), (4)	0.33	0.36	(3), (4)	0.48	0.34
(1), (5)	0.41	0.48	(3), (5)	0.56	0.49
(2), (3)	0.37	0.53	(4), (5)	0.89	0.88

Sources and notes: [i] Estimated regulatory tax values are from Glaeser *et al.* (2005a). [ii] Regulatory index values are from Saiz (2010) and Saks (2008) respectively. [iii] The share developed land measures are derived from the National Land Cover Data 1992 and from the Land Use and Land Cover GIRAS Spatial Data 1976. The following land uses are classified as non-developable: barren, water, ice, wetlands, and shrubland (1992 classifications) and 'undefined', barren, water, ice, wetlands, shrub/brush land, dry salt flats, beaches, sandy areas, bare exposed rock, strip mines, all categories of tundra except herbaceous tundra (1976 classifications).

Appendix Table A2

Robustness check: Alternative proxy measures for relative influence of owners of developed land *(N=93)*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	PANEL A: First stage / Dependent variable: Alternative proxy measures for the relative influence of owners of developed land										
	Alternative measures of share developed land (*SDL*)										Property value per m^2 developable land
	Developed residential + industrial	20 km radius, residential + industrial	20 km radius, residential only	Excluding parkland, res. + ind.	Excluding parkland, res. only	Average place in MSA, res. + ind.	Av. place in MSA, res. only	Median place in MSA, res. + ind.	Median place in MSA, res. only	Developed residential to all land	
Major coastline	0.0779***	0.131**	0.125**	0.0921***	0.0845***	0.0964**	0.0977**	0.106**	0.112**	0.0265*	18.35**
	(0.0247)	(0.0484)	(0.0461)	(0.0284)	(0.0279)	(0.0427)	(0.0423)	(0.0481)	(0.0474)	(0.0151)	(9.037)
Average January temperature	0.00494**	0.00514	0.00601	0.00569*	0.00573*	0.00528	0.00600*	0.00661*	0.00706*	0.000864*	0.584***
	(0.00198)	(0.00434)	(0.00438)	(0.00331)	(0.00325)	(0.00328)	(0.00343)	(0.00341)	(0.00363)	(0.000462)	(0.206)
Population density in 1880	172***	247***	265***	109***	104***	215***	231***	222***	238***	88.7***	35,800***
	(27.7)	(34.3)	(34.2)	(34.5)	(32.0)	(45.6)	(41.9)	(49.1)	(46.6)	(16.0)	(5450)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. *R*-squared	0.699	0.496	0.512	0.496	0.472	0.488	0.522	0.481	0.507	0.734	0.811
	PANEL B: Second-stage / Dependent variable: *WRLURI* / TSLS										
Proxy for infl. of own. of dev. land	**1.891****	**1.573****	**1.421****	**1.947****	**1.960****	**1.427****	**1.309****	**1.244****	**1.157****	**4.287****	**0.0111****
	(0.830)	(0.656)	(0.616)	(0.811)	(0.824)	(0.597)	(0.559)	(0.530)	(0.502)	(1.919)	(0.00567)
Homeownership rate	**3.457**	**4.370***	**4.106**	**3.119**	**2.982**	**2.659**	**2.635**	**2.403**	**2.364**	**3.103**	**4.166***
	(2.386)	(2.523)	(2.503)	(2.402)	(2.339)	(2.112)	(2.086)	(2.119)	(2.103)	(1.996)	(2.308)
Population density	27.28	81.24	76.14	49.63	50.57	58.40	57.27	55.16	52.83	32.15	-70.52
	(98.47)	(104.6)	(103.9)	(97.82)	(96.77)	(95.73)	(96.06)	(96.10)	(97.31)	(90.56)	(128.0)
Population * 10^{-6}	0.0214	-0.00659	0.00716e	0.0134	0.0190	0.0149	0.0192	0.0135	0.0186	0.00544	0.0345
	(0.0385)	(0.0436)	(0.0401)	(0.0360)	(0.0337)	(0.0370)	(0.354)	(0.0352)	(0.0342)	(0.0347)	(0.0433)
Total open land	-0.00563**	-0.0131***	-0.0126***	-0.00531*	-0.00562*	-0.00722	-0.00713	-0.00841	-0.00816	-0.00296	-0.00543*
	(0.00281)	(0.00464)	(0.00448)	(0.00306)	(0.00303)	(0.00504)	(0.00480)	(0.00548)	(0.00527)	(0.00446)	(0.00307)
Share Democratic votes	0.0432**	0.0417*	0.0391*	0.0458**	0.0430**	0.0386*	0.0366*	0.0410**	0.0382*	0.0375*	0.0430*
	(0.0213)	(0.0223)	(0.0216)	(0.0225)	(0.0217)	(0.0209)	(0.0208)	(0.0209)	(0.0210)	(0.0204)	(0.0223)
Household wage	0.0204	0.0283*	0.0272*	0.0244*	0.0238*	0.0277*	0.0265*	0.0255*	0.0244*	0.0111	0.0113
	(0.0142)	(0.0152)	(0.0150)	(0.0141)	(0.0140)	(0.0146)	(0.0145)	(0.0144)	(0.0144)	(0.0156)	(0.0152)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap	69.7	33.7	37.6	28.6	30.4	84.2	89.7	64.1	70.1	43.4	52.8

