

# On the origins of land use regulations:

## The ‘influential landowner’ hypothesis\*

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**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 are interpreted as shadow taxes that increase the land rent of already developed plots and increase the cost of developing new housing units. At equilibrium, locations with nicer amenities (or lower development costs) are more developed and, *as a consequence*, more regulated. We test our model predictions by geographically matching amenity, land use, and historical Census data to metropolitan area level survey data on regulatory restrictiveness. Following the predictions of the model, we use access to the coast as an instrumental variable and we control for a number of alternative explanations in order to demonstrate that metropolitan areas with better access are more developed and more tightly regulated. Consistent with theory, more regulated metropolitan areas also grow more slowly.

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# 1. Introduction

The ‘credit crunch’ that triggered the ongoing worldwide recession finds its source in major imbalances in the U. S. housing market. Local and macroeconomic shocks constantly interact with asset markets and, as the most important asset category for most households, housing is no exception. In markets with a relatively *inelastic supply* of land or housing, demand shifts mostly affect house prices. Conversely, the quantity of housing is the main variable of adjustment in housing markets with land readily convertible into new developments. The determinants of the supply elasticity of land may be physical (topography) or man-made (regulations restricting land use). In this paper, we focus on the latter and develop a general theory of the determinants of land use regulations. We test its empirical implications on a sample of the largest Metropolitan Statistical Areas (MSAs) in the United States. Our theory suggests that places that are more developed or urbanized are also more regulated.

From a historical perspective, land use regulations are a recent phenomenon. In the early 20<sup>th</sup> century, when only about a quarter of humans lived in urbanized areas, few cities had any zoning laws. San Francisco (1880) and New York City (1916) were early exceptions. Now that eighty percent of the U.S. and over half of the world populations live in cities (United Nations 2007), land use regulations are ubiquitous in all developed countries. Our theory proposes a causal link from this demographic pattern (increasing urbanization rates) to the political one (increasing regulation).

Land use regulations impose substantial restrictions on the property rights of landowners, they take many forms (e.g., zoning, growth boundary controls, building height or minimum lot size restrictions), and they serve various purposes (e.g., internalizing visual and fiscal externalities, rent-seeking). Though they differ in purpose, kind and scope, all these regulations have a component in common: they act as quantitative restrictions to land use and, as such, they have a shadow tax equivalent. These taxes can be extremely high and they vary considerably across and within countries. Though a breadth of literature studies the *effects* of such regulations on a variety of outcomes, the literature that studies the *determinants* of land use restrictions is sparse. In this paper, we provide a general, simple theory that explains why land use restrictions might vary across space and we confront the equilibrium predictions of our model to data from the United States. By nature, our theory cannot explain each specific form of land use regulations; instead, we take a general view of how regulations are determined. The determinant we emphasize in this paper is a *political struggle among conflicting economic*

*interests* that does not only include residents but also ‘absentee landlords’ and owners of undeveloped land.

In the current paradigm, most authors hypothesize that the dominant determinant of land use restrictions is the homeownership rate. Fischel’s (2001, 2003) ‘home-voter hypothesis’ postulates (i) that homeowners favor land use restrictions so as to protect the value of their property and (ii) jurisdictions that have a large number of homeowners should be more regulated, since the ‘swing voter’ is more likely to be a homeowner. In our view, this explanation is incomplete. Although planning boards are typically elected by local residents, the election process in general and the decisions of planning boards in particular may also be influenced by lobbying of absentee landlords on the one hand and owners of undeveloped land on the other hand. Our ‘influential landowner’ hypothesis is that this conflict of interest is of first order importance in shaping land use regulations and that other explanations may also be useful but are of second order importance. In his seminal paper, Molotch (1976) claims that various urban groups seek to influence the ‘urban growth machine’ in a way that favors their interests at the expense of others. Urban elites, including environmentalists and homeowners, form one such group that typically favors urban growth restrictions. Land developers, typically opposed to such restrictions, form another one. Accordingly, we develop a theory in which the objective function of planning boards aggregates local ‘land-based interests’ (Molotch 1976). Our aggregator is a version of the common agency framework developed by Bernheim and Winston (1986) and Grossman and Helpman (1994): each place independently and non-cooperatively chooses the degree of regulation that maximizes the aggregate local land rent; this regulation benefits the owners of developed land but makes the owners of undeveloped land worse off. In the common agency framework, the various lobbies influence the planning board by offering contributions that are contingent on all feasible regulations; in the literal interpretation of this working hypothesis, stakeholders (or lobbies) bribe the planning boards and other decision bodies.<sup>1</sup> However, we understand the word ‘influence’ in a broad sense that includes more benign cases, such as pressure groups acting as experts and conveying useful information to the executives they actively lobby. Reconciling the two interpretations, legal contributions may buy access to pressure groups and provide

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<sup>1</sup> The recent indictments of the Chicago land developer and fund raiser Tony Rezko by federal prosecutors in investigations involving the Illinois Governor Rod Blagojevich in December 2008 and of Baltimore Mayor Sheila Dixon in January 2009 for taking over twenty thousands dollars in gifts are only the latest reminders that this is more than a theoretical possibility.

credible information to legislators in the sense of Austen-Smith (1995) or Lohmann (1995).<sup>2</sup> As a result, we expect the regulatory restrictiveness to be strongly correlated with any measure of the influence of owners of developed land relative to the influence of owners of undeveloped land. Using the share developed land (**SDL**) in a MSA as a proxy for the relative influence of the two groups, our empirical results are strongly supportive of that view; by contrast, they do not support the homevoter hypothesis.

Figure 1 illustrates the flavor of our findings. Panel a plots the Wharton Residential Urban Land Regulation Index (**WRLURI**) – a measure of regulatory restrictiveness – for the year 2005 computed by Saiz (2008) against SDL in 1992 for 95 of the largest MSAs.<sup>3</sup> The correlation between these two variables is 0.32 and it is statistically significant at the one-percent level. Figure 1 (Panel c) reveals that the relationship between SDL and land use restrictions has been positive since the late 1970s/1980s at least (the regulatory index for the late 1970s and 1980s on the vertical axis in Panel c has been computed by Saks (2008) for 82 MSAs; we subsequently call this index **SAKS**). The remaining two Panels (b and d) in Figure 1 suggest that the relationship between WRLURI or SAKS and the homeownership rate at the MSA level (for the year 2000 or 1980, respectively) is negative.<sup>4</sup> Below, we regress WRLURI on SDL in 1992 to show that there is a causal link between these variables. We also test for alternative explanations (like the homevoter hypothesis) and we address the endogeneity issues related to the focal explanatory variables. In our baseline specification, we find that a one standard deviation increase in SDL *causes* an increase of the WRLURI by 0.54 standard deviations.

Two words of caution are in order regarding the normative implications of our results. First, if lobbies contribute directly and financially to planning boards, then this does not entail any loss to society at large (leaving aside redistributive or ethical issues). By contrast, if pressure groups hire lawyers to spend precious time and other real resources to bend the planning board towards their own interests, then such resources are wasted from the society's point of

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<sup>2</sup> The non-partisan research group Centre for Responsive Politics reports that the National Association of Realtors (3.9 million US\$) and the National Association of Home Builders (2.1 million US\$) both enter the CPR's top-20 list of Political Action Committees contributing to federal candidates in 2007/2008.

<sup>3</sup> Of course, lobbying activities are not *directly* reflected in regulatory indices, such as the WRLURI. In fact, real estate developers may spend significant efforts bypassing restrictive regulations that they distaste rather than preventing them in the first place. However, we would expect a strong positive correlation between measures of regulatory restrictiveness and the relative political influence of owners of developed land. In this context it is important to note that elected officials are entitled to vote on matters that benefit their campaign contributors. They are merely not allowed to "sell" their votes for cash or personal favors (Lefcoe 2005: 879).

<sup>4</sup> Note that the homevoter-hypothesis predicts a positive relationship. Our empirical results reveal that this negative correlation rarely survives in rigorous empirical work.

view, as stressed by Tullock (1967) and Krueger (1974). Obviously, such wastes are very likely to apply in practice.<sup>5</sup> The Centre for Responsive Politics (CPR) reports that the real estate sector spent over 62 million dollars lobbying the U.S. Congress and federal agencies in 2008 alone.<sup>6</sup> These CPR figures exclude contributions to state politicians or local agencies. We have strong reasons to expect that contributions at the local level are even more substantial.<sup>7</sup> While realtors benefit from tighter regulation that increases house prices and consequently transaction related fees, land developers benefit from flexible zoning laws that facilitate future development.

We also want to stress that our interpretation of the model and of our empirical results does not exclude the possibility that the observed regulatory outcomes are close to the first best policy.<sup>8</sup> However, even when the observed outcome is close to first best, such policies create losers and winners. Owners of plots of land just outside a city growth boundary are clearly worse off than owners of neighboring plots that fall just inside the area zoned for development, since the former commands a lower land rent than the latter.<sup>9</sup> To allow some role for the welfare economics explanation (whereby regulation is an instrument that optimally corrects for market failures), we include population density in developed areas as a control. It is a reasonable proxy for the welfare economics view if one accepts the assumption that externalities require more frequent corrections in densely populated places. It turns out that population density is statistically insignificant in all our empirical results, providing no support for the welfare economics view.

Some people may be more favorable to regulations in general than others for cultural or ideological reasons (e.g. ‘liberals’, in North-American parlance). These people might disproportionately reside in the most developed places (and influence the polity accordingly) for reasons that are exogenous to the political struggle emphasized by our model.<sup>10</sup> To control

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<sup>5</sup> Gottdiener (1977) provides direct evidence that “lawyers with political connections to the leadership were more successful in obtaining re-zonings than lawyers without traceable connections.”

<sup>6</sup> Freddie Mac, Fannie Mae and the Federal Loan Banks together amount for about 11 million dollars. See <http://www.opensecrets.org> for details.

<sup>7</sup> Plenty of anecdotic evidence suggests that realtors, land developers and environmentalists figure prominently among the major lobbyist-employers and donors to electoral campaigns, e.g., in California. See <http://cal-access.ss.ca.gov> (web site of the Secretary of State of California, accessed January 29<sup>th</sup>, 2009).

<sup>8</sup> Maximizing land value is equivalent to maximizing social welfare in the small open city model (Brueckner, 1990). See e.g. Fischel (1992) and Duranton (1997) for surveys on the economic foundations of zoning.

<sup>9</sup> Examples of growth boundaries include Portland, OR, Boulder, CO, and ‘green belts’ in the UK. In their detailed study of Reading, UK, Cheshire and Sheppard (2002) find that both costs and benefits of land use planning are high; their results suggest that the net welfare effect of such restrictions is negative in their sample.

<sup>10</sup> Gyourko, Mayer and Sinai (2006) provide evidence of households sorting across U.S. MSAs along income.

for these influences, we include the percentage of votes collected by the democratic candidate in prior U.S. presidential elections as well as regional dummies.<sup>11</sup> *Ceteris paribus*, cities in states that are democratic-leaning are relatively more regulated, as are cities in the West and the North-East; cities in the Mid-West are the least regulated. These cultural and ideological controls are statistically significant in all our specifications. Finally, in a similar vein, households may sort by income and higher income groups may have stronger (or weaker) preferences for regulation. To check whether our results may be driven by such sorting we control for household wages, but this variable turns out to be insignificant. Interestingly, the quantitative impact of SDL on regulation gets stronger when we add all these controls.

To summarize our findings, we find strong empirical support for our political economy mechanism that stresses the role of influence of ‘land based interests’ as well as for the ideological and cultural control variables. We find no supportive evidence for either the homevoter hypothesis or the welfare economics view. We want to stress that the primary aim of the paper is to uncover the role of ‘land based interests’, not to run a fair horserace among several possible explanations. Our work is only a first step in this direction.

The rest of the paper is organized as follows. We selectively review the relevant literature in the next section. Section 3 introduces the model and solves it. Section 4 tests our empirical predictions and conducts a battery of robustness checks. Section 5 concludes.

## **2. Related literature**

The restrictiveness of land use regulations varies strongly across the United States. Glaeser, Gyourko and Saks (2005a, b) estimate that the ‘regulatory tax’ represents more than half of house values in highly developed places such as Manhattan or San Francisco but zero in Detroit or Pittsburgh. Estimated regulatory tax rates also vary greatly across European cities. Cheshire and Hilber (2008) estimate the regulatory tax for office space relative to marginal construction cost to range from 68% in Brussels to over 800% in the London borough of Westminster.

The first empirical contribution of this paper is to identify the origins of this cross-sectional variation. Evenson and Wheaton (2003) and Glaeser and Ward (2008) regress measures of

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<sup>11</sup> We use presidential elections because the relevant choice set is the same for all U.S. voters across the whole country: using state elections, for instance, would bias our results because New England Democrats are different from Southern ‘Dixie’ Democrats; likewise, Californian or Mid-West Republicans tend to be more conservative than their North-Eastern counterpart. In addition, using presidential elections provides time variation (absent in regional dummies), which is useful when we replicate our analysis with the 1976 SDL data and SAKS.

various types of land use regulations on historical and other characteristics of Massachusetts towns. For instance, historical population density (1915 in the case of Glaeser and Ward) has a positive effect on current minimum lot size restrictions. However, they conclude from this exercise that ‘the bulk of these rules seem moderately random and unrelated to the most obvious explanatory variables’ (Glaeser and Ward 2008: 3). Our analysis shows that looking at joint measures of regulation (WRLURI and SAKS) and aggregating across the major U.S. MSAs reveals systematic patterns. The most closely related study to ours is Saiz’s (2008) and the papers complement each other in important ways. For each MSA in his sample, Saiz builds a measure of *developable land* and regresses 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* (SDL) that has developable land at the denominator.<sup>12</sup> 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 in the U.S. should indirectly be the most regulated. This accords well with the findings of Glaeser et al. (2005a), who find that the regulatory tax is highest in the Bay area and in New York City (Manhattan in particular) while they find no evidence for a regulatory tax in places such as Pittsburgh or Detroit. In addition, our paper enables us to shed a new perspective on some of the results unveiled by Burchfield, Overman, Puga and Turner (2006). For instance, they find that cities with better natural amenities sprawl more than others – likely because of minimum lot size restrictions that reduce the capital-to-land ratio. In the model, we attribute this phenomenon to endogenous land use constraints; in our empirical work, we find that locations with more desirable amenities are more developed and more regulated.

