Land-Use Restrictions: Implications for House Prices, Inequality, and Mobility*

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Abstract

I investigate the extent to which land-use restrictions, through their impact on house prices, act as a barrier to labor mobility. To do so, I develop a multi-region heterogeneous agents model of migration and housing, where land-use restrictions act as a friction affecting the productivity of land and the housing supply. Using the structure of the model, along with data on regional prices, output, and housing densities, I estimate a measure of implied restrictions across a panel of U.S. states. Consistent with the existing measure of restrictions, the model-implied measure suggests that restrictions are most stringent in regions with high incomes and house prices. Further, the measure shows that the states that were most restricted in the past have become even more restrictive over time. I calibrate the model to 2014 and show that the variation in regional productivities and land-use restrictions generate the income and house price gaps observed in the data. Performing a counterfactual exercise, I find that lowering the level of restrictions in California back to its level in 2000 results in a large reallocation of labor. The state's population rises by 45%, while the income gap and house value gap between California and the rest of the U.S. falls by 3.7% and 2.7%, respectively. I also study the importance of borrowing constraints and moving costs in hindering labor mobility and find that conditional on the observed income and house price gaps, neither plays a significant role.

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1 Introduction

The United States has experienced large and increasing income differentials between its regions. Traditionally the movement of labor, away from poorer regions and into more prosperous regions, has helped smooth out these differentials.[1] This is however no longer the case. As has been well documented in the literature, labor mobility has in fact declined significantly, with the rate of internal migration across the country falling steadily since the 1980's.[2] Numerous works, including Van Nieuwerburgh and Weill (2010) and Ganong and Shoag (2017), have highlighted the importance of housing costs in explaining these patterns. Higher house prices in high income regions can act as barrier to entry making it unaffordable for poorer households to move into prosperous regions with better opportunities. In this paper, I investigate the extent to which land-use restrictions are a potential source of the higher house prices and study the degree to which they limit the mobility of labor.

Land-use restrictions vary significantly across the U.S., both in their stringency and in their particular form. The restrictions can be thought of as arising from two broad causes. Firstly, natural limitations such as poor soil quality, a very steep gradient, or being located in an earthquake zone as is the case for parts of California, might make land unsuitable to hold large structures. Secondly, imposed land-use regulations, such as density requirements, floor area requirements, restrictions on the number of units allowed, and limitations on building permits, also limit the extent to which land can be developed. While the former is an innate feature of the land or surrounding geography, and hence cannot be changed, the latter is directly controlled by policy. Regardless, both broad groups of restrictions limit the productivity of land by limiting the amount of buildings and housing that can be put up. This consequently limits the supply of housing, which in turn raises the price of housing. However, since the impact of a given restriction varies so significantly, there does not exist a good measure of restrictions that is representative and comparable over time and space.

In order to get around this data limitation, I develop a multi-region model of migration where the level of land-use restrictions in a region directly affects the degree to which land

[1] Prominent papers documenting the adjustment of labor in response to regional differences include Blanchard and Katz (1992), and Barro and Martin (1991).

[2] Examples include Kaplan and Schulhofer-Wohl (2017) and Molloy, Smith, and Wozniak (2011).

can be used for construction and production. Combining the structure of the model with regional data on wages, house prices, available land, housing stock, and output, I estimate state-level panel measures of land-use restrictions and productivity. Comparing the model-implied measure of restrictions to the available measure of land-use regulations, detailed in Gyourko et al. (2008), I show that the level restrictions in a state is highly correlated to its level of regulation. This suggests that regulations may account for a significant share of the variation in restrictions across states.

Consistent with Hsieh and Moretti (2019) and Herkenhoff et al. (2018) who perform similar exercises, as well as other studies focusing on individual regions, I find that states with high levels of land-use restrictions also tend to have higher incomes, house prices, and productivities.[3] The states of California and Massachusetts which are known to have high restrictions are particularly striking examples of this relationship. The panel measure further suggests that most states have experienced a tightening of restrictions, and that in fact the states experiencing the largest increase in restrictions were those that were most restricted to begin with.