Notes: Robust standard errors in parentheses (observations are clustered by US state). *** p<0.01, ** p<0.05, * p<0.1. **Bold** coefficients are instrumented.

Figures

Figure 1. Equilibrium

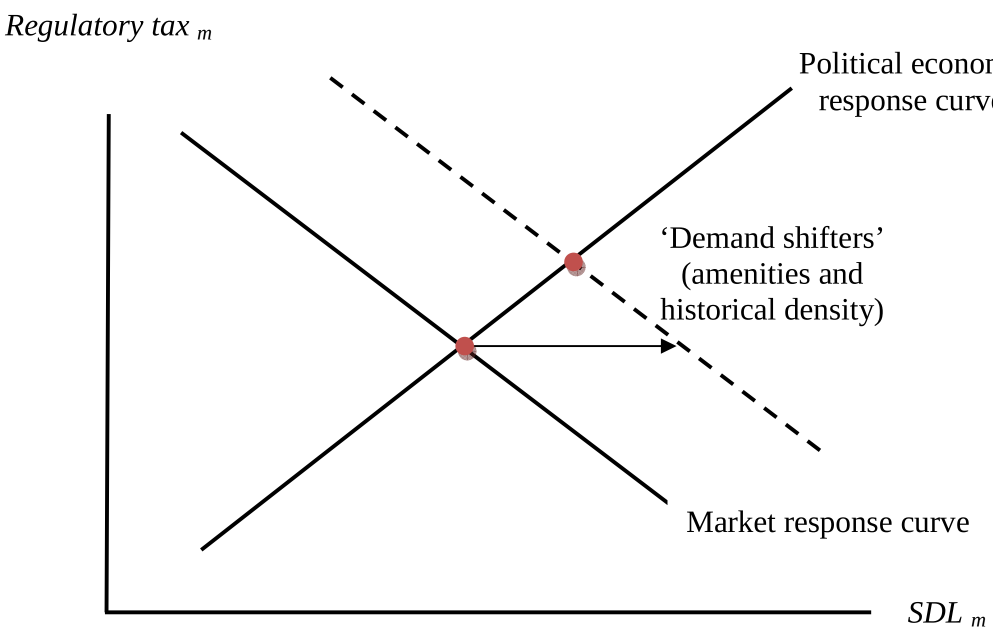


Figure 2. Unconditional correlation between regulatory restrictiveness and share developed residential land.