Second, a dynamic interpretation of our model is consistent with the findings of Fischel (2004), Gyourko, Saiz, and Summers (2008), and Rudel (1989). According to Fischel (2004), the origins of land use regulation are within larger cities but zoning then spreads quickly to the suburbs and towns surrounding the cities. In a similar vein, Gyourko et al. (2008) document that municipalities within MSAs tend to be more highly regulated than the counterparts outside MSAs. The most direct evidence that the timing and restrictiveness of

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<sup>12</sup> To construct his measure of developable land, Saiz (2008) uses the U.S. Geographic Service’s Digital Elevation Model and excludes rasters on water bodies, wetlands and those that have a slope of 15% or more. We use a comparable dataset, except that we define the share of non-developable land in an MSA based on land cover data. In doing so, we follow the approach by Hilber and Mayer (2009). See also Burchfield et al. (2006).

zoning is tied to the distance from the central city comes from Rudel (1989) who shows – using disaggregated municipal level data for Connecticut – that the municipalities adopted land-use laws later if they lived at a greater distance to New York City.

Third, we find that current regulations slow down new development confirming the findings of Quigley and Rafael (2005) for California or Glaeser and Ward (2008) for Greater Boston.<sup>13</sup> Our estimates imply that a one standard deviation difference in MSA-level SDL in 1976 results in a 2½ percentage point-difference in the growth of housing supply between 1990 and 2000 via differentially affecting regulatory restrictiveness during the late 1970s and 1980s. This accounts for almost 20 percent of the growth in new construction during that period.

We also contribute to the theoretical literature in several ways. First, our combination of a discrete choice model and of a standard monocentric city (**MCC**) model for the ‘macro’ and ‘micro’ location decisions, respectively, is unique in the urban economics literature.<sup>14</sup> This combination provides a useful generalization of the currently extreme versions of the MCC model, whereby each city is either fully isolated (‘closed’) – in which case population supply to each city is inelastic and utility varies across cities – or small and fully ‘open’, in which case the utility level is exogenous to each city and population supply is infinitely elastic (Brueckner 1987). In our model, both city sizes and average utility levels vary across MSAs and are determined endogenously. The key distinction works as follows. The literature on systems of cities, including Henderson (1974) or Fujita, Mori and Krugman (1999), assumes that each city is a-priori identical on the demand side, i.e. from the mobile population’s point of view (‘consumers’). This is a limiting case, as is the case of homogenous products in the imperfect competition literature. Our model relaxes this extreme assumption by assuming that cities offer heterogeneous amenities, which are valued differently by heterogeneous workers, as in the industrial economics discrete choice models (Anderson, Palma and Thisse, 1992). This generalization has many benefits, one of them being that we can easily use the model to study strategic interactions among jurisdictions.

This leads us to our second contribution: jurisdictions set their policies non-cooperatively and a jurisdiction’s policy spills over to other communities because consumers are mobile, as in

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<sup>13</sup> Therefore, as also suggested by our theory, there is a two-way relationship between regulation and SDL, resulting in a downward bias of the coefficient of SDL in regressions where regulation is the dependant variable. This is why we instrument for SDL in our central regressions.

<sup>14</sup> To the best of our knowledge, Quigley (1976) is the first study to include discrete location choice to the urban economics literature; by contrast to us, he uses random utility to model location choices *within* cities. The role of amenities in household location decisions across cities has been addressed by e.g. Roback (1982).

Brueckner (1995) and Helsley and Strange (1995). In our model, the Nash equilibrium in land use regulations exists and is unique under fairly mild conditions; Helsley and Strange (1995) use a model in which at least one jurisdiction is inactive and acknowledge that ‘it is not possible to consider population controls when all communities are active without substantially modifying [their] model’ (p. 456). We propose one such modification.

Third, Fischel (1978) and Ortalo-Magné and Prat (2007), among others, assume that local planning boards cater to the interests of local residents and implement the policy chosen by majority voting. By contrast, we assume that landowners lobby and influence planning boards and that these implement policies that maximize land value as a result. Such policies may then hurt consumers and overall welfare, as stressed by Brueckner (1995) and Helsley and Strange (1995). In addition, Brueckner and Lai (1996) focus on the distinction between absentee landowners and resident landowners. Unlike the former, the latter rent land to themselves, so they partly factor in the consumer loss that regulations entail. By contrast, we emphasize the conflict between the interests of owners of developed land and those of the owners of undeveloped land, irrespective of their place of residence.

Finally, a large body of literature aims to explain the economic effect of various institutional democratic arrangements.<sup>15</sup> Our paper adds to the literature explaining the causes of institutions. La Porta, Lopez-de-Silanes, Schleifer and Vishny (1998), Acemoglu, Johnson and Robinson (2001) and many others study the origins of uneven economic development, addressing the issue of the endogeneity of institutional arrangements at the country level. The spirit of our work is similar to the first stage of La Porta et al. (1998) and Acemoglu et al. (2001): we ‘explain’ the cross-MSA variation of land use regulation (using a political economy mechanism in our case).

### **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 jurisdictions simultaneously choose a zoning policy, taking the other planning boards’ choices as given. 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 and finally payoffs are realized. The equilibrium concept is a

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<sup>15</sup> For instance, in their worldwide sample of democracies, Persson and Tabellini (2003) find that presidential regimes have smaller governments than parliamentary regimes. Feld and Matsusaka (2003) provide evidence from Swiss Cantons that mandatory referendums reduce the size of government spending by almost a fifth at the median, and Besley and Case (1995) find that gubernatorial term limits in the United States effectively reduce the accountability of Governors for whom term limits are binding.

(subgame perfect) Nash equilibrium in zoning policies. We now formally describe the set of players, their strategy sets and their payoff functions.

### 3.1. Households' location choice

In stage 2, a continuum of  $H$  households allocate themselves to a number  $J > 1$  of jurisdictions (or cities).<sup>16</sup> Households established in city  $j$  derive utility  $u_j$ ,  $j \in \mathfrak{J} \equiv \{1, \dots, J\}$ . Following the *Random Utility Theory*, which finds its origins in psychology, we assume that  $u_j$  is a random variable and we model the fraction  $f_j$  of households that choose to live in city  $j$  as  $f_j = \Pr\{u_j = \max_k u_k : k \in \mathfrak{J}\}$ . Specifically, the household-specific realization of  $u_j$ , denoted as  $u_j(h)$ , has a common component  $\tilde{V}_j$  and an idiosyncratic, households-specific component  $\tilde{\varepsilon}_j(h)$ , with  $h \in [0, H]$ . That is, we assume

$$u_j(h) = \tilde{V}_j + \tilde{\varepsilon}_j(h), \quad \tilde{\varepsilon}_j(h) \sim \text{i.i.d. } G_j(\cdot) \quad (1)$$

where  $G_j$  is the jurisdiction-specific cumulative density of  $\tilde{\varepsilon}_j$ .<sup>17</sup> The common component  $\tilde{V}_j$  is deterministic and summarizes the monetary costs and benefits from living in city  $j$ ; the idiosyncratic component  $\tilde{\varepsilon}_j(h)$  summarizes the utility  $h$  derives from consuming local amenities. Households are heterogeneous in their appreciation of these amenities.<sup>18</sup> The economic interpretation of (1) is that the deterministic component  $\tilde{V}_j$  is observable by the modeler or the econometrician and that the random component  $\tilde{\varepsilon}_j(h)$  can be observed only imperfectly (Manski 1977).<sup>19</sup>

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<sup>16</sup> We work with MSA-level data (for reasons to be explained in section 4) so one way to interpret the model is to assume that there is a representative jurisdiction (and hence a representative planning board) in each city.

<sup>17</sup> We assume that the support of  $G_j$  is convex and that  $G_j$  is twice continuously differentiable over the support. We also assume that for any  $x$  that belongs to the support of  $G$ ,  $\Pr\{\tilde{\varepsilon} = x\} = 0$ .

<sup>18</sup> To fix ideas, think of  $j$  as being either Boulder, CO or San Francisco, CA. Then some people like skiers enjoy the proximity of the Rockies more strongly, while windsurfers value the proximity of the Ocean more strongly. *Ceteris paribus*, the former will prefer to live in Boulder, CO relative to the latter. Mathematically, we may write  $\tilde{\varepsilon}_{\text{Boulder}}(\text{skier}) - \tilde{\varepsilon}_{\text{SF}}(\text{skier}) > \tilde{\varepsilon}_{\text{Boulder}}(\text{surfer}) - \tilde{\varepsilon}_{\text{SF}}(\text{surfer})$ .

<sup>19</sup> The interpretation in psychology is that the ‘sensation’ or ‘psychological state’  $u_j(h)$  that household  $h$  derives from living in  $j$  is a function of the realization  $\varepsilon_j(h)$  of a random variable (Thurstone 1927). In the remainder of the paper, we stick to the economic interpretation. See Anderson, de Palma and Thisse (1992) for a synthesis. Also, the reader may be more familiar to modeling discrete location decisions with the multinomial logit model. We show in Appendix B that the equilibrium properties of the multinomial logit are qualitatively similar to the linear case. We choose to work with the linear model because we obtain simple, closed form solutions. In a different context, there is a long tradition in the Political Economics literature to use linear discrete choice models to model voters’ decisions to cast their ballot for a candidate or another (Persson and Tabellini, 2000).

Though households differ in their appreciation of the local amenities, some jurisdictions are more desirable than others on average. One way to model this is by assuming that the distribution of  $\tilde{\varepsilon}_j(\cdot)$  stochastically dominates the distribution of  $\tilde{\varepsilon}_k(\cdot)$ , some  $j \neq k \in \mathfrak{J}$ .

Alternatively, it is more convenient to replace (1) by

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

where  $G$  is the cumulative density of  $\varepsilon$  and  $V_j \equiv a_j + \bar{V}_j$  is the observable *indirect utility* (or *real income*) enjoyed by people living in city  $j$ , and to assume that  $\varepsilon_j(h)$  is identically and independently distributed; note that the c.d.f.  $G$  no longer depends on  $j$  here. We interpret  $a_j$  as a measure of the observable quality of the local amenities (converted in monetary units). Thus, the fraction of households wishing to reside in  $j$ , given  $V_1, \dots, V_J$  and  $G(\cdot)$ , is

$$f_j = \Pr\{V_j + \varepsilon_j = \max_{k \in \mathfrak{J}} V_k + \varepsilon_k\} \quad (3)$$

In order to get simple, explicit solutions, we assume that the  $\varepsilon$ 's are uniformly distributed on the interval  $[-\sigma/2, \sigma/2]$ , where  $\sigma$  is proportional to the standard deviation of  $G$ .<sup>20</sup> Throughout the paper, we use ‘upper bars’ to denote averages across cities: e.g., let  $\bar{V} \equiv \sum_{k \in \mathfrak{J}} V_k / J$ . The resulting location choice probabilities are given by the linear function

$$f_j = \frac{1}{J} \left[ 1 + \frac{V_j - \bar{V}}{\sigma} \right] \quad (4)$$

An immediate implication of (4) is that cities that command a higher-than-average indirect utility  $V_j$  attract more households than the average city.

What are the components of indirect utility  $V_1, \dots, V_J$ ? Let

$$V_j = a_j + w - c_j - t_j \quad (5)$$

where  $w$  denotes the household's income,  $c_j$  captures the monetary costs of living associated with  $j$  and  $t_j$  is a ‘regulatory tax’ levied on residents (more on this below). In this paper, the land market outcomes play the central role, so we treat  $a_j$  and  $w$  as parameters but we endogenize the cost of living as follows.

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<sup>20</sup> Specifically,  $\text{Var}(\varepsilon) = \sigma^2/12$ . Note also that the deterministic case obtains at the limit  $\sigma = 0$ .

Assume that city  $j$  is a linear monocentric city (Alonso 1964), in which the per-unit distance commuting cost is equal to  $\tau$  and the unit cost of converting land into housing is constant and equal to  $m$ . Then, if  $H_j$  households live in  $j$ , (5) is equal to:<sup>21</sup>

$$V_j = \omega_j - \tau H_j - t_j; \quad \omega_j \equiv a_j + w - m \quad (6)$$

where  $\omega_j$  summarizes the ‘fundamental’ (parametric) determinants of welfare in city  $j$ . We say that a city characterized by a high  $\omega_j$  is a ‘desirable’ location *ex ante* (or that it is *fundamentally desirable*). The expression in (6) conveys the intuitive result that cities that are more regulated and larger (and thus more congested) are less desirable *ex post*.<sup>22</sup>

To summarize, the fraction of households wishing to live in city  $j$ ,  $f_j$  in (4), is decreasing in the regulatory tax levied in  $j$  and its level of congestion, but increasing in the desirability of city  $j$ , which includes amenities and wages by (6).

Households treat  $t_j$  as a parameter. We define a *location equilibrium*  $H_1, \dots, H_J$  as a situation in which, given the induced equilibrium values of (4) and (6), no household wishes to relocate to another jurisdiction. Therefore, at a location equilibrium the actual fraction of households living in  $j$ ,  $H_j/H$ , must be equal to  $f_j$ . Then the following must hold at equilibrium:<sup>23</sup>

$$\forall j \in \mathfrak{J}: \quad f_j = \frac{H_j}{H} \Rightarrow \frac{H_j}{\bar{H}} = 1 + \frac{(\omega_j - t_j - \tau H_j) - (\bar{\omega} - \bar{t} - \tau \bar{H})}{\sigma} \quad ; \quad \bar{H} \equiv \frac{H}{J} \quad (7)$$

That is, the fraction of people living in  $j$  is increasing in the well-being net of the regulatory tax and congestion costs of  $j$  and decreasing in the well-being net of regulatory tax and congestion costs of cities  $k \neq j$ . Since households directly consume one unit of land for housing purposes in the linear MCC model, the equilibrium  $H_j$  is also the equilibrium amount of developed land in city  $j$ . We readily obtain the following:

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<sup>21</sup> 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  $H_j$ . Assume further that the unit cost of converting farm land for housing consumption is equal to  $m_j$ . 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 rent are identical across city locations, thus the equilibrium bid rent schedule (net of conversion costs  $m_j$ ) is  $r(d) = \tau(H_j - d)$ . As a result, the cost of living is  $c_j = \tau H_j + m_j$ , the aggregate land rent is equal to  $\tau H_j^2/2$  and  $\omega_j = a_j + w - m_j$  in (6). In the main empirical specification, we don’t exploit the cross-sectional variation in  $m_j$ . In Appendix C, we do exploit this variation; the theoretical implication of (6) is that the coefficient of  $m_j$  should have the opposite sign of the coefficient of  $a_j$ .