Since this project focuses on the impact of land-use restrictions on an agent's migration decision, through its impact on house prices, I model a rich household sector of the economy. Agents are heterogeneous in ability and wealth, make a dynamic migration choice as well as a continuous housing choice, and have access to a risk-less asset which they can use to borrow against their house. This marks a key departure from the existing literature, which has looked at migration decisions without all the ingredients in this model. Given the importance of housing in the agent's migration choice, it is essential to allow a housing choice. Excluding this feature would force agents to purchase equally sized houses when they move from a poorer region to a higher income region, thereby overestimating the prohibitiveness of housing costs. This is not a feature of the data as agents move into smaller units when they migrate into higher house price regions. Similarly, the ability to save in a risk-less asset and borrow against one's house is essential in modeling a realistic housing and migration choice, as we see agents using savings to cover moving costs as well as taking out mortgages

[3]Studies include: Glaeser and Gyourko (2018) and Whittemore (2012) which look at cities, and Levine (1999) which focuses on California.

when purchasing houses.

I Calibrate the model to two regions, California and the rest of the U.S., as at 2014, and find that the spatial variation in land-use restrictions and productivities generate the income and house value gaps observed in the data. The high productivity and severe land-use restrictions in California keep wages in the region high and push up house prices by restricting housing supply. The prohibitively high house prices prevent agents from moving into California despite the higher wage. Agents sort along two dimensions. The returns to the higher wage are increasing in an agent's ability, making California more attractive to higher skilled agents. Thus agents sort by ability. Furthermore, only high net worth agents are able to absorb the moving costs as well as the house price differential faced when moving, as they have to sell their less valuable house and purchase a considerably more expensive house in California. Consequently, the model also generates sorting by wealth.

In order quantify the impact of the current level of land-use restrictions, I perform a counterfactual exercise where I loosen the level of restrictions in California down to its level in 2000 keeping all else unchanged. I find that lowering restrictions has a significant impact on the agent's migration choice as the minimum ability and wealth thresholds required to move reduce significantly. Consequently, California's population increases by 45% as agents who previously found California's house prices prohibitively high now move in. The increase in California's housing supply and large reallocation of labor reduces the income and housing wealth gaps between the two regions by 3.7% and 2.7%, respectively. I show that agents in both regions enjoy an increase in welfare, with the largest gains being concentrated among those outside of California who were closest to the minimum ability and wealth thresholds required to move in.

Further, the lower restrictions also raise aggregate output via two channels. Firstly, the reallocation of labor shifts a larger share of the population to the more productive region, leading to an increase in efficiency. Secondly, lower restrictions effectively increase the supply of usable land, which is a factor of production for the consumption goods producing firm, thereby raising the firm's output. Overall, aggregate output rises by 0.65%.

Lastly, I exploit the heterogeneity and richness of the households in the model to study the importance of credit conditions and moving costs for labor mobility. I find that conditional on the observed income and house price gaps, looser credit constraints do not significantly increase an agent desire to move into the more productive region and consequently lead to only a small shift in the population distribution across regions. Further, while the moving cost does impact the migration rate in the steady-state of the model, it does not significantly affect the population share in each region.

The remainder of the paper is organized as follows. Section 2 discusses how this paper relates to the existing literature. Section 3 describes the model and highlights the features that allow me to separately identify land-use restrictions and productivities. Section 4 presents the model implied measures and provides some intuition regarding the patterns they depict. Section 5 studies the baseline model and presents the results from the counterfactual exercise of lowering land-use restrictions in California. Section 6 discusses extensions to the baseline model, alternate factors that may affect an agent's migration decision, and immediate next steps, while section 7 concludes.

2 Related Literature

This paper relates to several strands of the literature. I build on the canonical models of migration, namely Rosen (1979), Roback (1982), and more recently Kennan and Walker (2011), by considering the roles of housing, ability, and wealth, on an agent's migration decision. Recent works have begun to study migration in heterogeneous agents environments with income risk. Halket and Vasudev (2014) for example, study the interaction of migration and homeownership over the life-cycle. Bilal and Rossi-Hansberg (2018) develop an analytical model to highlight a channel by which agents can migrate to smooth-out income risk and transfer wealth intertemporally.

There is also a significant literature documenting the regional differences this paper takes as a key motivation. Berry and Glaeser (2005) highlight the divergence of human capital levels across cities, while Ganong and Shoag (2017) document the reversal of the migration patterns for low skilled agents who have begun migrating out of high-income regions. Complementary work by Eeckhout, Pinheiro, and Schmidheiny (2014) and Giannone (2019), emphasize the role of skill complementarities in generating spatial sorting, while Diamond

(2016) additionally highlights differences in amenities as a source of sorting.