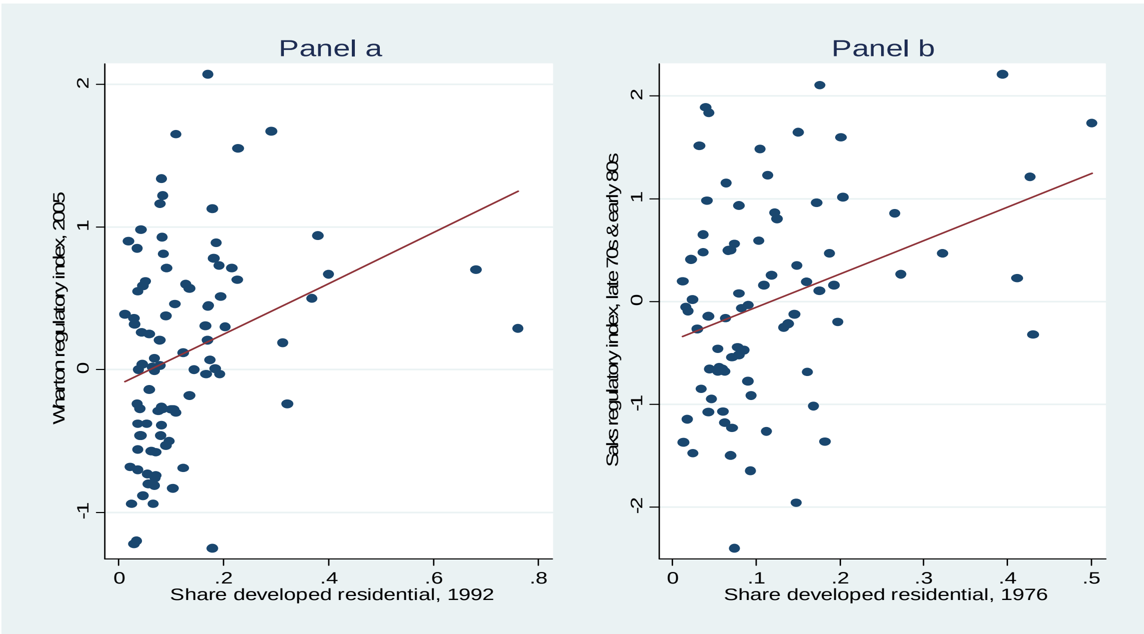
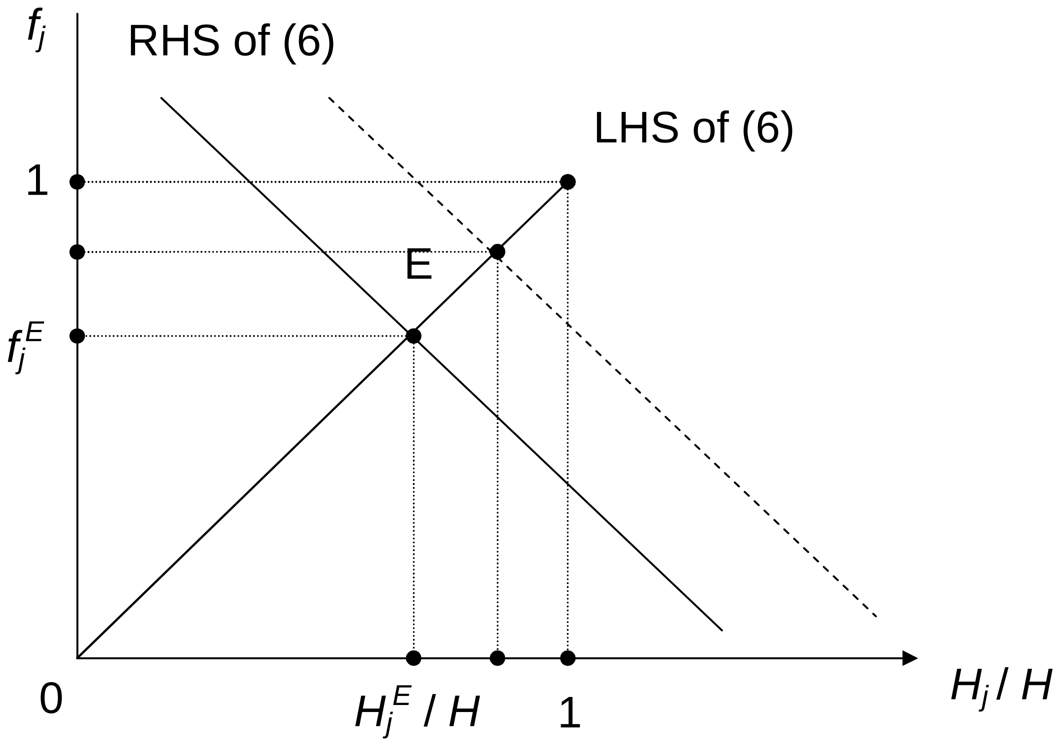


Figure 3. Spatial equilibrium.