<sup>22</sup> This negative relationship between  $V_j$  and  $H_j$  holds for all  $H_j$  in the MCC model because we assume away agglomeration economies. Importantly, this negative relationship holds *in general* around the stable equilibria of generic urban models with a system of cities (Henderson 1974). For our purposes, this is all we need so we stick to this simple model.

<sup>23</sup> With  $H_j = 0$  or  $H_j = 1$  in an obvious way whenever the solution to (7) does not belong to  $[0, J]$ .

**Proposition 1 (existence and uniqueness of the location equilibrium).** Assume that the fraction of households that wishes to live in city  $j$  is given by (4) and that the observable real income is given by (6). Then the location equilibrium given by (7) exists and is unique.

*Proof.* See Appendix A.

Figure 2 illustrates the equilibrium concept. The downward-sloping schedule illustrates the fact that larger cities are more congested and thus less desirable, *ceteris paribus*. A higher  $\omega_j$  and/or a lower  $t_j$  shifts this schedule to the right. Thus, at equilibrium more desirable locations have more people. To see this formally, solve (7) explicitly for  $H_j$ :

$$\frac{H_j}{\bar{H}} = 1 + \frac{(\omega_j - \bar{\omega}) - (t_j - \bar{t})}{\sigma + \tau \bar{H}} \quad (8)$$

Several aspects of (8) are noteworthy. On average, each location gets  $\bar{H}$  households; cities that receive more households than the average are *ex post* more desirable (i.e. net of regulation costs) at equilibrium. Also, the effect of either variable on the location outcome is decreasing in  $\sigma$ , which captures the heterogeneity of households, and in the overall crowding of cities. Absent congestion costs and heterogeneously perceived differences in amenities, all locations would be a-priori identical and all households would locate in the location that offers the highest  $\omega_j - t_j$ . Finally, (8) points towards a crucial source of bias for our empirical work. There, we essentially regress  $t_j$  on  $H_j$  (see Proposition 2 below). However, (8) says that such a regression suffers from a *downward reverse causation bias*. We address this issue by instrumenting for  $H_j$  and our results confirm the existence of such a bias.

Together with (6), (8) implies

$$V_j = \frac{\sigma}{\sigma + \tau \bar{H}} (\omega_j - t_j) + \frac{\tau \bar{H}}{\sigma + \tau \bar{H}} (\bar{\omega} - \bar{t}) - \tau \bar{H} \quad (9)$$

At the location equilibrium, households obtain a real income that is a weighted average of the economic amenities they actually receive (the first term in the RHS above) and of the economic amenities available on average (the second term), minus the average congestion cost. The weight of  $j$ -specific characteristics (relative to the average) increases in  $\sigma$ , our measure of the intensity of idiosyncratic household preferences for local specificities. Households do not enjoy the same real wage everywhere because they are willing to forego some economic benefits to live in cities that offer non-economic amenities that they enjoy the most. This desirable and realistic property of the model is typical of Random Utility Models.

### 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 cost of living in the city by  $t_j$ . We interpret  $t_j$  as a ‘regulatory tax’ (Glaeser et al. 2005a,b) and we assume that it is capitalized into the price of developed land (Oates 1969, Palmon and Smith 1998; Fischel 1992 for a survey). Insofar as such a tax decreases the desirability of  $j$  as per (6) and, as result, the equilibrium amount of land being developed in city  $j$  as per (7), a regulatory tax hike in  $j$  hurts the owners of undeveloped land in city  $j$  and benefits the owners of developed land.

Here, we depart from the standard literature by assuming that the planning board caters to the landowners’ interests. Following Bernheim and Whinston (1986) and Dixit, Grossman and Helpman (1997), we assume that the owners of developed land and the owners of undeveloped land (or land developers) form two competing lobbies that influence the planning board by way of lobbying contributions.

Specifically, we first assume that the planning board maximizes a weighted sum of aggregate lobbying contributions  $C_j(t_j) \equiv \sum_{\Lambda} c_j^{\Lambda}(t_j)$ , with  $\Lambda \in \{\text{owners of developed land, land developers}\}$ , and resident’s welfare (including the share  $\alpha$  of land rents  $R_j$  earned by local residents):  $\Omega_j(t_j) \equiv b[H_j(t_j)V(t_j) + \alpha R_j(t_j)] + (1-b)C_j(t_j)$ , where  $b \in [0,1)$  captures the ‘benevolence’ of the planning board. This objective function conveys the idea that the planning board caters to the interests of both *residents*, which includes tenants and homeowners, via elections or referenda and of owners of land (developed and undeveloped), which includes *absentee* landlords, via lobbying. 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. 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  $R_j^{\Lambda}$  is the aggregate land rents pertaining to lobby  $\Lambda = \{\text{owners of developed land, land developers}\}$  and  $c_j^{\Lambda}$  is a constant determined at equilibrium.<sup>24</sup> As a

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<sup>24</sup> 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  $c_j^{\Lambda}$  so as to ensure that the agent accepts the contribution and enforce a regulation that is closer to the

result,  $C_j(t_j) = (1 - \alpha)R_j(t_j) - \sum_{\Lambda} c_j^{\Lambda}$ . To get clear cut results, we further assume  $b = 0$  as in Krishna (1998). As a result of these simplifications, the planning board maximizes total land rents:

$$\begin{aligned} R_j(\mathbf{t}) &\equiv \int_0^{H_j} \tau(H_j(\mathbf{t}) - x) dx + t_j H_j(\mathbf{t}) \\ &= \frac{\tau}{2} [H_j(\mathbf{t})]^2 + t_j H_j(\mathbf{t}), \quad \mathbf{t} \equiv [t_1, \dots, t_j]' \end{aligned} \quad (10)$$

where  $H_j(\mathbf{t})$  is given by (8).

### 3.3. Subgame perfect equilibrium

We solve for a Nash (subgame perfect) equilibrium in regulatory taxes. Thus,  $j$ 's planning board chooses  $t_j \in \mathfrak{R}_+$  so as to maximize (10) subject to (8) taking the vector  $\mathbf{t}_{-j}^0 \equiv \{t_k^0\}_{k \in \mathfrak{S} \setminus \{j\}}$  as given (the subscript '0' pertains to equilibrium values). The first order conditions for this program can be written as:

$$\left. \frac{\partial}{\partial t_j} R_j(t_j, \mathbf{t}_{-j}^0) \right|_{t_j=t_j^0} = H_j^0 \left[ 1 - \frac{\tau \bar{H}}{\sigma + \tau \bar{H}} \frac{J-1}{J} \right] - t_j^0 \left[ \frac{\bar{H}}{\sigma + \tau \bar{H}} \frac{J-1}{J} \right] \leq 0, \quad t_j^0 \geq 0 \quad (11)$$

with complementary slackness; in (11),  $H_j^0$  is the equilibrium city size, namely (8) evaluated at the Nash tax vector  $\mathbf{t}^0 \equiv [t_1^0, \dots, t_j^0]'$ . Note that the actual solutions to (11) are interior because the term in the square bracket of the RHS is always positive by virtue of

$$\frac{J-1}{J} \frac{\tau \bar{H}}{\sigma + \tau \bar{H}} < 1. \quad (12)$$

Assuming (for the time being) that the resulting  $H_j^0$ 's in (11) are also all interior, we may then write the closed form solutions to the  $J \times 2$  system composed by (11) and (8) as:<sup>25</sup>

$$t_j^0 = (\sigma J + \tau \bar{H}) \left[ \frac{1}{J-1} + \frac{\sigma}{\sigma + \tau \bar{H}} \frac{\omega_j - \bar{\omega}}{\sigma(J-1) + J(\sigma + \tau \bar{H})} \right] \quad (13)$$

and

$$\frac{H_j^0}{\bar{H}} = 1 + \frac{1-Z}{\sigma + \tau \bar{H}} (\omega_j - \bar{\omega}); \quad Z \equiv \left[ 1 + \frac{\sigma}{\sigma + \tau \bar{H}} \frac{J-1}{J} \right]^{-1} \in (\frac{1}{2}, 1). \quad (14)$$

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interests of lobby  $\Lambda$ . 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.

<sup>25</sup> The proof of proposition 2 below provides an algorithm to get (13) and (14).

Four aspects of (13) and (14) are noteworthy. First, the equilibrium regulatory tax increases in own desirability and decreases in the attractiveness of other cities. Second, this effect is higher, the *more* heterogeneous households are (the higher  $\sigma$ ) and the lower the congestion costs  $\tau\bar{H}$ . The former cross-effect arises because a homogenous population is more responsive to any differences in amenities and taxes across locations; the latter arises because, when congestion costs are large, cross-city differences along other dimensions matter relatively less for households' location choices. Third, ceteris paribus, equilibrium tax rates are decreasing in the number of jurisdictions (a pro-competitive effect) and they are increasing in the heterogeneity of workers. This can be interpreted as a pro-competitive effects: as  $\sigma$  rises, each jurisdiction perceives a *lower* elasticity of household demand. Finally, places that are more desirable are more developed at equilibrium, *despite being more regulated*.

The necessary second order condition to this problem is automatically satisfied:

$$\forall j \in \mathfrak{J}: \quad 0 > \frac{\partial^2}{\partial t_j^2} R_j(\mathbf{t}^0) = -\frac{J-1}{J} \frac{\bar{H}}{(\sigma + \tau\bar{H})^2} \left[ 2\sigma + \frac{1+J}{J} \tau\bar{H} \right] \quad (15)$$

We can now establish the subgame perfect equilibrium properties of our model (we establish its existence and uniqueness in Proposition 3 below).

**Proposition 2 (properties of the subgame perfect equilibrium).** Assume:

$$\forall j \in \mathfrak{J}: \quad -\frac{\sigma + \tau\bar{H}}{1-Z} + \bar{\omega} < \omega_j < \bar{\omega} + (J-1) \frac{\sigma + \tau\bar{H}}{1-Z} \quad (16)$$

Then the equilibrium characteristics of the model, summarized in (13) and (14), imply:

(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 test directly include:

**Corollary 2.1 (further properties of the SPE).** Assume that (16) holds. Then the following also follow from (13) and (14):

(iii) Regulatory taxes are strictly positive for all  $j$ ;

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

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

*Proof.* See Appendix A.

Our model can also shed light on the demographic origins of land use regulations that we mention in the introduction:

**Corollary 2.2 (urbanization and land use regulations).** The overall extent of regulation increases with the size of the urban population in the economy; furthermore, all cities are affected:

(vi) The *average* regulatory tax is increasing in  $H$  and in  $\bar{H}$ :  $\partial \bar{t}^0 / \partial H > 0$  and  $\partial \bar{t}^0 / \partial \bar{H} > 0$ ;

(vii) The *variance* of the regulatory tax is decreasing in the size of the urban population:  $\partial \text{Var}(t^0) / \partial H < 0$ .

The parameter restriction (16) requires the variation in the desirable fundamentals to be bounded above relative to household heterogeneity and congestion costs – not a very stringent condition – in order to ensure that the equilibrium population in any  $j$  is positive for the interior solution  $t^0$ . We make this assumption for analytical convenience only. Relaxing it would require us to replace the strict inequalities in Proposition 2 by weak inequalities.

**Proposition 3 (existence and uniqueness of the SPE tax setting game).** Assume (16) holds. Then the equilibrium described in Proposition 2 exists and is unique.

*Proof.* See Appendix A.

## 4. Empirical Analysis

The main purpose of our empirical analysis is to explore the causal effect, at the MSA-level, of amenities on the degree of physical development and, in turn, its causal effect on regulatory restrictiveness. We conduct our analysis for two time periods. We use land use data from 1992 to explore the causal effect of SDL on regulatory restrictiveness around 2005 (WRLURI). We then replicate our analysis with land use data from around 1976 to identify the causal effect on regulatory restrictiveness in the late 1970s and 1980s (SAKS). Proposition 2 implies positive causal effects in both periods. Using both recent and older data

from two different sources provides a useful robustness check of our results. We carry out a number of additional checks to test whether our results are sensitive to the definition of SDL or to MSA boundary definitions. We also use alternative IV estimating procedures.

#### 4.1. Description of Data

Our data is derived from various sources and geographical levels of aggregation. We geographically match all data to the MSA level using GIS. Tables 1 and 2 provide a data overview. Table 1 reports the values of key variables of interest for 21 MSAs, namely, those areas for which Glaeser, Gyourko and Saks (2005a) report a regulatory tax measure. Table 2 reports summary statistics for the variables used in the empirical analysis. Below, we describe the focal variables and their sources in greater detail.

The more recent of our two land use datasets, the National Land Cover Data 1992 (NLCD 92), is derived from satellite images. The earlier dataset, the Land Use and Land Cover GIRAS Spatial Data, is derived from aerial photos taken mostly in the mid 1970s (with 1976 being the mode and median year).<sup>26</sup> Both datasets cover the surface areas of all MSAs in our sample.<sup>27</sup> There is a considerable difference in map resolution and in land use definitions between 1976 and 1992, making direct comparisons of the data difficult. The two datasets are described in more detail in Burchfield et al. (2006). Following Hilber and Mayer (2009) we define the SDL in an MSA as

$$SDL \equiv \frac{\text{developed residential} + \text{developed industrial land}}{\text{developable land area}}, \quad (17)$$

whereas the ‘developable land area’ is the total land area minus the surface area that is covered by ‘non-developable’ land uses (i.e., soil that does not sufficiently support permanent structures and/or is extremely costly to develop).<sup>28</sup>

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<sup>26</sup> Missing map cells from the Albuquerque, New Mexico, Cedar City, Utah and Tampa Bay, Florida areas were obtained from Diego Puga at <http://diegopuga.org/data/sprawl/>. Map data was unavailable for Santa Cruz, California and a mis-projected map for Erie, Pennsylvania necessitated the removal of affected census tracts. Fourteen census tracts with no observed developed area or developable land were removed from the analysis.

<sup>27</sup> One special case is the MSA of Washington, DC. While we have data for the surface area of the MSA outside the District of Columbia, we do not have any information for the District itself. Hence we imputed SDL by assuming that land uses within the District are similar to that at the boundaries. This adjustment only increases the SDL measure for the MSA by about half a percentage point. This is because the District covers only about 1 percent of the surface area of the MSA. None of our results changes notably if we assume that the District is either not at all or fully developed nor if we drop the MSA altogether from our regression sample. In fact, one justification for dropping Washington, DC is that it is the capital; many of Washington DC’s land use restrictions are of a federal rather than local nature.