As is this project, Van Nieuwerburgh and Weill (2010) are motivated by the income gap and disproportionately larger house price gap observed in the data. Their work highlights a complementary channel by which productivity differences drive regional price differentials. Given their interest in aggregate prices, the authors abstract from wealth and income risk, which are important features when quantitatively analyzing an agent's migration choice as in this paper.

This paper also contributes to an empirical strand of literature explicitly focusing on land-use restrictions and its implications for the supply and price of housing. Numerous works by Edward Glaeser, including Glaeser and Gyourko (2018), have brought land-use restrictions to the forefront of research considering regional differences. Gyourko, Saiz, and Summers (2008) construct a measure of land-use regulations, which are a key source of the observed differentials in land-use restrictions. Regional studies by Levine (1999) and Jackson (2016) focusing on California motivate my focus on the state, as well as the importance of considering the change in restrictions over time. Saiz (2010) develops a measure of housing supply elasticity and links the variation in the elasticities to variation in land-use regulations. Lastly, Turner, Haughwout, and van der Klaauw (2014) evaluates the impact of land-use regulations on land values and welfare. Taking the empirical findings presented in these works as motivation, this project studies the quantitative implications of land-use restrictions in a general equilibrium framework.

The three papers closest to this project take a similar approach. Parkhomenko (2018) develops a model in which restrictions are endogenously determined, and emphasizes why certain regions are more restricted than others. Since I study the impact of restrictions on labor mobility, I model exogenous restrictions but allow for income-risk and a continuous housing choice. This allows me to more closely match the patterns of sorting on ability and wealth observed in the data. My approach in backing out model implied measures of land-use restrictions and productivities is inspired by Herkenhoff, Ohanian, and Prescott (2018) and Hsieh and Moretti (2019) who perform similar exercises. Given their focus on spatial misallocation, both the aforementioned papers abstract from the household heterogeneity and income risk which are fundamental to the focus of this paper.

3 Model

The model consists of two distinct parts. First, I model a rich dynamic heterogeneous household sector, building on the standard Bewley (1977) framework, and expanding the economy to allow for multiple regions, migration, regional housing markets, and a continuous housing choice. This enables me to investigate the individual's migration choice as well as its interaction with the agent's ability draw, asset holdings, and housing choice.

Second, I model a static non-durable good producing sector and construction sector in each region. The functional form assumptions on the technology in these sectors allow me to separately identify regional productivities and land-use restrictions, as well as back them out as functions of observables, as will be discussed in section 3.5.

3.1 Environment

The economy consists of N regions and a continuum of measure one of infinitely lived ex-ante identical agents who can move across regions each period. Time is discrete and agents maximize their expected life-time utility over an aggregate consumption good $\tilde{C}_t$ and the amenity value associated with their region of residence. The aggregate good is made up of non-housing consumption c_t and the individual's housing stock h_t as follows,

$$\tilde{C}_t = {c_t}^{\chi}(h_t - \bar{h})^{1-\chi},$$

where χ is the share of non-housing consumption in utility. The agent has log utility over this aggregate good. Each agent has a stochastic endowment of efficiency units of labor, $\epsilon_t \in E$. The shocks are i.i.d across agents and follow a Markov process with transition probability $\pi(\epsilon', \epsilon) = P(\epsilon_{t+1} = \epsilon' | \epsilon_t = \epsilon)$. Agents pay a fixed cost to relocate between regions, and must own their house. Agents can also borrow or save in a one-period risk-less asset at an exogenously given interest rate r. The problem of an agent in a given region n is given by,

$$\bar{V}(a, h, n, \epsilon) = \max \; log(\tilde{C}) + z_n + \beta \mathbb{E}[\bar{V}(a', h', n', \epsilon')|\epsilon] \tag{1}$$

s.t.

$$c + a' + P_{n'}h' + \mathbb{1}[n' \neq n]\kappa = (1+r)a + w_n\epsilon + P_n h(1-\delta) \tag{2}$$

$$a' \geq -\theta P_{n'} h', \tag{3}$$

where a refers to the agent's asset holdings, h is the housing stock, z_n is the amenity value of living in region n, κ is the fixed cost of relocating, w_n is the wage rate per efficiency unit in region n, P_n is the price of housing in region n and δ is the depreciation rate of housing. The agent's budget constraint is given by (2), while (3) is the agent's borrowing constraint, with θ being the maximum loan-to-value ratio.