Appendix A. Proofs of Propositions

Proof of Proposition 1. Let us generalize (3) and (6) for any $\sigma > 0$:

$$\forall j \in \Im_+ : \qquad f_j = \frac{H_j}{H} \quad \Rightarrow \quad f_j = \frac{H_j}{H} = \frac{\left(\omega_j - t_j - \tau H_j\right)^{1/\sigma}}{\sum_{k\in\Im+}\left(\omega_k - t_k - \tau H_k\right)^{1/\sigma}}.$$

The RHS of this expression is decreasing in H_j by inspection and it belongs to the unit interval for any $H_j \in [0, H]$ (with complementary slackness), so there always exists a jurisdiction j such that a positive mass of households desires to live in j. Conversely, the left-hand-side (LHS) is linearly increasing in H_j and it spans over the unit interval. It follows that there exists at least one $j \in \Im$ such that the LHS and the RHS intersect exactly once in the interior of the unit interval; if (14) holds, then the LHS and the RHS intersect exactly once for all $k \in \Im$. *QED*.

Proof of Proposition 2.[9] SPE in pure strategies characterized by (11) and (12) exist if $R_j(\mathbf{t})$ is quasi-concave in t_j (this is a consequence of Kakutani's (1941) fixed point theorem). Twice differentiating (9) with respect to t_j (keeping $\mathbf{t^0_{-j}}$ constant) yields

$$\frac{\partial^2 R_j}{\partial t_j^2} \equiv \left[2 + \tau \frac{\partial H_j}{\partial t_j}\right]\frac{\partial H_j}{\partial t_j} + \tau H_j \frac{\partial^2 H_j}{\partial t_j^2}.$$

This is negative (and as a consequence R_j is quasi-concave in t_j) if

$$2 + \tau \frac{\partial H_j}{\partial t_j} > 0 \qquad \text{and} \qquad \frac{\partial^2 H_j}{\partial t_j^2} < 0$$

because $\partial H_j/\partial t_j < 0$ by (7). Using (7), (14) and the definition of f_j and rearranging yield

$$2 + \tau \frac{\partial H_j}{\partial t_j} = \frac{2V_j + f_j H\tau\left(1 + f_j\right)}{\omega_j - t_j} > 0 \qquad \text{and} \qquad \frac{\partial^2 H_j}{\partial t_j^2} = -\frac{2H\sum_{k\neq j}\left(\omega_k - t_k\right)}{\left[\sum_{k\in\Im+}\left(\omega_k - t_k\right)\right]^3} < 0 \qquad (18)$$

as was to be shown. *QED*.

Proofs of Proposition 3 and Corollary 3.1.[10] It is convenient to rewrite the SPE relationship (12) as $\omega_j - t_j^0 = \left(1 - f_j^0\right)\left(t_j^0 + f_j^0 H\tau\right)$. Totally differentiating this expression and making use of (11) yields $l_j \mathrm{d}t_j^0 = r_j\left(\mathrm{d}\omega_j - \mathrm{d}t_j^0\right)$, where

---

[9] See Guide to calculations in Appendix C.1 (not intended for publication) for details.