<sup>28</sup> These land uses include barren, water, ice, wetlands, and shrubland (based on the 1992 NLCD 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 (based on 1976 classifications). We also

The reader might worry that the boundaries of MSAs are arbitrary and, consequently, that SDL is arbitrary as well. However, it is easy to demonstrate that ‘more developed’ MSAs are more developed at any radius from the center than ‘less developed’ MSAs. In our sensitivity analysis we report results for alternative measures of share developed land including two measures that are based on a 20 km radius around the centroid of the MSA. The latter two measures are not endogenous to the way MSA boundaries are defined. Our results are virtually unchanged. In a similar vein, Burchfield, Overman, Puga and Turner (2006) show that whatever the buffer one takes does not affect the results.

The regulatory data is derived from two different sources and time periods. 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 activity. It is arguably the most comprehensive survey to date. See Gyourko, Saiz and Summers (2008) for details on how WRLURI is computed. Saiz (2008) reports WRLURI values for the 95 MSAs in our sample. A WRLURI value of 1 implies that the measure is one standard deviation above the national mean. It is worth pointing out that the WRLURI measure does not include attitudes towards regulation of coastal areas and that the majority of municipalities responding to the survey do not have access to the coast (even if the MSA as a whole does). This point is worth keeping in mind when we discuss our IV strategy. The SAKS (Saks 2008) measure is created as a “comprehensive index of housing supply regulation” by using the simple average of six independent surveys. The six sources are: The Wharton Urban Decentralization Project (carried out during the late 1980s), the Regional Council of Governments (1975-1978), the International City Management Association (ICMA, 1984), the Fiscal Austerity and Urban Innovation project (1983-1984), the National Register of Historic Places (NRHP) and the American Institute of Planners (1976). The method of index construction is described in detail in the Data Appendix of Saks (2008). Saks (2005) reports regulatory index values for 83 MSAs. We lose one observation in our analysis because the NLCD 92 does not report land use information for Honolulu, HI.

There is considerable variation in the degree of land use regulation across U.S. MSAs. Gyourko, Saiz and Summers (2008), based on their analysis of the WRLURI measure, suggest that there is more variation across than within MSAs. Other empirically motivated reasons also led us to choose to run our regressions at the MSA level. In many MSAs only

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experimented classifying all tundra as either ‘non-developable’ or as ‘developable’. Results are virtually unchanged in *all* the specifications to follow.

few municipalities responded to the surveys that are the foundation of the WRLURI and SAKS measures and many potentially important controls are available at the MSA- or state-level only. (See also Gyourko, Saiz and Summers (2008) and Saiz (2008) on the merits of using MSA aggregates in this context.) 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 2008). In a similar vein, Pollakowski and Wachter (1990) emphasize that the joint effect of land use regulations is larger than the effects of the parts.

Our amenity measure, the ‘MSA has major coast line’ variable and the region dummies are derived from the Environmental Systems Research Institute’s (ESRI) Census 2000 MSA-level shape file. The sources for our other (excluded) instruments and controls are listed in the note to Table 2.

## 4.2. Empirical Specification

Our objective in this section is to test the predictions of our model as directly as possible. We begin by testing the first equilibrium prediction stated in Proposition 2 (i), namely, that places with better amenities will be more developed. The prediction is stated as:

$$SDL_j = \alpha_0 + \alpha_1 (\textit{amenity}_j) + \alpha_2 (\textit{controls}_j) + \varepsilon_j \quad (18)$$

with  $\alpha_1 > 0$ . Next, we test the second equilibrium prediction stated in Proposition 2(ii). Jurisdictions that have better amenities and, consequently, are more developed should be more regulated. The prediction can be tested by estimating:

$$\textit{regulation}_j = \beta_0 + \beta_1 (\mathbf{SDL}_j) + \beta_2 (\mathbf{HOR}_j) + \beta_3 (\textit{controls}_j) + \mu_j \quad (19)$$

with  $\beta_1 > 0$  (by the ‘influential landowner’ hypothesis) and  $\beta_2 < 0$  (by the ‘homevoter’ hypothesis). The bold variables in (19) are endogenously determined. We use the amenity variable as an (excluded) instrument to identify the MSA’s SDL. There is no reason to believe that access to major coast line is systematically correlated with land use regulation, making our measure of amenity potentially a valid instrument.<sup>29</sup> Equation (19) also includes the homeownership rate (HOR) as a control variable. The homeownership rate is arguably

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<sup>29</sup> Recall that attitudes towards regulation of coastal areas are not a question in the Wharton survey from 2005. In addition, it could be argued that ‘access to major coastline’ also captures some physical constraint on the growth of the MSA in addition to being a desirable amenity. This makes it an even more convincing instrument.

endogenously determined as well. The strategy we use to identify the homeownership rate and the tests to confirm the validity of the instruments are described below.

Finally, a dynamic corollary of Proposition 2 implies that more regulated jurisdictions should grow more slowly than their less regulated neighbors (controlling for past growth and the contemporaneous housing stock).<sup>30</sup> This prediction is formulated as follows:

$$g_{jt}^H = \gamma_0 + \gamma_1(\text{regulation}_{jt}^e) + \gamma_2(g_{j,t-1}^H) + \gamma_3 H_{jt} + \omega_j \quad (20)$$

with  $\gamma_1 < 0$  by (8) and where  $g_{jt}^H$  is the growth rate of the housing stock in MSA  $j$  between time period  $t$  and  $t+1$ ,  $g_{j,t-1}^H$  is the equivalent growth rate between time period  $t$  and  $t-1$ ,  $\gamma_0$  is the common trend,  $\text{regulation}_{jt}^e$  is the predicted level of regulatory restrictiveness in MSA  $j$  at time  $t$  and  $H_{jt}$  is the housing stock at time  $t$ . The latter variable controls for the size of the MSA taking into account that larger locations may grow at a slower (or faster) pace.

### 4.3. Empirical Results

In Tables 3 to 6 we report the results for the empirical specifications stated in (18) to (20). We cluster the standard errors by U.S. State (when relevant) and report the robust standard errors throughout. To begin with, in Table 3 we report simple OLS estimates of our central specification (19) by regressing regulatory restrictiveness on the SDL variable plus controls, adding one at a time. These controls include the homeownership rate (to test for Fischel's 'homevoter-hypothesis'), the population density (controlling for the possibility that regulation is driven by externality zoning and that this is more beneficial in denser areas), the share democratic votes (testing the proposition that regulatory restrictiveness may be driven by political ideology), household wage (as a control for the possibility that the findings are driven by sorting by income), and regional dummies (to capture all other region-specific unobservable characteristics).

Consider first the result for the WRLURI reported in Panel A in our sample of 95 MSAs pertaining to our more contemporaneous analysis (i.e. 2005). Two observations are particularly noteworthy. First, the coefficient on the share developed variable is not only positive but also highly statistically significant in all specifications, despite likely being

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<sup>30</sup> If one were to interpret (8) literally, one would have to use the *growth* (i.e. first difference) of new housing units. However, the growth *rate* has a more straightforward interpretation. Hence we opted to report results for growth rates. Nevertheless, we also estimated specifications using the growth in housing stock and our results are qualitatively unchanged. The negative coefficient on the estimated regulatory measure is statistically significant at the one percent level in both cases (see next subsection).

substantially downward biased. Second, the coefficient on SDL is quite stable, ranging from 1.3 to 1.8. Adding controls tends to increase both the size of the coefficient as well as its statistical significance. Among the control variables, only the share democratic votes and the region dummies have a statistically significant and consistent impact. The Democrat-leaning MSAs prefer above average levels of regulation, at least in the 2000s. The coefficients on the region dummies are also as one might expect. The West, in particular, and the North East are the most strongly regulated, while the Midwest is least regulated. We report the results for the SAKS-index in our sample of 82 MSAs in Panel B. These results, pertaining to the earlier analysis (i.e. late 1970s and 1980s), are qualitatively similar, although the coefficient on the share developed-variable is now no longer statistically significant in two cases. Interestingly, in these specifications the coefficients on the homeownership variable are not only negative but also statistically significant. On the other hand, political ideology is seemingly unrelated to regulatory restrictiveness in the late 1970s and 1980s. One important caveat with these OLS-estimates is of course that several of the explanatory variables are likely endogenous determined, causing the estimates to be biased.

Tables 4 and 5 address the endogeneity issues related to the SDL and the homeownership rate variables. Table 4 reports the OLS estimates of the first-stage of the TSLS-estimates. Our identifying assumption for the SDL variable is that coastal places are developed earlier, attract more residents over time and, as a result, are more developed in our cross-section of MSAs, but that access to the coast is not directly related to regulatory restrictiveness. Column (1) (both panels) reports results for our *standard* definition of SDL (17), including as controls all the exogenous variables discussed in Table 3. The coefficient on ‘major access to coast line’ is positive and statistically significant at the 1 percent level. Households obviously value access to the seafront (and possibly the corresponding milder climate). The adjusted  $R^2$  is reasonably high with 0.48. The specification estimated in Column (2) differs from that in Column (1) only in that we additionally include the MSA’s share of households that consist of married couples without children. This variable helps us identify the homeownership rate and is used as an instrument in our TSLS estimates. 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. By contrast, we do not expect that the share of households

that consist of married couples without children helps us identifying the SDL. Our empirical results reported in Column (2) are consistent with this intuition. Column (3) finally reports OLS estimates of the effect of the ‘share married without children’ measure on the homeownership rate. As predicted, the coefficient of the ‘share married without children’ measure is positive and highly statistically significant at the 1 percent level. The adjusted  $R^2$  is quite high with 0.66. Our results contained in Table 4 thus establish that our proposed instruments for SDL and the homeownership rate fulfill the necessary condition that they are strongly correlated with the alleged endogenous variable.

We turn next to Table 5, where we examine whether the instrumented SDL has a causal effect on regulatory restrictiveness. We report results for the second stage of the TSLS regression using WRLURI in Panel A and SAKS in Panel B as the dependent variable. For comparison purposes we also report the corresponding OLS estimates in Column (1); this specification is identical to the one reported in the Column (6) of Table 3. In Column (2) we report results for the second stage that corresponds to the specification with only one endogenous variable (SDL), treating the MSA-level homeownership rate as exogenous. Column (3) reports the findings for our preferred specification (19), which assumes that both the SDL and the homeownership rate are endogenously determined. The coefficient on the SDL measure is positive and highly statistically significant in both specifications (Columns 2 and 3). It is indicative of a *causal* effect that is in line with the theoretical predictions of Proposition 2. Moreover, the size of the coefficient and statistical significance levels increase when we identify SDL using the ‘access to coast’ variable as an excluded instrument (i.e., when we compare Column 1 with Columns 2 and 3). This evidence of a downward bias introduced by the reverse causation of regulation on land development is again consistent with our theory by (8). The *quantitative* effects of SDL on the two regulation measures are quite large. A one standard deviation increase in SDL implies that the median MSA ‘climbs’ in the ranking of regulatory restrictions from position 48 to 33 when using the WRLURI data and from 42 to 19 or 20 when using the SAKS data.

The results with respect to the homeownership variable are mixed. In Panel A, the effect of the homeownership rate on WRLURI is positive in all cases but only becomes marginally statistically significant when we instrument for it. The quantitative effect even in the latter case is relatively small however. In Panel B, the coefficient on the homeownership rate-variable remains negative, even when controlling for other factors that potentially affect regulatory restrictiveness. However, in contrast to the OLS-specification, the effect is no

longer statistically significant. Overall, we conclude that the evidence in favor of the homevoter hypothesis at the MSA level in the United States is weak at best. This might be due to the presence of rent controls (which share the rent between the landlord and the renter) in some of the most regulated MSAs.

Interestingly, the coefficient on the variable ‘population density in the developed area’ (our proxy for the Welfare Economics view) is statistically insignificant at all conventional levels in all cases (OLS and TSLS and both Panels).<sup>31</sup> Our findings lead us to reject this alternative explanation for regulatory restrictiveness. Population density in the developed area does not drive land use regulations; SDL does.

By contrast, cultural differences and ideology are significant at the five percent confidence level (or beyond) in virtually all specifications. Regional dummies are always significant and the share democratic vote is significant in all specifications pertaining to 2005.

Table 5 also reports Kleibergen-Pappa Wald F-statistics, a test for weak instruments in the presence of robust (clustered) standard errors.<sup>32</sup> The test statistics are quite high and indicate with 95 percent confidence that the maximum TSLS size is either below 15% or around 15% . See Stock and Yogo (2005) and Kleibergen and Paap (2006) for details on the test-statistic and its critical values.

Finally, Table 6 reports the results for the test of the more subtle corollary prediction of our model outlined in (20), namely, that controlling for lagged growth and city size, more regulated MSAs should grow more slowly than less regulated ones. We use the predicted (fitted) values of the regulatory index from the estimating equations in Table 5 (Columns 2 and 3). Because the regulatory index measures are estimated values we report bootstrapped (and robust) standard errors using 1,000 replications. Here, bootstrapping increases the standard errors only marginally and has virtually no effect on the statistical confidence levels. The results reported in Columns (1) and (2) of Table 6 use the predicted values from the corresponding Columns (2) to (3) of Table 5. Both specifications control for the existing housing stock in the MSA in 1990 and the (lagged) housing supply growth rate in the 1980s. In both specifications the predicted regulatory tax has a negative and statistically highly significant effect on the growth rate in housing supply in the 1990s. In both cases the effect is

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<sup>31</sup> In section 4.4 we instrument for population density in the developed area but the second stage coefficient of this variable remains statistically insignificant.

<sup>32</sup> The Cragg-Donald F-statistic, proposed by Stock and Yogo (2005) to test for weakness of instruments in the presence of multiple endogenous regressors, is strictly speaking not the correct test statistic when the standard errors are heteroskedastic or clustered.

statistically significant at the 1 percent level as well as economically meaningful. An increase of the predicted SAKS-index by one standard deviation (+1.0) reduces the growth rate of housing supply by 2.9 percentage points. This is equivalent to a drop in the growth rate league table from rank 42 to 56. Overall, our results in Table 6 imply that while more ‘desirable’ MSAs grew more quickly in the past when little land was developed and the places were little regulated, their growth rate has later slowed down significantly when compared with ‘less desirable’ MSAs. We attribute this effect to tighter land use controls.