To simplify the agent's problem I assume that households can choose their housing stock in period t after the realization of their ability shock ϵ_t. The agent's financial position at the beginning of period t is then summarized by net worth

$$b = a + P_n h,$$

and the agent's state in period t is (b, n, ϵ). The agent's problem in recursive form is then given by,

$$V(b, n, \epsilon) = \max_{b', n', c, h} log(\tilde{C}) + z_n + \beta \mathbb{E}[V(b', n', \epsilon')|\epsilon] \tag{4}$$

s.t.

$$c + b' + \mathbb{1}[n' \neq n]\kappa + uP_n h = (1 + r)b + w_n \epsilon \tag{5}$$

$$P_n h \leq \frac{b}{1 - \theta}, \tag{6}$$

where $u = r - \delta$, is the user cost of housing, which is increasing in the interest rate and the rate of depreciation of housing. With this timing assumption, allowing agents to make their housing quantity choice after realizing their ability shock, housing is now chosen in a static manner along with consumption. The only dynamic choices are that of net worth b_{t+1} and next period's location n_{t+1}.

The housing choice is then simply characterized by,

$$h_t = \min\left[\left(\frac{1-\chi}{\chi}\right)\left(\frac{1}{u_t P_{t,n_t}}\right)c_t, \frac{b_t}{(1-\theta)P_{t-1,n_t}}\right], \tag{7}$$

where the second term is simply the housing choice of a constrained agent.

3.2 Production Sector

A representative competitive final good producing firm operates in each region and uses labor and structures to produce the trade-able consumption good using Cobb-Douglas technology as follows:

$$Y_n(L_{ny}, X_{ny}) = A_n L_{ny}^{\alpha} (\tau_{ny} X_{ny})^{1-\alpha},$$

where A_n is the regional productivity, L_{ny} is the firm's labor demand, and X_{ny} is the quantity of land used by the production firm. τ_{ny} captures the degree to which land-use restrictions inhibit production in region n and so can be thought of as the effective productivity of a unit of land in region n.

The production firm's problems is then given by,

$$\max_{L_{ny}, X_{ny}} A_n L_{ny}^{\alpha} (\tau_{ny} X_{ny})^{1-\alpha} - w_n L_{ny} - q_n X_{ny},$$

where q_n is the rental cost of a unit of land.

3.3 Construction Sector

Within each region there is a continuum of construction firms that combine labor and land to produce new housing units G_n using Cobb-Douglas technology as follows,

$$G_n(L_{nh}, X_{nh}) = L_{nh}^{\xi} (\tau_{nh} X_{nh})^{1-\xi},$$

where τ_{nh} captures the degree to which land-use restrictions inhibit construction in region n. The problem of the representative construction firm is then simply given by,

$$\max_{L_{nh}, X_{nh}} P_n L_{nh}^{\xi} (\tau_{nh} X_{nh})^{1-\xi} - w_n L_{nh} - q_n X_{nh}.$$

For simplicity, I assume that the fixed stock of land in each region, denoted X_n, is owned by a government that rents it out to the construction and production sectors at the competitive rental rate q_n, equal to the marginal product of land.

3.4 Equilibrium Definition

Let S denote the state space, λ be the distribution of agents over states, and λ_n be the distribution of agents in region n.

A stationary recursive competitive equilibrium consists of a value function $V(\epsilon, b, n)$, policy functions for the household $c(\epsilon, b, n), b'(\epsilon, b, n)$, $n'(\epsilon, b, n)$, $a(\epsilon, b, n)$, and $h(\epsilon, b, n)$, production firm choices $\{L_{ny}, X_{ny}\}_{n\in N}$, construction firm choices $\{L_{nh}, X_{nh}\}_{n\in N}$, prices $r, \{P_n\}_{n\in N}, \{q_n\}_{n\in N}, \{w_n\}_{n\in N}$, and a stationary measure λ, such that:

- given prices $r, \{P_n\}_{n\in N}$, and $\{w_n\}_{n\in N}$, the household policy functions solve the household's problem, and V is the associated value function;
- given $\{q_n\}_{n\in N}$, and $\{w_n\}_{n\in N}$, the production firm in each region chooses its inputs optimally, i.e.
  1. $w_n = \alpha A_n L_{ny}^{\alpha-1}(\tau_n X_{ny})^{1-\alpha}$;
  2. $q_n = (1-\alpha)A_n L_{ny}^{\alpha}\tau_n^{1-\alpha}X_{ny}^{-\alpha}$;
- given $\{P_n\}_{n\in N}$, $\{q_n\}_{n\in N}$ and $\{w_n\}_{n\in N}$, the construction sector chooses its inputs optimally, i.e.
  1. $w_n = \xi P_n L_{nh}^{\xi-1}(\tau_n X_{nh})^{1-\xi}$;
  2. $q_n = (1-\xi)P_n L_{nh}^{\xi}\tau_n^{1-\xi}X_{nh}^{-\xi}$;
- all available land in each region $n \in N$ is utilized, i.e.

$$X_{ny} + X_{nh} = X_n;$$

- the labor market in each region $n \in N$ clears:

$$L_n = \int_S \epsilon \, d\lambda_n;$$

- the housing market in each region $n \in N$ clears:

$$H_n^* = \int_S h(.) \, d\lambda_n;$$

- the law of motion for housing in each region $n \in N$ satisfies:

$$H_n' = H_n(1-\delta) + G_n,$$

  since we are considering a stationary equilibrium we have $H_n' = H_n = H_n^*$ and so $G_n = \delta H_n^*$, which states that the quantity of newly constructed structures is equal to the amount of depreciated strcutures from the previous period;
- the mass of agents migrating out of a region is equal to the mass of agents migrating into a region, so that the popuation in each region $n \in N$ is constant;

- the invariant probability distribution λ satisfies :

$$\lambda = \int_S Q((\epsilon, b, n), \mathcal{E} \times \mathcal{B} \times \mathcal{N}) d\lambda,$$

where $Q(.)$ is the transition function defined by,

$$Q((\epsilon, b, n), \mathcal{E} \times \mathcal{B} \times \mathcal{N}) = \mathbb{1}[b'(\epsilon, b, n) \in \mathcal{B}] \; \mathbb{1}[n'(\epsilon, b, n) \in \mathcal{N}] \sum_{\epsilon \in \mathcal{E}} \pi(\epsilon', \epsilon).$$

3.5 Identifying Land-Use Restrictions and Regional Productivity

The specification of the production and construction sectors allows me to separately identify land-use restrictions and regional productivities as functions of observables. This exercise closely follows Herkenhoff, Ohanian, and Prescott (2018). Since I expand on their framework by allow a housing choice, the identifying equations below include the housing stock in a region unlike the aforementioned paper. The identification relies on three key assumptions.

Firstly, as is standard in the literature, I assume Cobb-Douglas technology using labor and land in both sectors. Secondly, I require a mapping between the level restrictions in each sector. Since evidence from Gyourko, Saiz, and Summers (2008) suggests that residential land-use restrictions are strongly correlated with commercial land-use restrictions, I simply impose symmetric land-use restrictions so that $\tau_{nh} = \tau_{ny}$, henceforth τ_n. Lastly, I assume regions do not differ in the productivity of their construction sectors so that differences in TFP A_n only turn up in the goods producing sector.

Given this specification, the optimality conditions of the production sector and construction sector, coupled with the market clearing conditions, allow me to derive the following expressions for regional land-use restrictions (8) and regional productivity (9). A detailed description of the derivation is left to Appendix A.

$$\tau_n = \frac{1}{X_n(1-\xi)} \left[\frac{w_n}{\xi P_n}\right]^{\frac{\xi}{1-\xi}} \left[(1-\xi)\delta H_n + \frac{(1-\alpha)Y_n}{P_n}\right], \tag{8}$$

$$A_n = \frac{Y_n}{L_{ny}^{\alpha}(\tau_n X_{ny})^{1-\alpha}}. \tag{9}$$

Equation (8) pins down land-use restrictions as a function of a region's endowment of land X_n, wage rate w_n, house price P_n, housing stock H_n, and output Y_n, all of which are observable in the data. Similarly, L_{ny} and X_{ny} in equation(9) are simply functions of the same observables as well.