[10] See Guide to calculations in Appendix C.1 (not intended for publication) for details.

$$l_j \equiv \left(V_j^0 + f_j^0 H\tau\right)\left(1 - f_j^0\right) \qquad \text{and} \qquad r_j \equiv V_j^0 + f_j^0\left(1 - f_j^0\right)t_j^0 + \left(3 - 2f_j^0\right)\left(f_j^0\right)^2 H\tau\,. \tag{19}$$

Both l_j and r_j are positive by inspection. This implies

$$\frac{\mathrm{d}\omega_j - \mathrm{d}t_j^0}{\mathrm{d}\omega_j} = \frac{l_j}{r_j} > 0 \qquad \text{and} \qquad 0 < \frac{\mathrm{d}t_j^0}{\mathrm{d}\omega_j} = \frac{r_j}{l_j + r_j} < 1\,. \tag{20}$$

The first property in (20) establishes (iv) and, together with the spatial equilibrium condition (7) (whereby jurisdictions with a higher $\omega_j - t_j^0$ have a higher equilibrium H_j^0) and the location preferences (3) (whereby jurisdictions with a higher V_j^0 command a higher H_j^0), implies (i) and (v), respectively. Finally, turn to (iii): (14) ensures $t_j^0 > 0$ and $V_j^0 > 0$, all j. To see this, recall that the jurisdiction with the minimum equilibrium deterministic utility and the lowest regulatory tax is the jurisdiction with the lowest ω_j – call this jurisdiction 'min'. From (i) and (iv), the least attractive jurisdiction has a less than average equilibrium population share, i.e. $f_{\min}^0 < 1/J$ (so that $\kappa_{\min}^0 > 1/2$). Using these as well as (12) and (13), we get:

$$V_{\min}^0 > \frac{\left(1 - J^{-1}\right)\omega_{\min} - J^{-1}H\tau}{2 - f_{\min}^0} \qquad \text{and} \qquad t_{\min}^0 > \frac{\omega_{\min} - J^{-1}H\tau}{2}\,. \tag{21}$$

Both lower bounds are positive if $\omega_{\min} > H\tau/\left(J - 1\right)$, i.e., if (14) holds. *QED.*

Appendix B. Guide to calculations (not intended for publication)

B.1. Guide to calculations

Derivation of (3). The location choice probabilities in (1) are equal to

$$
\begin{aligned}
f_j &= \frac{\exp\left(\ln V_j / \sigma\right)}{\sum_{k\in\Im} \exp\left(\ln V_k / \sigma\right)} \\
&= \frac{V_j}{\sum_{k\in\Im} V_k} \\
&= \frac{1}{J}\frac{V_j}{\overline{V}}.
\end{aligned}
$$

The first equality above follows from the distributional assumption of the stochastic term in (1), the second follows from $\sigma \equiv 1$, and the third by definition of $\overline{V}$.

It is useful to totally differentiate (7) for further reference. Using the definition $f_j \equiv H_j / H$ yields

$$
\mathrm{d}f_j = f_j\left(1 - f_j\right)\frac{1}{\omega_j - t_j}\left(\mathrm{d}\omega_j\text{-}\mathrm{d}t_j\right). \tag{22}
$$

Derivation of the SPE (12). Using (22) to substitute for $\mathrm{d}H_j^0 / \mathrm{d}t_j^0$ in (10) yields

$$
\begin{aligned}
0 &= \frac{\mathrm{d}R_j^0}{\mathrm{d}t_j^0} \\
&\equiv \left(\tau H_j^0 + t_j^0\right) H \frac{\mathrm{d}f_j^0}{\mathrm{d}t_j^0} + H_j^0 \\
&= \left(\tau H_j^0 + t_j^0\right) f_j^0 H \left[\frac{-1}{\omega_j - t_j^0} + \frac{1}{J}\frac{1}{\overline{\omega} - \overline{t}^0}\right] + f_j^0 H \\
&= f_j^0 H \left\{\left(f_j^0 H\tau + t_j^0\right)\frac{1}{\omega_j - t_j^0}\left(-1 + f_j^0\right) + 1\right\},
\end{aligned}
$$

where the second line follows from (10) and (7), the third one follows from (7) and (11) and the final one follows from rearranging terms and using (11). For cities that are non-empty in equilibrium, this implies that the term in the curly bracket is equal to zero. This fact and imposing (14) together enable us to write

$$
\omega_j - t_j^0 = \left(1 - f_j^0\right)\left(t_j^0 + f_j^0 H\tau\right). \tag{23}
$$

Isolating t_j^0 yields (12), as was to be shown. In (12), $\kappa_j^0 \in \left(\frac{1}{2},1\right)$ holds by $f_j^0 \in (0,1)$. Imposing (14) ensures that $f_j^0 > 0$ for all *j*; relaxing it would imply $f_j^0 = V_j^0 = 0$ for some *j*.