#### **4.4. Robustness checks and quantitative effects**

The Tables A1 to A6 in Appendix C summarize the findings of our robustness checks, focusing on our more contemporaneous analysis (using WRLURI and 1992 land use) and computing a number of alternative measures of SDL based on other plausible definitions. To begin with, in Table A1 we re-estimate our focal specifications (18) and (19) – similar to the respective Panel A in Tables 4 and 5 – but we now also endogenize the population density in the developed area (in addition to the SDL and homeownership rate variables). Various types of land use controls – including minimum lot size restrictions, the most obvious type – differentially affect the population density, suggesting reversed causation and biased estimates. Two (excluded) instruments are used to identify the ‘population density in the developed area’ variable. The first instrument is the share of ‘flat plains’ in an MSA. The identifying assumption is that sprawl is easier in particularly flat areas, where it is particularly easy to build. Hence, we would expect the share of flat plains to *negatively* affect population density. There is no reason to expect that the share of completely flat plains (relative to all other topography classifications) should directly affect regulatory restrictiveness. The second instrument is historical MSA-level population density from 1880. We would expect that MSAs that were already densely populated in the 19<sup>th</sup> century (prior to the evolution of land use regulation in the United States) are also densely populated today. At the same time, historic population density should not be directly related to contemporaneous land use restrictiveness. The two variables may also be valid instruments for the SDL. We would expect completely flat plains to have comparably low conversion costs. Hence, MSAs with a large fraction of flat plains should be more developed, all else equal. Similarly, we would expect the places that were densely populated in the 19<sup>th</sup> century to be the ones that were developed first, arguably because they have particularly attractive amenities. Consistent with our theory, these places should also be more developed today.

One obvious concern with instruments is that they are ‘weak’. Unfortunately, while we can calculate (and report) Kleibergen-Paap rank Wald F-statistics (Kleibergen and Paap 2006), critical value are not available from Stock and Yogo (2005) for specifications with more than two endogenous variables. To correct for the *possible* presence of weak instruments, we re-estimate (19) using the JIVE and LIML estimators. Angrist, Imbens and Krueger (1999) show that JIVE estimators generate smaller bias than TSLS-estimators in the presence of weak instruments.<sup>33</sup> LIML is approximately median unbiased for over-identified models (we have four instruments and three endogenous explanatory variables) and its asymptotic properties are the same as those of the TSLS estimator; therefore, as a rule of thumb, we hope to find similar coefficients in the TSLS and LIML regressions (Angrist and Pischke 2009). The advantage is that LIML produces a smaller bias than TSLS in finite samples.<sup>34</sup>

The results of the first-stage reported in Columns (1) to (3) of Table A1 reveal that all the instruments have the expected effect on our three endogenous variables. Moreover, all the relevant coefficients are highly statistically significant at the 1-percent level. The results of the second-stage are equally reassuring. Not only is the estimated coefficient on the SDL variable similar in magnitude to the estimates reported in Table 5 but also, the coefficient is somewhat larger when using the JIVE-estimator. This suggests that even if the instruments used to identify the endogenous variables were (jointly) weak, the resulting bias would be small. Our LIML results (column 6) are also excellent: the point estimate of the coefficient of SDL is virtually identical to the corresponding TSLS coefficient and is similarly precisely measured. This suggests that the small-sample bias of our TSLS is small.

Tables A2 and A3 replicate the focal specifications (18) and (19) using ten alternative definitions of SDL. The alternative definitions and summary statistics are provided in Table 2. Panel A of the respective Tables A2 and A3 reports specifications assuming that the population density variable is exogenous (base specification). Panel B reports specifications that assume that population density is endogenously determined. The results are again strongly in line with our baseline specification. Consider the first-stage results first (Table A2). The ‘access to coast’ variable is positive and highly statistically significant in all specifications in Panel A. The variable is also statistically significant in all but two cases

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<sup>33</sup> JIVE gets round the correlation between stage-one and stage-two errors by predicting the value of SDL of MSA  $j$  by running the first stage on all MSAs but  $j$ . As a result, this IV estimator bias is smaller than the TSLS bias but the standard errors are larger.

<sup>34</sup> We carry out a battery of other tests, including Hansen-J statistics, suggested to assess the validity of the instrumental variables and none of these tests indicates a problem. We should note, however, that these cannot ‘prove’ in any way the validity of the identification strategy.

(where the variable is close to being significant) in Panel B. In Panel B, the ‘share flat plains’ variable and the historic population density measure are reasonably strongly correlated with the coastal variable, explaining the somewhat lower statistical significance levels and size of the coefficient on the coastal variable. The second-stage results reported in Table A3 are equally bold. *In all 20 reported specifications* – using quite different definitions for SDL and treating the population density variable either as an exogenous or as an endogenous variable – *we find that SDL has a positive and statistically highly significant causal impact on WRLURI.*

Table A4 replicates the specifications reported in Table 5 (again with Panels A and B for WRLURI and SAKS, respectively). However, we add one additional control: the population size of the MSA. The sheer size of a city could be argued to be another potential explanatory variable of regulatory restrictiveness; in larger cities there may be more scope for regulation. While the first-stage results reported in Columns (1) and (2) suggest that larger cities are also more developed, the second-stage results reported in Column (3) imply that, all else equal, population size is not related to regulatory restrictiveness. The coefficients on the population size variable are negative but the effects are statistically insignificant. We note that the coefficient on SDL slightly increases in magnitude when we add population size as a control.

We perform a final check on our instruments following Chernozhukov and Hansen (2008) and Angrsit and Pischke (2009: 213). We run a reduced form OLS on our excluded instruments (and other exogenous variables) with regulation as the dependant variable for each specification of Table 4 and Table A1. These OLS estimates are unbiased and they are valid whether our instruments are weak or not. We find that ‘access to coast’ is statistically positive at the five percent level or beyond in all specifications but that the other excluded instruments are in general not significant. We also find that the excluded instruments are jointly significant at the five or one percent level in all relevant specifications. All these results, which we don’t report, are entirely consistent with our findings so far and thus raise our confidence in the robustness of our findings.

Our regressions use different samples of MSAs for data availability reasons. In Tables A5 and A6, we thus rerun the baseline regressions of Table 5 using the restricted samples of the growth regression (19). We first drop Oklahoma City and Tulsa, OK from the large sample; the results are reported in Table A5. We then reduce the sample further by keeping only MSAs for which we have both the SAKS and WRLURI measures; the sample shrinks by roughly a third to N=63. Nevertheless, our results, reported in Table A6, are robust to this

artificial attrition. Remarkably, the evidence in favor of our ‘influential landowner’ hypothesis even comes out quantitatively and statistically stronger.

Finally, Table A7 reports quantitative effects for the main specifications reported in Tables 4 to 6. Overall, the quantitative analysis implies that land use regulations are an important determinant of the volatility of key measures of housing markets. More attractive places in terms of amenities are significantly more regulated and in turn grow more slowly. Although, we cannot show this in our analysis, the findings also imply greater price volatility in more attractive and regulated markets.

## 5. Conclusions

In this paper we develop a parsimonious model that provides an explanation for why ‘desirable’ locations have tighter land use regulations compared to ‘less desirable’ places. The comparative statics of the model imply that in an economy with a growing population, the jurisdictions with the best amenities will be developed first. When in turn attractive jurisdictions become more filled up, owners of developed land (property owners) become politically more influential compared to owners of undeveloped land (e.g., land developers). Owners of developed land – in contrast to owners of undeveloped land – have an incentive to increase the cost of future development. Hence, all else equal, the more developed a jurisdiction already is, the greater should its regulatory tax be. Moreover, while different locations may grow at different paces for various (unobserved) reasons, we would expect a more developed and consequently more regulated jurisdiction to have a smaller rate of new housing construction when compared to its less regulated neighboring location. Our empirical analysis for a reasonably sized sample of MSAs in the United States, and for two time periods roughly two decades apart, confirms all the aforementioned predictions of the model.

Our theoretical and empirical analyses imply that local planning authorities cater to the interests of land owners beyond and above to those of local voters (although in the case of homeowners the two interests coincide) and of the residential population at large (the welfare economics view). Our empirical findings strongly support our ‘influential landowner’ hypothesis; we find no support for the homevoter hypothesis or the welfare economics view. Fascinatingly enough, in 1925 – that is, in the early stages of land use regulation – the Committee on Community Planning of the American Institute of Architects (AIA) came to a very similar conclusion: “[Zoning] is concerned only feebly and incidentally with the community function the land will best serve; it focuses its attention mainly upon stabilizing of the existing uses and the values that are derived from them, whether these are to the best

advantage of the community or not.” Whether land use regulations have gone too far, as Glaeser et al. (2005a) suggest for the case of Manhattan, or fall short of the social optimum remains a question open to further research.

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## Summary Statistics and Tables

Table 1  
MSA-level rankings of measures of regulatory restrictiveness and land scarcity

Metropolitan Area	(1)		(2)		(3)		(4)		(5)	
	Regulatory Tax in % of House Value 1998 <sup>i)</sup>	Rank	Regulatory Index 2005 <sup>ii)</sup>	Rank	Regulatory Index late 1970s & 1980s <sup>ii)</sup>	Rank	Share Developed Land in % 1992 <sup>iii)</sup>	Rank	Share Developed Land in % 1976 <sup>iii)</sup>	Rank
San Francisco	53.1	<b>1</b>	0.78	<b>5</b>	2.10	<b>2</b>	20.8	<b>10</b>	25.4	<b>8</b>
San Jose	46.9	<b>2</b>	0.21	<b>10</b>	1.65	<b>3</b>	19.9	<b>12</b>	25.2	<b>9</b>
Los Angeles	33.9	<b>3</b>	0.50	<b>8</b>	1.21	<b>4</b>	44.2	<b>1</b>	54.7	<b>1</b>
Oakland	32.1	<b>4</b>	0.63	<b>7</b>	0.10	<b>14</b>	26.6	<b>5</b>	27.6	<b>6</b>
Washington, D.C.	21.9	<b>5</b>	0.21	<b>10</b>	0.86	<b>6</b>	10.2	<b>17</b>	16.1	<b>16</b>
Newport News, VA	20.7	<b>6</b>	0.12	<b>12</b>		(-)	17.5	<b>13</b>	20.5	<b>14</b>
Boston	18.6	<b>7</b>	1.67	<b>2</b>	0.86	<b>7</b>	33.2	<b>4</b>	33.9	<b>3</b>
New York <i>Manhattan</i>	12.2	<b>8</b>	0.67	<b>6</b>	2.21	<b>1</b>	43.9	<b>2</b>	50.7	<b>2</b>
	>50									
Salt Lake City	11.9	<b>9</b>	-0.03	<b>17</b>	0.96	<b>5</b>	23.3	<b>6</b>	28.8	<b>4</b>
Chicago	5.7	<b>10</b>	0.01	<b>16</b>	-1.01	<b>20</b>	22.4	<b>7</b>	26.2	<b>7</b>
Baltimore	1.8	<b>11</b>	1.65	<b>3</b>	0.80	<b>8</b>	14.2	<b>15</b>	18.3	<b>15</b>
Birmingham	0	<b>12</b>	-0.24	<b>18</b>	-0.46	<b>16</b>	4.8	<b>21</b>	7.5	<b>21</b>
Cincinnati	0	<b>12</b>	-0.58	<b>21</b>	0.16	<b>12</b>	9.3	<b>18</b>	14.8	<b>18</b>
Detroit	0	<b>12</b>	0.07	<b>14</b>	-0.69	<b>19</b>	22.3	<b>8</b>	22.9	<b>11</b>
Houston	0	<b>12</b>	-0.30	<b>20</b>	-0.52	<b>17</b>	14.8	<b>14</b>	12.3	<b>19</b>
Minneapolis	0	<b>12</b>	0.38	<b>9</b>	-0.16	<b>15</b>	11.1	<b>16</b>	9.4	<b>20</b>
Philadelphia	0	<b>12</b>	1.13	<b>4</b>	0.47	<b>9</b>	21.1	<b>9</b>	27.8	<b>5</b>
Pittsburgh	0	<b>12</b>	0.08	<b>13</b>	0.26	<b>11</b>	8.5	<b>19</b>	15.4	<b>17</b>
Providence	0	<b>12</b>	2.07	<b>1</b>	0.35	<b>10</b>	20.6	<b>11</b>	22.2	<b>12</b>
Rochester	0	<b>12</b>	0.04	<b>15</b>	-0.68	<b>18</b>	5.3	<b>20</b>	21.8	<b>13</b>
Tampa	0	<b>12</b>	-0.24	<b>18</b>	0.16	<b>13</b>	35.6	<b>3</b>	24.2	<b>10</b>
Pair:	Correlation		Rank Correlation				Correlation		Rank Correlation	
HOR 1990, (4)	-0.61		-0.44		(2), HOR 1990		-0.24		-0.32	
HOR 1980, (5)	-0.69		-0.39		(3), HOR 1980		-0.64		-0.45	
(1), (2)	0.12		0.37		(1), (4)		0.33		0.36	
(1), (3)	0.68		0.65		(2), (4)		0.28		0.31	
(1), HOR 1990	-0.52		-0.68		(3), (5)		0.50		0.34	

*Sources:* <sup>i)</sup> Estimated regulatory tax values are from Glaeser, Gyourko and Saks (2005a). <sup>ii)</sup> Regulatory index values are from Saiz (2008) and Saks (2008 respectively). <sup>iii)</sup> The share developed land measures are derived from the 1992 and 1976 National Land Cover Data. Homeownership rates (HOR) are from the 1990 and 1980 US Census (tract level data geographically matched to the metropolitan area level).