4 Model Implied Values

In this section, with the expressions for land-use restrictions and regional productivity in hand, I feed in state level data into equations 8 and 9 to back-out model-implied values across states and over time. Comparing the implied values to the existing measure of land-use restrictions, I confirm that τ matches the qualitative patterns already documented in the literature. Further, I study how land-use restrictions vary with regional incomes, house prices, and productivities, and also investigate how restrictions have evolved over time.

4.1 Data

I perform this exercise at the state level for two primary reasons. Firstly, the state is the smallest geographic unit for which representative data covering the whole U.S. is available for each of the necessary variables, going back before the year 2000. Secondly, the model and research question focuses on individuals who are forced to work and live in the same region. Consequently, I require the location of the agent's labor market to be equivalent that of her housing market, and this is not necessarily the case when considering smaller units such as cities, where an agent could work in the city but reside outside of it.

The data required come from many sources. I obtain urban land area at the state level from the US Department of Agriculture. The Census Bureau recognizes two types of urban areas, (i) Urbanized Areas (UA) of 50,000 or more people, and (ii) Urban Clusters (UC) of at least 2,500 and less than 50,000 people. While Urban land represents only a small share of the U.S. land mass, 3% in 2012, it accounts for over 80% of the total population. Due to a change in the definition and measurement of urban land, between 1997 and 2000, the values before and after this period are not directly comparable, and so my analysis will focus only on the years following 2000. Further, since the data is available only for selected years, I use linear interpolation to obtain the urban area for each state in the years of interest.

I obtain annual wage and house price data from the Census and the American Community

Survey using the Integrated Public Use Microdata Series, provided by Ruggles et al. (2019). In calculating the mean wage by state, I consider only those of working age (18-65), who were employed and worked more than 26 weeks in the year in question. I construct adjusted wages, controlling for differences in educational attainment and industry concentration across states, so that all of the cross-sectional variation in wages is coming from the state fixed effect. I leave a more detailed description of the computation of adjusted wages to appendix B. The median house price is constructed using only owner-occupied single-family housing units and I deflate both wages and house prices using a national deflater.

Housing stock data comes from the Census, which uses use the most recent decennial census to form the base for the annual housing unit estimates. Building permits, estimates of non-permitted construction, mobile home shipments, and estimates of housing loss, are the used to estimate the change in the housing stock. Lastly, I use the state level GDP from the Bureau of Economic Analysis (BEA) to compute state level output shares and deflate this measure using a national deflater with base year 2017 in order to obtain real output shares.

4.2 Comparison to Available Measure of Land-Use Regulations

Thus far, I have not referenced the source of the heterogeneity in land-use restrictions, which as detailed in section 1, could result from (i) physical limitations in a region's endowment of land, or (ii) imposed land-use regulations which inhibit the productivity of a unit of land. However, having derived the model-implied measure of land-use restrictions τ, I now compare it to a measure of imposed land-use regulations, in order to better understand the relative importance of imposed regulations in explaining regional differences in restrictions.

The best available and most comprehensive measure of land-use regulations in the literature is the Wharton Residential Land-Use Regulation Index (WRLURI), which is based on surveys sent to municipalities across the country. The survey asks local municipalities 15 questions regarding such items as the involvement of residents in local politics, density restrictions, local zoning approvals, approval delays, and exactions. I aggregate the WRLURI, which is available at the MSA level, up to the state. Figure 1 depicts this state level WRLURI against the model-implied measure of restrictions τ, for 2010. Note, a higher WRLURI

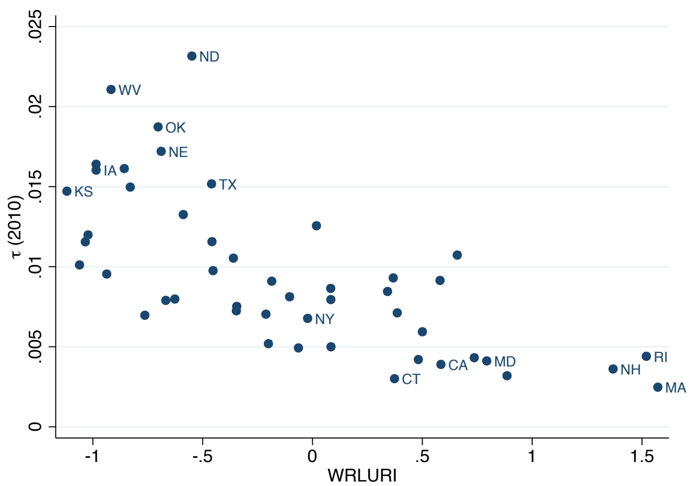


Figure 1: Model-implied restrictions vs. WRLURI

value indicates tighter regulations, while a lower value of τ represents higher restrictions.