Establishing (18). Using (22) with $\mathrm{d}\omega_j = 0$ and using $\mathrm{d}H_j = H\mathrm{d}f_j$ by definition of f_j yields

$$\begin{aligned}
2+\tau\frac{\mathrm{d}H_j}{\mathrm{d}t_j} &= 2+\frac{H_j\tau}{\omega_j - t_j}\left(-1+f_j\right) \\
&= \frac{2\left(\omega_j - t_j\right) - H_j\tau\left(1-f_j\right)}{\omega_j - t_j} \\
&= \frac{2\left(\omega_j - t_j - H_j\tau\right) + H_j\tau\left(1+f_j\right)}{\omega_j - t_j} \\
&= \frac{2V_j + H_j\tau\left(1+f_j\right)}{\omega_j - t_j} > 0,
\end{aligned}$$

where the fourth equality follows from (4). The inequality follows from $V_j > 0$ and establishes the first part of (18). We now show that $H_j(t_j)$ is concave; differentiating (22) one more time yields:

$$\begin{aligned}
\frac{\mathrm{d}^2 f_j}{\mathrm{d}t_j^2} &= -\frac{2\left[J\left(\bar{\omega}-\bar{t}\right) - \left(\omega_j - t_j\right)\right]}{\left[J\left(\bar{\omega}-\bar{t}\right)\right]^3} \\
&= -\frac{2\sum_{k\neq j}\left(\omega_k - t_k\right)}{\left[\sum_{k\in\Im+}\left(\omega_k - t_k\right)\right]^3} < 0.
\end{aligned}$$

This implies the second part of (18) by $\mathrm{d}H_j = H\mathrm{d}f_j$, as was to be shown.

Establishing (19) **and** (20). Differentiating (23) yields

$$\begin{aligned}
\mathrm{d}\omega_j - \mathrm{d}t_j^0 &= -\mathrm{d}f_j^0\left(t_j^0 + f_j^0 H\tau\right) + \left(1-f_j^0\right)\left(\mathrm{d}t_j^0 + H\tau\mathrm{d}f_j^0\right) \\
&= \left(1-f_j^0\right)\mathrm{d}t_j^0 + \left[-\left(t_j^0 + f_j^0 H\tau\right) + \left(1-f_j^0\right)H\tau\right]\mathrm{d}f_j^0 \\
&= \left(1-f_j^0\right)\mathrm{d}t_j^0 + \left[-\left(t_j^0 + f_j^0 H\tau\right) + \left(1-f_j^0\right)H\tau\right] f_j^0\left(1-f_j^0\right)\frac{1}{\omega_j - t_j}\left(\mathrm{d}\omega_j\text{-}\mathrm{d}t_j^0\right),
\end{aligned}$$

where the third equality follows from (22). Isolating the term $\left(\mathrm{d}\omega_j\text{-}\mathrm{d}t_j^0\right)$ and rearranging yield:

$$\left(\omega_j - t_j^0\right)\left(1-f_j^0\right)\mathrm{d}t_j^0 = \left\{\left(\omega_j - t_j^0\right) + \left[\left(t_j^0 + f_j^0 H\tau\right) - \left(1-f_j^0\right)H\tau\right] f_j^0\left(1-f_j^0\right)\right\}\left(\mathrm{d}\omega_j - \mathrm{d}t_j^0\right).$$