Table 2  
Summary statistics

Variable	N	Mean	Std. Dev.	Min	Max
Wharton regulatory index ( <b>WRLURI</b> ), 2005 <sup>a)</sup>	95	0.10	0.70	-1.25	2.07
Homeownership rate, 1990 <sup>b)</sup>	95	0.63	0.070	0.32	0.74
Developed land as % of developable land ("share developed"), 1992 <sup>c)</sup>	95	0.15	0.13	0.020	0.85
<i>Alternative measures for robustness checks</i>					
Developed residential land as % of developable non- industrial land ("share developed residential"), 1992 <sup>c)</sup>	95	0.12	0.12	0.012	0.76
Share developed, 20km radius, 1992 <sup>c)</sup>	95	0.36	0.21	0.058	1
Share developed residential, 20km radius, 1992 <sup>c)</sup>	95	0.31	0.20	0.044	1
Share developed, excluding parks, 1992 <sup>c)</sup>	95	0.15	0.14	0.020	1
Share developed residential, excluding parks, 1992 <sup>c)</sup>	95	0.12	0.13	0.012	1
Share developed of average place, 1992 <sup>c)</sup>	95	0.46	0.16	0.098	1
Share developed residential of average place, 1992 <sup>c)</sup>	95	0.42	0.17	0.082	1
Share developed of median place, 1992 <sup>c)</sup>	95	0.46	0.19	0.095	1
Share developed residential of median place, 1992 <sup>c)</sup>	95	0.41	0.19	0.079	1
Population density in the developed area (per m <sup>2</sup> ), 1990 <sup>d)</sup>	95	0.0015	0.00080	0.00011	0.0061
%Democratic votes in state, av. presidential elections 1988/92 <sup>e)</sup>	95	48.7	4.9	34.4	58.8
Average household wage, 1990 <sup>b)</sup>	95	29892	5201	17041	46530
Region = Midwest (omitted) <sup>f)</sup>	95	0.21	0.41	0	1
Region = North East <sup>f)</sup>	95	0.18	0.39	0	1
Region = South <sup>f)</sup>	95	0.39	0.49	0	1
Region = West <sup>f)</sup>	95	0.22	0.42	0	1
Metro area has major border with coast <sup>f)</sup>	95	0.24	0.43	0	1
% Households with married couples and no children, 1990 <sup>b)</sup>	95	0.29	0.028	0.24	0.43
Share land in topography classification "plains – flat plains" <sup>g)</sup>	95	0.14	0.32	0	1
Population density in metro area (per km <sup>2</sup> ), 1880 <sup>i)</sup>	93	125.5	490.3	0.088	4699
Saks-index of housing supply regulation ( <b>SAKS</b> ), late 1970s and 1980s <sup>h)</sup>	82	-0.011	1.0	-2.4	2.2
Homeownership rate, 1980 <sup>b)</sup>	82	0.64	0.074	0.28	0.76
Developed land as % of developable land, 1976 <sup>c)</sup>	82	0.17	0.13	0.026	0.57
Population density in the developed area (per m <sup>2</sup> ), 1980 <sup>d)</sup>	82	0.0015	0.00076	0.00032	0.00592
%Democratic votes in state, av. presidential elections 1972/76 <sup>e)</sup>	82	44.8	4.0	27.3	54.8
Average household wage, 1980 <sup>b)</sup>	82	15982	2379	9172	21967
Region = Midwest (omitted) <sup>f)</sup>	82	0.207	0.408	0	1
Region = North East <sup>f)</sup>	82	0.159	0.367	0	1
Region = South <sup>f)</sup>	82	0.390	0.491	0	1
Region = West <sup>f)</sup>	82	0.24	0.43	0	1
Metro area has major border with coast <sup>f)</sup>	82	0.28	0.45	0	1
% Households with married couples and no children, 1990 <sup>b)</sup>	82	0.30	0.04	0.20	0.45
Share land in topography classification "plains – flat plains" <sup>g)</sup>	82	0.13	0.32	0	1
Population density in metro area (per km <sup>2</sup> ), 1880 <sup>i)</sup>	81	75.3	110.0	0	647.7
Percent change, housing units, 1990-2000 <sup>b)</sup>	82	0.13	0.09	0.03	0.48
Percent change, housing units, 1980-1990 <sup>b)</sup>	82	0.21	0.15	0.01	0.64
Housing units, 1990 <sup>b)</sup>	82	624775	636755	35041	3442841

Sources: <sup>a)</sup> Saiz (2008); <sup>b)</sup> US Census and Neighborhood Community Database (NCDB); <sup>c)</sup> National Land Cover Data (NLCD) 1976 and 1992 from the U.S. Geological Survey; <sup>d)</sup> Derived from NLCD and NCDB; <sup>e)</sup> Dave Leip's Atlas of Presidential Elections; <sup>f)</sup> Derived from ESRI's Census 2000 MSA-level shape file; <sup>g)</sup> Natural Amenity Scale Data from the Economic Research Service, United States Department of Agriculture; <sup>h)</sup> Saks (2008); <sup>i)</sup> Interuniversity Consortium for Political and Social research (ICPSR) study #2896.

Table 3  
Relationship between land scarcity and restrictiveness of land use regulations  
Method: OLS

PANEL A (N=95)						
Dependent Variable: WRLURI from 2005						
	(1)	(2)	(3)	(4)	(5)	(6)
Share developed, 1992	1.7 *** (0.55)	1.3 ** (0.57)	1.3 ** (0.56)	1.8 *** (0.49)	1.7 *** (0.53)	1.7 *** (0.53)
Homeownership rate, 1990		-1.7 * (0.97)	-1.8 (1.2)	-1.2 (1.0)	-0.99 (1.1)	0.97 (1.0)
Population density in developed area, 1990			-5.1 (106.2)	-156.5 (114.1)	-181.3 (109.4)	-23.6 (114.7)
Share democratic votes in state, average 1988 and 1992				0.069 *** (0.016)	0.065 *** (0.017)	0.045 ** (0.020)
Household wage, 1990 (in thousand US dollar)					0.020 (0.013)	0.018 (0.014)
North East						0.45 * (0.25)
South						0.34 ** (0.16)
West						0.82 *** (0.19)
Constant	-0.15 (0.11)	0.99 (0.63)	1.0 (0.87)	-2.6 ** (1.1)	-3.0 ** (1.1)	-3.8 *** (1.3)
Adjusted R-squared	0.10	0.12	0.12	0.32	0.33	0.44
PANEL B (N=82)						
Dependent Variable: SAKS from late 1970s and 1980s						
	(1)	(2)	(3)	(4)	(5)	(6)
Share developed, 1976	2.3 ** (0.95)	1.4 (0.98)	1.6 * (0.93)	1.7 ** (0.82)	1.7 * (0.84)	1.2 (0.84)
Homeownership rate, 1980		-4.1 *** (1.4)	-5.0 *** (1.8)	-4.9 ** (2.4)	-4.9 ** (2.4)	-3.8 * (2.1)
Population density in developed area, 1980			-149.2 (165.4)	-185.4 (161.7)	-184.2 (161.9)	-165.9 (124.8)
Share democratic votes in state, average 1972 and 1976				0.021 (0.039)	0.022 (0.040)	0.013 (0.037)
Household wage, 1980 (in thousand US dollar)					-0.0016 (0.037)	-0.0026 (0.044)
North East						0.59 * (0.35)
South						0.29 (0.37)
West						1.0 ** (0.39)
Constant	-0.40 ** (0.18)	2.4 ** (0.98)	3.1 ** (1.4)	2.2 (2.3)	2.2 (2.2)	1.4 (2.5)
Adjusted R-squared	0.087	0.17	0.18	0.18	0.18	0.31

*Notes:* Robust standard errors in parentheses. \*\*\* Significant at 1%; \*\* significant at 5%; \* significant at 10%. In Columns (4) to (6) of Panels A and B, observations are clustered by U.S. state.

Table 4  
First-stage regressions (OLS): Determinants of land scarcity and homeownership

	(1)	(2)	(3)
	PANEL A (N=95)		
	% Developed 1992	% Developed 1992	Homeownership rate 1990
Metro area has major border with coast	0.15 *** (0.047)	0.17 *** (0.045)	-0.038 *** (0.011)
Homeownership rate, 1990	-0.69 *** (0.25)		
% Households with married couples, no children, 1990		-0.50 (0.40)	1.4 *** (0.23)
Population density in developed area, 1990	-4.5 (23.7)	22.1 (29.6)	-23.0 *** (10.1)
Share democratic votes in state, average 1988 and 1992	-0.0072 ** (0.0029)	-0.0081 ** (0.0036)	0.0013 (0.0018)
Household wage, 1990 (in thousand US dollar)	0.00041 (0.0024)	0.00055 (0.0036)	0.00039 (0.0012)
North East	0.060 ** (0.028)	0.082 ** (0.034)	-0.040 ** (0.016)
South	-0.058 ** (0.024)	-0.036 (0.022)	-0.024 ** (0.011)
West	-0.035 (0.031)	0.016 (0.030)	-0.064 *** (0.015)
Constant	0.91 *** (0.28)	0.60 ** (0.25)	0.24 * (0.13)
Adjusted <i>R</i> -squared	0.48	0.41	0.66
	PANEL B (N=82)		
	% Developed 1976	% Developed 1976	Homeownership rate 1980
Metro area has major border with coast	0.11 *** (0.033)	0.10 *** (0.037)	-0.054 *** (0.015)
Homeownership rate, 1980	-0.049 (0.21)		
% Households with married couples, no children, 1980		0.51 (0.42)	1.1 *** (0.20)
Population density in developed area, 1980	45.4 * (24.0)	57.7 *** (18.2)	-43.1 *** (10.9)
Share democratic votes in state, average 1972 and 1976	-0.0066 ** (0.0031)	-0.0060 * (0.0032)	-0.00083 (0.0017)
Household wage, 1980 (in thousand US dollar)	0.0081 * (0.0044)	0.011 ** (0.0049)	0.0035 (0.0032)
North East	0.062 *** (0.020)	0.059 *** (0.020)	-0.025 (0.022)
South	-0.021 (0.032)	-0.012 (0.027)	-0.032 * (0.018)
West	0.0065 (0.039)	0.013 (0.034)	-0.024 (0.016)
Constant	0.26 (0.31)	-0.023 (0.30)	0.40 ** (0.14)
Adjusted <i>R</i> -squared	0.36	0.37	0.69

Notes: Robust standard errors in parentheses. \*\*\* Significant at 1%; \*\* significant at 5%; \* significant at 10%. Observations are clustered by U.S. state.

Table 5  
The causal effect of land scarcity on the restrictiveness of land use regulations  
Method: OLS and TSLS (2<sup>nd</sup> Stage)

	(1) OLS	(2) TSLS	(3) TSLS
PANEL A (N=95)			
Dependent variable: WRLURI, 2005			
Share developed, 1992	1.7 *** (0.53)	<b>2.7 ***</b> <b>(0.93)</b>	<b>2.9 ***</b> <b>(0.94)</b>
Homeownership rate, 1990	0.97 (1.0)	1.8 (1.1)	<b>3.60 *</b> <b>(2.1)</b>
Population density in developed area, 1990	-23.6 (114.7)	-22.2 (109.9)	59.6 (152.3)
Share democratic votes in state, average 1988 and 1992	0.045 ** (0.020)	0.052 ** (0.021)	0.052 ** (0.021)
Household wage, 1990 (in thousand US dollar)	0.018 (0.014)	0.016 (0.014)	0.017 (0.016)
Region dummies and constant	Yes	Yes	Yes
Adjusted R-squared	0.44		
Kleibergen-Paap rk Wald F statistic:		14.7	8.7
PANEL B (N=82)			
Dependent variable: SAKS, late 1970s and 1980s			
Share developed, 1976	1.2 (0.84)	<b>7.0 ***</b> <b>(2.2)</b>	<b>6.2 ***</b> <b>(1.4)</b>
Homeownership rate, 1980	-3.8 * (2.1)	-2.1 (2.5)	<b>-5.1</b> <b>(4.0)</b>
Population density in developed area, 1980	-165.9 (124.8)	-395.4 (263.2)	-539.8 (355.4)
Share democratic votes in state, average 1972 and 1976	0.013 (0.037)	0.052 * (0.030)	0.040 (0.028)
Household wage, 1980 (in thousand US dollar)	-0.0026 (0.044)	-0.038 (0.040)	-0.040 (0.035)
Region dummies and constant	Yes	Yes	Yes
Adjusted R-squared	0.31		
Kleibergen-Paap rk Wald F statistic:		8.8	5.4
Critical Values (for Panels A and B):			
10% maximal IV size		16.4	7.0
15% maximal IV size		9.0	4.6
20% maximal IV size		6.7	4.0

*Notes:* **Bold** coefficients are estimated under the assumption that the explanatory variable is endogenously determined. Excluded instruments are: “major border with coast” (column 2) and additionally “share married couples without children” (column 3). Numbers in parentheses are robust standard errors. \*\*\* Significant at 1%; \*\* significant at 5%; \* significance at 10%. Observations are clustered by U.S. state.

Table 6  
Explaining the growth rate of housing supply (N=82)  
Dependent variable: Percent change in housing units, 1990-2000

	(1)	(2)
Based on estimated regulatory index from:	Table 5, Column (2)	Table 5, Column (3)
<b>Predicted Saks-Index of Housing Supply Regulation</b>	-0.029 *** (0.0058)	-0.029 *** (0.0057)
Percent change, housing units, 1980-1990	0.37 *** (0.051)	0.37 *** (0.050)
Housing units, 1990 (in million units)	0.0016 (0.0089)	0.00079 (0.010)
Constant	0.057 *** (0.012)	0.057 *** (0.012)
Adjusted R-squared	0.47	0.47

*Notes:* Standard errors are (robust) bootstrap standard errors, computed using the bootstrap procedure in order to account for the fact that the regulatory index variable is estimated (using the fitted values from columns (2) and (3) of Table 5. **Bold** variable is endogenous. We performed 1000 bootstrap replications for each of the two regressions. Bootstrapping only slightly increases the standard errors. Statistical significance levels are little changed. \*\*\* Significant at 1%; \*\*significant at 5%; \* significant at 10%. Results are qualitatively virtually unchanged if the 1990 population size is used as control variable instead of the number of housing units in 1990.

# Figures

Figure 1. Share developed, regulation and homeownership rate.