Clearly, I observe a strong relationship between both measures, suggesting that regional differences in the severity of regulations may in fact be a significant source of the differentials in land-use restrictions. Ranking states by the severity of restrictions, as measured by τ, and the severity of regulations, as measured by WRLURI, we have a rank-rank correlation of 0.78. Given the inability to disentangle regulations from the physical limitations of land, I cannot directly quantify the extent to which regulations explain differences in restrictions. However, the strong correlation between land-use restrictions and regulations, which are directly controlled and hence changeable by policy, suggests that studying the implications of changing the level of restrictions is a worthy endeavor.

Notably, the states comprising the North East as well as California stand out as being the most restricted while the Central states are the least restricted. This is consistent with findings from numerous empirical studies such as Glaeser and Gyourko (2018), Whittemore (2012), and Levine (1999), which focus on cities, particularly those in California and the North East. Further, the model-implied measure τ, is also consistent with measures derived by Hsieh and Moretti (2019) and Herkenhoff et al. (2018), who perform a similar exercise.

4.3 Incomes, House Prices, and Productivities

Figure 2 plots land-use restrictions against state-level adjusted wage incomes and house prices, as at 2014. We see that the highest income states, which consist of California and those in North East, also have the highest levels of restrictions. Similarly, the states with the highest house values also seem to have the highest levels of restrictions. This pattern once again highlights the mechanism of interest in this paper, where differences in land-use restrictions exacerbate differences in house prices, and prevent the re-allocation of labor due to the proportionately higher costs of living in high income in regions.

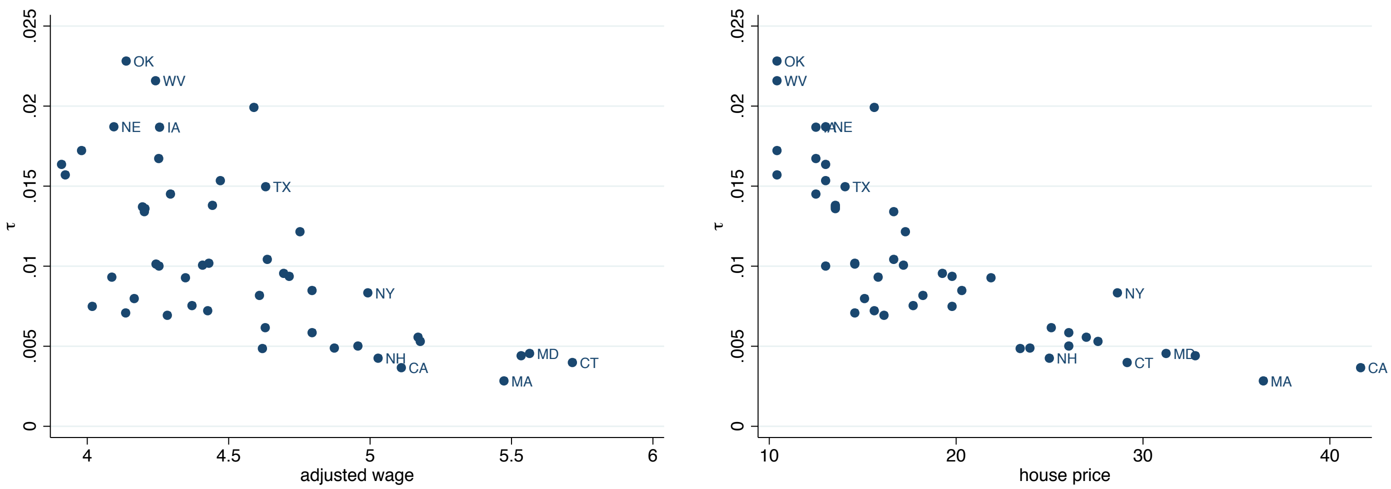


Figure 2: Land-use restrictions vs. wage income and house prices.