In turn, using the definition of V_j in (4) and rearranging yield:

$$\begin{aligned}\left(V_j^0+f_j^0H\tau\right)\left(1-f_j^0\right)\mathrm{d}t_j^0&=\left\{\left(V_j^0+f_j^0H\tau\right)+\left[t_j^0+\left(2f_j^0-1\right)H\tau\right]f_j^0\left(1-f_j^0\right)\right\}\left(\mathrm{d}\omega_j-\mathrm{d}t_j^0\right)\\&=\left\{V_j^0+f_j^0\left(1-f_j^0\right)t_j^0+\left[1+\left(2f_j^0-1\right)\left(1-f_j^0\right)\right]f_j^0H\tau\right\}\left(\mathrm{d}\omega_j-\mathrm{d}t_j^0\right)\\&=\left[V_j^0+f_j^0\left(1-f_j^0\right)t_j^0+\left(3-2f_j^0\right)\left(f_j^0\right)^2H\tau\right]\left(\mathrm{d}\omega_j-\mathrm{d}t_j^0\right),\end{aligned}$$

which we rewrite as $l_j\mathrm{d}t_j^0=r_j\left(\mathrm{d}\omega_j-\mathrm{d}t_j^0\right)$, where l_j and r_j are defined in (19)**.** Both terms are positive by inspection. This implies (20) and, together with (22):

$$\frac{\mathrm{d}f_j^0}{\mathrm{d}\omega_j}=f_j^0\left(1-f_j^0\right)\frac{1}{\omega_j-t_j^0}\frac{l_j}{r_j}>0,$$

which is another way of getting property (i).

Establishing (21). Using (12) for the least desirable jurisdiction yields

$$\begin{aligned}t_{\min}^0&=\kappa_{\min}^0\omega_{\min}-\left(1-\kappa_{\min}^0\right)f_{\min}^0H\tau\\&>\frac{\omega_{\min}-J^{-1}H\tau}{2},\end{aligned}$$

which is positive if (and only if) $\omega_{\min}>H\tau/J$; the inequality follows from $f_{\min}^0<1/J$ and $\kappa_{\min}^0>1/2$. By the same token, applying (13) to the least desirable jurisdiction yields

$$\begin{aligned}V_{\min}^0&=\left(1-\kappa_{\min}^0\right)\omega_{\min}-\kappa_{\min}^0f_{\min}^0H\tau\\&>\frac{\left(1-J^{-1}\right)\omega_{\min}-J^{-1}H\tau}{2-f_{\min}^0},\end{aligned}$$

which is positive if (and only if) $\omega_{\min}>H\tau/\left(J-1\right)$; the inequality follows from $f_{\min}^0<1/J$. As a result, both $t_j^0>0$ and $V_j^0>0$ hold for all *j* if (14) holds, as was to be shown.

B.2. The lobbying game

We follow Bernheim and Whinston (1986) and Dixit *et al.* (1997) in assuming that the owners of undeveloped land (or land developers) and the owners of developed land form two competing lobbies that influence the planning board by way of lobbying contributions. Specifically, we assume that the planning board maximizes aggregate lobbying contributions $C_j\equiv\sum_\Lambda c_j^\Lambda$, with $\Lambda\in$ {owners of developed land, land developers}. This objective function conveys the idea that the planning board caters only to the interests of land stakeholders. Note that land stakeholders include absentee landlords, local landlords, land developers, homeowners and even renters when rent controls are in place (de facto, rent controls act as way to share land rents between the owner and the renter).

We also assume that each group offers a 'menu' of contributions to the planning board, contingent on the degree of regulation t_j actually chosen so that $c_j^{\Lambda} = c_j^{\Lambda}(t_j)$. The timing of the contribution game is as follows. The lobbies (the 'principals') move first and simultaneously, the planning board (the 'agent') then chooses to accept the contributions or not and, contingent on accepting some, both, or no contributions, chooses t_j. Since the principals move first, at equilibrium they choose c_j^{Λ} so as to ensure that the agent accepts the contribution and enforces a regulation that is closer to the interests of lobby Λ. Many contribution schemes are possible (and thus many Nash equilibria exist), but Bernheim and Whinston (1986) show that the set of best responses of each lobby to *any* contribution scheme chosen by the other players includes a linear schedule of the form $c_j^{\Lambda}(t_j) = R_j^{\Lambda}(t_j) - c_j^{\Lambda}$, where R_j^{Λ} is the aggregate land rent pertaining to lobby Λ and c_j^{Λ} is a constant determined at equilibrium. These linear contribution schedules also have the desirable property to produce the unique 'coalition proof Nash equilibrium' of the game. Goldberg and Maggi (1999) show how a model in which t_j is set by cooperative Nash bargaining produces a similar policy outcome.[11]

As a result of these assumptions, the planning board maximizes aggregate land rents as in equation (9) of the main text.