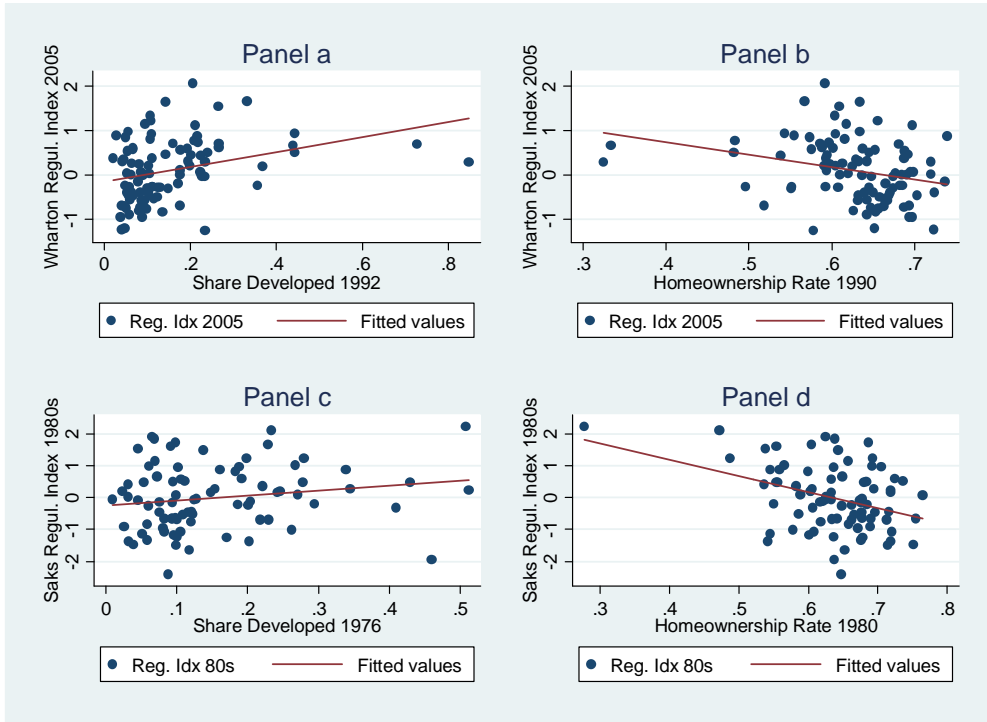
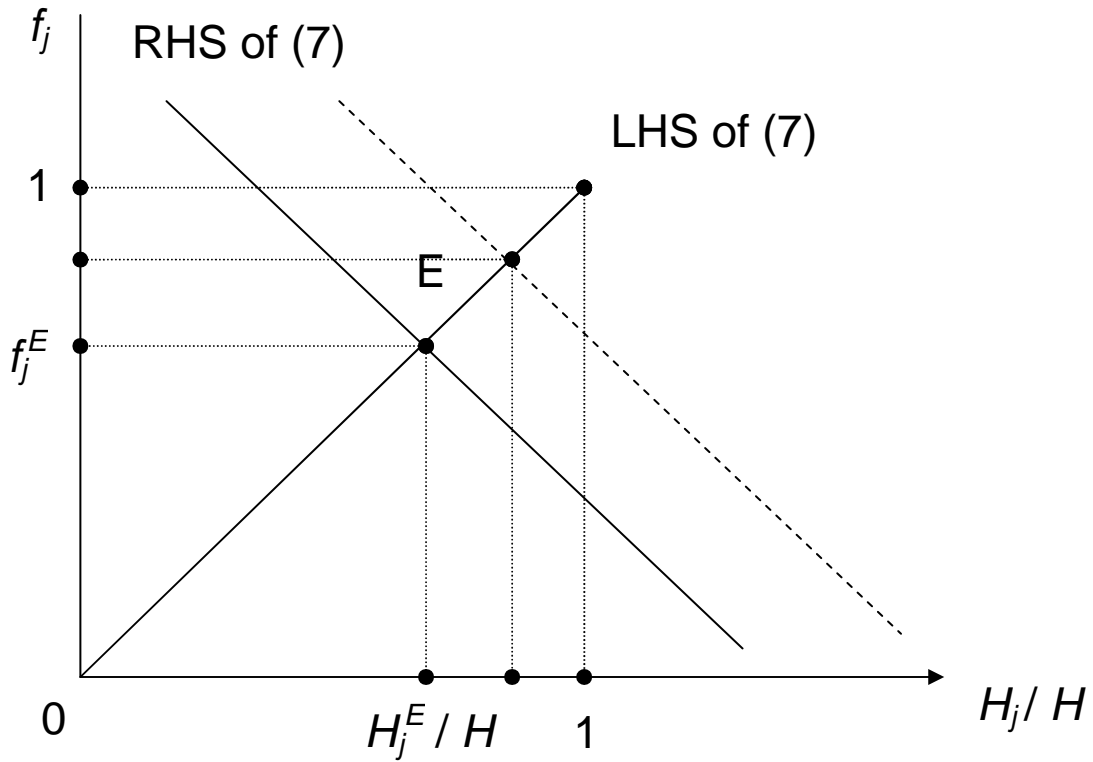


Figure 2. Location equilibrium.



## Appendix A. Proofs of Propositions

*Proof of Proposition 1 .* By inspection, the RHS of (7) is decreasing in  $H_j$  and it belongs to the unit interval for any  $H_j \in [0, H]$  (with complementary slackness), so there always exists a city  $j$  such that a positive mass of households desires to live in  $j$ . Conversely, the LHS of (7) is linearly increasing in  $H_j$  and it spans over the unit interval, all  $H_j \in [0, H]$ . It follows that there exists at least one  $j \in \mathfrak{S}$  such that the LHS and the RHS intersect exactly once in the interior of the unit interval; in general, the LHS and the RHS intersect at most once for any  $k \in \mathfrak{S}$ . *QED.*

*Proof of Proposition 2 and Corollaries 2.1 and 2.2.* The proofs of Proposition 2 and Corollary 2.1 follow by inspection of (13) and (14). We now lay out the algorithm that we use to derive these expressions, which is also helpful to build the intuition for these results. It is convenient to start with (iii). Using (11),  $R_j$  is increasing at  $t_j^0 = 0$  by (12) and  $R_j(\cdot)$  is concave by (15). Also,  $H_j^0 \in (0, H)$  by (16). Thus  $t_j^0 > 0$ . Then (i) immediately follows from (11), since the terms in the square brackets are both strictly positive. (ii) Using (8) to substitute for  $H_j^0$  in (11), isolating  $t_j^0$  and  $\omega_j$ , repeating these operations for variables pertaining to city  $k$  and taking differences yields

$$t_j^0 - t_k^0 = Z(\omega_j - \omega_k) \quad (21)$$

To get (iv), note that (21) is equivalent to  $[(\omega_j - t_j^0) - (\omega_k - t_k^0)]/(\omega_j - \omega_k) = 1 - Z$ , which belongs to  $(0, 1)$ . Then (v) follows from (21) and (9). Next, substitute (14) into (11) in order to obtain (13). From (13), it follows that  $\bar{t}^0 = (\sigma J + \tau \bar{H}) / (J - 1)$ , which is increasing in  $H$  and  $\bar{H}$  by inspection. This establishes (vi). It also follows from (13) that the variance of  $t_j^0$  is equal to

$$\text{Var}(t_j^0) = \left[ \frac{\sigma J + \tau \bar{H}}{\sigma + \tau \bar{H}} \frac{1}{\sigma(J-1) + J(\sigma + \tau \bar{H})} \right]^2 \text{Var}(\omega_j)$$

Then (vii) follows by inspection. *QED.*

*Proof of Proposition 3.* Since the (necessary) second order condition (15) holds for any vector of taxes  $\mathbf{t}$ , it is also sufficient to ensure that  $\mathbf{t}^0$  in (13) characterizes the unique SPE of the game and that this equilibrium exists. *QED.*

## Appendix B. Multinomial logit discrete choice model

In this appendix we replace the multinomial uniform discrete choice model of section 3 by the multinomial logit (MNL) discrete choice model. *The aim is to show that the theoretical predictions of Proposition 2 also hold in this case.*

We replace (2) by

$$u_j(h) = \ln V_j + \varepsilon_j(h)$$

and assume that the  $\varepsilon_j$ 's are iid distributed according to the double exponential distribution with dispersion parameter  $\sigma$ . As a result, we replace (3) by

$$f_j = \frac{\exp(\ln V_j / \sigma)}{\sum_{k \in \mathfrak{S}} \exp(\ln V_k / \sigma)} \quad (22)$$

Simplifying (22) yields

$$f_j = \frac{V_j^{1/\sigma}}{\sum_{k \in \mathfrak{S}} V_k^{1/\sigma}}$$

The determinants of  $V_j$  are the same as in the model of section 3. The equilibrium condition (7) can now be rewritten as

$$\forall j \in \mathfrak{S}_+: \quad f_j = \frac{H_j}{H} \Rightarrow \frac{H_j}{H} = \frac{(\omega_j - t_j - \tau H_j)^{1/\sigma}}{\sum_{k \in \mathfrak{S}_+} (\omega_k - t_k - \tau H_k)^{1/\sigma}} \quad (23)$$

That is, the fraction of people living in  $j$  is increasing in the well-being net of the regulatory tax of  $j$  and decreasing in the well-being net of regulatory tax of cities  $k \neq j$ . It follows from (23) that the most desirable locations have a larger than average population. To see this, substitute the variables pertaining to location  $j$  in (23) by the corresponding averages and take the ratio of the two to get:

$$\frac{H_j}{\bar{H}} = \frac{(\omega_j - t_j - \tau H_j)^{1/\sigma}}{(\bar{\omega} - \bar{t} - \tau \bar{H})^{1/\sigma}}$$

which implies (i)  $\omega_j - t_j = \bar{\omega} - \bar{t} \Leftrightarrow H_j = \bar{H}$  and (ii) given  $\bar{H}$ ,  $dH_j/d(\omega_j - t_j) > 0$ . Together, these in turn imply  $H_j > \bar{H} \Leftrightarrow \omega_j - t_j > \bar{\omega} - \bar{t}$ , as was to be shown.

*The location equilibrium exists and is unique;* the method of proof is equivalent to the one of Proposition 1 in the main text.

In order to obtain closed form solutions for both  $H_j$  and  $V_j$ , let us next normalize the variance of  $\varepsilon_j$  so that  $\sigma=1$ . In this case, solving (23) for  $H_j$  and plugging the outcome into (6) yields:

$$\frac{H_j}{\bar{H}} = \frac{\omega_j - t_j}{\bar{\omega} - \bar{t}}, \quad V_j = (\omega_j - t_j) \left[ 1 - \frac{\tau \bar{H}}{\bar{\omega} - \bar{t}} \right] \quad (24)$$

Planning boards maximize (10) non-cooperatively, anticipating (24). The first order conditions that solve this program and replace (11) can be written implicitly as ( $\forall j \in \mathfrak{S}$ ):

$$\frac{t_j^0}{V_j^0} = \max \left\{ 0, \frac{\bar{\omega} - \bar{t}^0}{(\bar{\omega} - \bar{t}^0) - (\omega_j - t_j^0)/J} - \frac{\tau \bar{H}}{\bar{\omega} - \bar{t}^0 - \tau \bar{H}} \right\}$$

where  $V_j^0$  is the level of welfare (24) evaluated at the subgame perfect equilibrium (SPE).

Finally, replacing assumption (16) by  $\tau \bar{H} < \bar{\omega}/2$ , one can show that the set  $\mathfrak{S}_0 \equiv \{j : t_j^0 > 0\}$  is not empty and, using the same method of proof as for Proposition 2 in the main text, one can show that *the properties of the SPE are qualitatively identical in the MNL model to the ones of the multinomial uniform model*, as was to be shown.

## Appendix C. Robustness checks and quantitative effects

Table A1  
Robustness check: Specifications with endogenous population density (N=93)

	1 <sup>st</sup> Stage			2 <sup>nd</sup> Stage		
	(1)	(2)	(3)	(4) TSLS	(5) JIVE	(6) LIML
	% Developed, 1992	Homeowner- ship rate, 1990	Pop. density in developed area, 1990	WRLURI, 2005	WRLURI, 2005	WRLURI, 2005
<b>Share developed, 1992</b>				2.0 ** (0.90)	2.5 ** (1.1)	2.0 ** (0.95)
<b>Homeownership rate, 1990</b>				3.9 (2.7)	3.0 (5.5)	4.3 (3.0)
<b>Population density in developed area, 1990</b>				150.7 (314.9)	-179.9 (650.3)	-192.7 (374.0)
Metro area has major border with coast	0.087 *** (0.026)	-0.028 (0.017)	0.00027 (0.00024)			
% Households with married couples, no children, 1990	-0.25 (0.33)	1.4 *** (0.27)	-0.005 (0.004)			
Population density in MSA ( $\times 10^{-3}$ ), 1880 <sup>†</sup>	0.13 *** (0.010)	-0.051 *** (0.0062)	0.00066 *** (0.00017)			
Share of land classified as “plains – flat plains”	0.13 ** (0.055)	-0.012 (0.019)	-0.00051 *** (0.00020)			
Share democratic votes in state, av. 1988 and 1992	-0.0045 ** (0.0021)	-0.00059 (0.0014)	0.000040 *** (0.000013)	0.042 * (0.025)	0.056 * (0.031)	0.041 * (0.026)
Household wage, 1990 (in thousand US dollar)	0.0035 ** (0.0015)	-0.00075 (0.0010)	0.000020 * (0.000012)	0.019 (0.017)	0.0027 * (0.0015)	0.019 (0.017)
Region dummies and constant	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.60	0.68	0.58			
Weak identification test (Kleibergen-Paap rk Wald F-statistic):				3.46		3.55
Stock-Yogo weak ID test critical values:				NA <sup>††</sup>		NA <sup>††</sup>

*Notes:* **Bold** variables are endogenous. Robust standard errors in parentheses. \*\*\* Significant at 1%; \*\* significant at 5%; \* significant at 10%. The Hansen J-statistic (an overidentification test of all instruments) cannot reject the hypothesis that the instruments are valid. <sup>†</sup> Based on historical MSA boundary definitions. <sup>††</sup> Stock and Yogo (2005) did not compute critical values for three endogenous explanatory variables and four excluded instruments. Observations are clustered by U.S. state.

Table A2  
Robustness check: 1<sup>st</sup> Stage using alternative measures of share developed land  
Dependent variable: Alternative measures of share developed land (1992)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Proxies for share developed:	Standard but based on 1976	Only residential, 1992	20 km radius, 1992	20 km radius, residential, 1992	Excluding parkland, 1992	Excluding parkland, residential, 1992	Average place in MSA, 1992	Av. place in MSA, residential, 1992	Median place in MSA, 1992	Med. place in MSA, residential, 1992
PANEL A (N=95): Population density in developed area (1990) is assumed to be <i>exogenously</i> determined										
Metro area has major border with coast	0.14 *** (0.034)	0.15 *** (0.043)	0.21 *** (0.068)	0.21 *** (0.071)	0.17 *** (0.056)	0.16 *** (0.056)	0.17 ** (0.066)	0.18 ** (0.070)	0.19 *** (0.070)	0.20 ** (0.074)
% Households with married couples, no children, 1990	-1.3 *** (0.42)	-0.33 (0.36)	-1.5 * (0.78)	-1.2 * (0.73)	-0.45 * (0.26)	-0.27 (0.24)	0.61 (0.72)	0.75 (0.75)	0.92 (0.76)	1.1 (0.76)
Population density in developed area, 1990	42.3 (34.4)	24.4 (27.1)	-26.4 (49.61)	-22.4 (50.4)	-12.3 (27.4)	-9.2 (26.7)	18.9 (34.2)	25.6 (35.5)	20.1 (36.5)	29.0 (37.2)
Controls and constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.38	0.41	0.22	0.22	0.32	0.30	0.26	0.27	0.26	0.28
PANEL B (N=93): Population density in developed area (1990) is assumed to be <i>endogenously</i> determined										
Metro area has major border with coast	0.088 *** (0.024)	0.076 *** (0.024)	0.084 (0.056)	0.073 (0.054)	0.093 *** (0.030)	0.082 *** (0.028)	0.073 * (0.040)	0.070 * (0.038)	0.088 * (0.044)	0.085 * (0.043)
% Households with married couples, no children, 1990	-0.98 *** (0.30)	-0.12 (0.31)	-0.95 * (0.53)	-0.69 (0.50)	-0.22 (0.41)	-0.084 (0.41)	0.71 (0.69)	0.82 (0.71)	0.99 (0.76)	1.1 (0.76)
Population density in MSA ( $\times 10^{-3}$ ), 1880 <sup>†</sup>	0.14 *** (0.0097)	0.12 *** (0.0090)	0.13 *** (0.022)	0.014 *** (0.021)	0.069 *** (0.014)	0.066 *** (0.013)	0.12 *** (0.015)	0.13 *** (0.015)	0.11 *** (0.018)	0.13 *** (0.018)
Share of land classified as "plains – flat plains"	0.048 (0.043)	0.13 ** (0.051)	0.24 ** (0.10)	0.25 ** (0.10)	0.16 ** (0.071)	0.16 ** (0.070)	0.20 * (0.10)	0.23 ** (0.10)	0.21 * (0.11)	0.24 ** (0.11)
Controls and constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.51	0.60	0.34	0.37	0.43	0.41	0.40	0.44	0.38	0.42

Notes: Robust standard errors in parentheses. \* Significant at 1%; \*\* significant at 5%; \* significant at 10%. † Based on historical MSA boundary definitions. Observations are clustered by U.S. state.

Table A3  
Robustness check: 2<sup>nd</sup> Stage using alternative measures of share developed land

Dependent variable: Wharton Regulatory Index (2005)										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
<i>Specification (proxy for share developed):</i>	<i>Standard but based on 1976</i>	<i>Only residential, 1992</i>	<i>20 km radius, 1992</i>	<i>20 km radius, residential, 1992</i>	<i>Excluding parkland, 1992</i>	<i>Excluding parkland, residential, 1992</i>	<i>Average place in MSA, 1992</i>	<i>Av. place in MSA, residential, 1992</i>	<i>Median place in MSA, 1992</i>	<i>Med. place in MSA, residential, 1992</i>
PANEL A (N=95): Population density in developed area (1990) is assumed to be <i>exogenously</i> determined										
<b>Share developed land (alternative measures)</b>	4.3 ** (1.7)	3.2 *** (1.0)	2.6 *** (0.99)	2.5 *** (0.96)	2.8 *** (0.89)	2.9 *** (0.95)	2.4 *** (0.79)	2.2 *** (0.76)	2.0 *** (0.66)	1.9 *** (0.63)
<b>Homeownership rate, 1990</b>	6.5 ** (3.1)	3.3 (2.1)	5.4 ** (2.3)	4.8 ** (2.3)	3.4 (2.2)	3.1 (2.2)	1.5 (2.0)	1.29 (1.96)	1.1 (2.0)	0.91 (2.0)
Population density in developed area, 1990	29.4 (198.7)	37.4 (150.9)	247.5 (156.4)	218.8 (158.3)	154.1 (148.2)	136.6 (147.1)	15.9 (154.6)	-2.2 (154.1)	9.3 (152.6)	-12.0 (154.0)
Controls and constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap Wald rk F-stat	4.6	8.1	5.2	5.2	5.5	4.8	7.0	7.0	7.5	7.6
Weak ID test critical values	10% max. IV size: 7.0; 15% max. IV size: 4.6; 20% max. IV size: 4.0; 25% max. IV size: 3.6									
PANEL B (N=93): Population density in developed area (1990) is assumed to be <i>endogenously</i> determined										
<b>Share developed land (alternative measures)</b>	3.2 ** (1.6)	2.1 ** (0.96)	1.6 ** (0.73)	1.5 ** (0.71)	2.2 ** (0.87)	2.2 ** (0.90)	1.5 ** (0.62)	1.3 ** (0.59)	1.4 ** (0.56)	1.2 ** (0.53)
<b>Homeownership rate, 1990</b>	4.9 (3.4)	3.7 (2.6)	5.3 * (2.9)	4.7 * (2.8)	4.6 (2.8)	4.3 (2.8)	3.0 (2.5)	3.0 (2.4)	2.8 (2.5)	2.7 (2.5)
<b>Population density in developed area, 1990</b>	-89.0 (410.5)	142.7 (311.8)	339.2 (305.0)	304.1 (302.1)	335.8 (290.3)	331.3 (287.7)	222.1 (295.6)	221.2 (293.9)	215.2 (295.8)	218.3 (295.4)
Controls and constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap Wald rk F-stat	2.3	3.5	3.7	3.6	3.8	3.8	3.6	3.6	3.6	3.6
Weak ID test critical values	Not available for specifications with >2 endogenous variables.									

*Notes:* Robust standard errors in parentheses. \*\*\* Significant at 1%; \*\* significant at 5%; \* significant at 1%. **Bold** variables are endogenous. Observations are clustered by U.S. state.

Table A4  
Robustness Check: Including population size as additional control

	1 <sup>st</sup> stage (OLS)		2 <sup>nd</sup> stage (TSLS)
	(1)	(2)	(3)
PANEL A (N=95)			
	% Developed, 1992	Homeownership rate, 1990	WRLURI, 1995
<b>Share developed, 1992</b>			3.0 *** (1.0)
<b>Homeownership rate, 1990</b>			3.5 (2.3)
Metro area has major border with coast	0.15 *** (0.048)	-0.037 *** (0.012)	
% Households with married couples, no children, 1990	-0.29 (0.45)	1.3 *** (0.24)	
Population density in developed area, 1990	12.0 (38.4)	-28.9 ** (10.8)	64.8 (155.6)
Share democratic votes in state, average 1988 and 1992	-0.0087 ** (0.0036)	0.0014 (0.0019)	0.053 ** (0.022)
Household wage, 1990 (in thousand US dollar)	-0.00092 (0.0023)	0.00054 (0.0012)	0.019 (0.014)
Population size ( $\times 10^6$ ), 1990	0.021 * (0.012)	-0.0022 (0.0045)	-0.022 (0.055)
Region dummies and constant	Yes	Yes	Yes
Adjusted R-squared	0.45	0.66	
PANEL B (N=82)			
	% Developed 1976	Homeownership rate 1980	SAKS, late 1970s and 1980s
<b>Share developed, 1976</b>			7.0 *** (1.7)
<b>Homeownership rate, 1980</b>			-5.3 (4.3)
Metro area has major border with coast	0.086 ** (0.035)	-0.051 *** (0.015)	
% Households with married couples, no children, 1980	0.46 (0.44)	1.1 *** (0.19)	
Population density in developed area, 1980	13.1 (20.9)	-36.3 *** (9.7)	-373.9 (333.4)
Share democratic votes in state, average 1972 and 1976	-0.0047 (0.0033)	-0.0010 (0.0017)	0.039 (0.027)
Household wage, 1980 (in thousand US dollar)	0.0056 (0.0054)	0.0044 (0.0029)	-0.021 (0.039)
Population size ( $\times 10^6$ ), 1980	0.035 ** (0.014)	-0.0054 (0.0039)	-0.17 (0.12)
Region dummies and constant	Yes	Yes	Yes
Adjusted R-squared	0.46	0.69	

*Notes:* **Bold** variables are endogenous. Robust standard errors in parentheses. \*\*\* Significant at 1%; \*\* significant at 5%; \* significant at 10%. Observations are clustered by U.S. state.

Table A5  
The causal effect of land scarcity on the restrictiveness of land use regulations  
with sample size restricted to that of Table A1  
Method: OLS and TSLS (2<sup>nd</sup> Stage)

	(1) OLS	(2) TSLS	(3) TSLS
PANEL A (N=93)			
Dependent variable: WRLURI, 2005			
Share developed, 1992	1.7 *** (0.54)	<b>2.7 ***</b> <b>(0.96)</b>	<b>2.9 ***</b> <b>(0.98)</b>
Homeownership rate, 1990	0.95 (1.0)	1.8 (1.1)	<b>3.6 *</b> <b>(2.1)</b>
Population density in developed area, 1990	-23.4 (114.9)	-22.9 (110.0)	60.3 (152.0)
Share democratic votes in state, average 1988 and 1992	0.044 ** (0.020)	0.051 ** (0.021)	0.051 ** (0.021)
Household wage, 1990 (in thousand US dollar)	0.018 (0.014)	0.016 (0.015)	0.017 (0.016)
Region dummies and constant	Yes	Yes	Yes
Adjusted R-squared	0.43		
Kleibergen-Paap rk Wald F statistic:		14.5	8.6
PANEL B (N=81)			
Dependent variable: SAKS, late 1970s and 1980s			
Share developed, 1976	1.1 (0.84)	<b>7.0 ***</b> <b>(2.3)</b>	<b>6.1 ***</b> <b>(1.4)</b>
Homeownership rate, 1980	-3.7 * (2.1)	-2.1 (2.5)	<b>-5.1</b> <b>(4.0)</b>
Population density in developed area, 1980	-144.4 (122.4)	-390.3 (267.5)	-533.2 (358.0)
Share democratic votes in state, average 1972 and 1976	0.0050 (0.038)	0.050 (0.031)	0.038 (0.030)
Household wage, 1980 (in thousand US dollar)	-0.00031 (0.043)	-0.038 (0.040)	-0.039 (0.035)
Region dummies and constant	Yes	Yes	Yes
Adjusted R-squared	0.22		
Kleibergen-Paap rk Wald F statistic:		9.4	5.7
Critical Values (for Panels A and B):			
10% maximal IV size		16.4	7.0
15% maximal IV size		9.0	4.6
20% maximal IV size		6.7	3.9

*Notes:* **Bold** coefficients are estimated under the assumption that the explanatory variable is endogenously determined. Excluded instruments are: “major border with coast” (column 2) and additionally “share married couples without children” (column 3). Numbers in parentheses are robust standard errors.

\*\*\* Significant at 1%; \*\* significant at 5%; \* significance at 10%. Observations are clustered by U.S. state.

Table A6  
The causal effect of land scarcity on the restrictiveness of land use regulations with  
sample size restricted to MSAs that have information on SAKS and WRLURI  
Method: OLS and TSLS (2<sup>nd</sup> Stage)

	(1) OLS	(2) TSLS	(3) TSLS
PANEL A (N=63)			
Dependent variable: WRLURI, 2005			
Share developed, 1992	1.8 *** (0.59)	<b>3.5 ***</b> (1.1)	<b>3.9 ***</b> (1.2)
Homeownership rate, 1990	1.0 (1.2)	2.1 * (1.2)	<b>4.5 **</b> (1.9)
Population density in developed area, 1990	49.6 (120.3)	82.7 (117.8)	194.3 (136.6)
Share democratic votes in state, average 1988 and 1992	0.025 (0.024)	0.037 (0.023)	0.040 * (0.024)
Household wage, 1990 (in thousand US dollar)	0.023 (0.018)	0.020 (0.018)	0.022 (0.021)
Region dummies and constant	Yes	Yes	Yes
Adjusted R-squared	0.40		
Kleibergen-Paap rk Wald F statistic:		12.6	7.4
PANEL B (N=63)			
Dependent variable: SAKS, late 1970s and 1980s			
Share developed, 1976	0.98 (1.3)	<b>10.2 **</b> (4.3)	<b>8.3 ***</b> (2.8)
Homeownership rate, 1980	-4.0 (2.4)	1.2 (3.4)	<b>-3.5</b> (5.1)
Population density in developed area, 1980	-36.2 (125.2)	-268.0 (337.5)	-453.8 (450.3)
Share democratic votes in state, average 1972 and 1976	-0.00088 (0.035)	0.066 * (0.034)	0.046 (0.029)
Household wage, 1980 (in thousand US dollar)	-0.035 (0.059)	0.045 (0.065)	0.010 (0.068)
Region dummies and constant	Yes	Yes	Yes
Adjusted R-squared	0.33		
Kleibergen-Paap rk Wald F statistic:		4.7	2.6
Critical Values (for Panels A and B):			
10% maximal IV size		16.4	7.0
15% maximal IV size		9.0	4.6
20% maximal IV size		6.7	3.9

*Notes:* **Bold** coefficients are estimated under the assumption that the explanatory variable is endogenously determined. Excluded instruments are: “major border with coast” (column 2) and additionally “share married couples without children” (column 3). Numbers in parentheses are robust standard errors.

\*\*\* Significant at 1%; \*\* significant at 5%; \* significance at 10%. Observations are clustered by U.S. state.

Table A7  
Quantitative effects

Effect of major access to coast line		
	Relative change in land scarcity (Change in percent)	Absolute change in land scarcity (Change in percentage points)
Table 4A.1/2	+100% ; + 113%	+15% ; +17%
Table 4.B.1/2	+65% ; +59%	+ 11% ; +10%
Effect of increase of land scarcity by one standard deviation (+13 percentage points) on regulatory restrictiveness		
	Change in regulatory index	Change in rank order
Table 5A.2	+0.35 (WRLURI)	48 → 33
Table 5A.3	+0.38 (WRLURI)	48 → 33
Table 5B.2	+0.91 (SAKS)	42 → 19
Table 5B.3	+0.81 (SAKS)	42 → 20
Effect of an increase in the homeownership rate by one standard deviation (+7.0 ; +7.4 percentage points) on the regulatory restrictiveness		
	Change in regulatory index	Change in rank order
Table 5A.2	(+0.13) <sup>†</sup>	(48 → 45) <sup>†</sup>
Table 5A.3	(+0.25) <sup>††</sup>	(48 → 39) <sup>††</sup>
Table 5B.2	(-0.16) <sup>†</sup>	(42 → 48) <sup>†</sup>
Table 5B.3	(-0.38) <sup>†</sup>	(42 → 51) <sup>†</sup>
Effect of increase in predicted regulatory index (SAKS) by one standard deviation (+1.0) on the growth rate of housing supply		
	Change in the growth rate of housing supply between 1990 and 2000 (Change in percentage points)	Change in rank order
Table 6.1	-2.9%	42 → 56
Table 6.2	-2.9%	42 → 56

Notes: The marginal effects are measured at the means of the independent variables. The marginal effect of having major access to a coast is measured for an MSA that does not have major access to a coast compared to one that has access. The change in rank order is calculated for the MSA with the median regulatory index and the median growth rate, respectively. <sup>†</sup> Effect is not statistically significant. <sup>††</sup> Effect is only marginally statistically significant.