B.3. Adding agglomeration economies

We claim in the text that adding agglomeration economies or external congestion costs do not affect the essence of our model and empirical strategy. To see this, let local amenities and local wages be a function of local population and a location-specific shifter, which we write $a_j = a\left(H_j, \tilde{a}_j\right)$ and $w_j = w\left(H_j, \tilde{w}_j\right)$ so that $\omega_j = \omega\left(H_j, \tilde{\omega}_j\right)$. Without loss of generality we let $a_2\left(\cdot\right) > 0$ and $w_2\left(\cdot\right) > 0$ (subscripts denote the variable with respect to which the function is differentiated). It is reasonable to assume $w_1\left(\cdot\right) > 0$ (agglomeration economies) and $a_1\left(\cdot\right) < 0$ if people prefer to live in places that are not too dense on average. Thus the term $\omega_1\left(\cdot\right)$ can be

[11] Goldberg, P., and G. Maggi. 1999. 'Protection for sale: An empirical investigation.' *American Economic Review*, 89(5): 1135-1155.

positive or negative a priori. Equation (7) still defines a spatial equilibrium in this context, though it is now an implicit equation. Its solution exists and is locally stable if the RHS of (6) is decreasing, which is the case iff $\omega_1\left(H_j,\cdot\right)<\tau$. Imposing $w_1\left(\cdot\right)+a_1\left(\cdot\right)<\tau$ for all j and all $H_j \in \mathbb{R}_+$ yields uniqueness. Turning to the regulation game, the first order condition for of the program $\max_{t_j} R_j\left(\mathbf{t}\right)$ reads (omitting complementary slackness for simplicity)

$$\frac{\mathrm{d}}{\mathrm{d}t_j}R_j(t_j,\mathbf{t}^{\mathbf{0}}_{\mathbf{-j}})\bigg|_{t_j=t_j^0}=H_j^0+\left(H_j^0\tau+t_j^0\right)\frac{\mathrm{d}}{\mathrm{d}t_j}H_j(t_j,\mathbf{t}^{\mathbf{0}}_{\mathbf{-j}})\bigg|_{t_j=t_j^0}=0,$$

where

$$\frac{\mathrm{d}}{\mathrm{d}t_j}H_j(t_j,\mathbf{t}_{\mathbf{-j}})=-\frac{1}{\bar{\varpi}-\bar{t}-\bar{H}\tau}\left(1-\frac{H_j}{H}\right)\left[1+\frac{\tau-\omega_1\left(H_j,\tilde{w}_j,\tilde{a}_j\right)}{\bar{\varpi}-\bar{t}-\bar{H}\tau}\left(1-\frac{H_j}{H}\right)\right]^{-1}<0.$$

Thus, the size of a jurisdiction still decreases with respect to its own regulation in equilibrium. By the same token, it is easy to show that more desirable locations are more populated in the spatial equilibrium by

$$\mathrm{d}H_j(\tilde{w}_j,\tilde{a}_j;\cdot)=\frac{1}{\bar{\varpi}-\bar{t}-\bar{H}\tau}\left(1-\frac{H_j}{H}\right)\left[1+\frac{\tau-\omega_1\left(H_j,\tilde{w}_j,\tilde{a}_j\right)}{\bar{\varpi}-\bar{t}-\bar{H}\tau}\left(1-\frac{H_j}{H}\right)\right]^{-1}$$
$$\times\left[\omega_2\left(H_j,\tilde{w}_j,\tilde{a}_j\right)\mathrm{d}\tilde{w}_j+\omega_3\left(H_j,\tilde{w}_j,\tilde{a}_j\right)\mathrm{d}\tilde{a}_j\right].$$

Likewise, the rest of the analysis goes through unaltered (adding some regularity conditions).