In addition to land-use restrictions, I also back-out a model-implied measure of regional productivity by feeding in data to equation 9. Figure 3 plots land-use restrictions vs. productivity for 2014. We see here an almost linear relationship where the most productive states, once again consisting of California and those in North East, also have the tightest restrictions.

While both, restrictions and productivity have implications for regional prices, housing density, and output, the ability to separately identify them relies on their specific effect on a given variable. To better understand this consider the following example. Suppose there are two identical regions. If region 1 were to experience a tightening of restrictions this would result in a fall in the housing supply in region 1, a subsequent increase in house prices, and

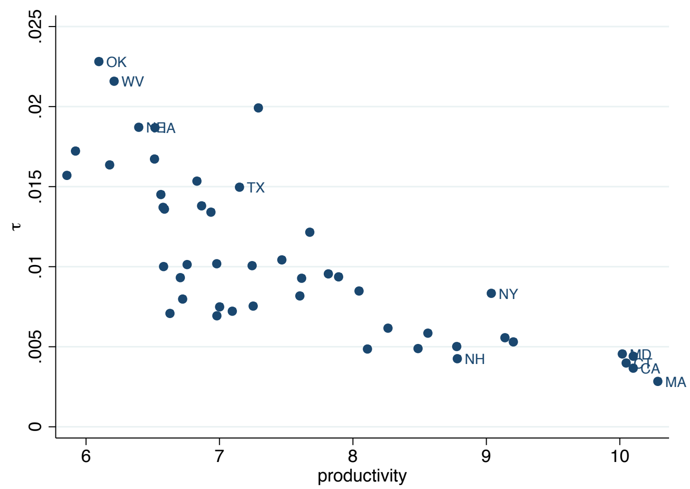


Figure 3: τ and productivity in 2014

so a shift of some of the population out of region 1 and into region 2, due to the increase in housing costs. This population shift will in turn put upward pressure on wages in region 1 and downward pressure on wages in region 2. Consequently, we finally have higher wages and house prices in region 1, along with a lower density of housing (since the housing stock has fallen while the amount of land remains unchanged).

Now consider what would happen if region 1 experienced an increase in productivity rather than a tightening of restrictions. Region 1 would enjoy an increase in wages, which increases the region's population share as people migrate to take advantage of the higher income. The higher population would increase the demand for housing which in turn would raise the house price in the region. Subsequently, as in the previous case, region 1 would have a higher wage and house price, however now region 1 would have an increase in housing density. Thus, the identification crucially depends on the cross-sectional variation in wages, house prices, and densities.

4.4 Land-Use Restrictions Over Time

The fact that the identifying equations express restrictions as a function of observable data also enables me to analyze how restrictions have evolved over time. Figure 4, plots the change in restrictions from 2000 to 2014, against their level in the year 2000. Firstly, we notice that

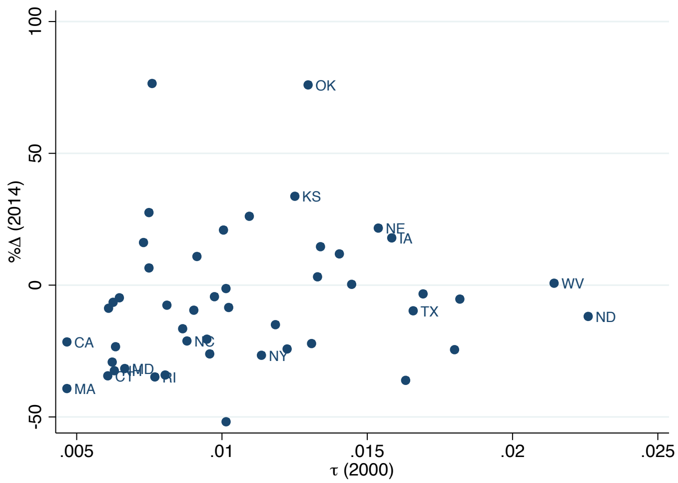


Figure 4: Change in restrictions over time

most states have experienced a tightening of restrictions as evidenced by the negative growth rate. Secondly, we see that the states experiencing the largest increase in restrictions (fall in τ), were those that were most regulated to begin with, namely California and those in the North East. To the extent that we believe that physical limitations of regional land endowments have not changed in this period, this decline in restrictions is indicative of an increase in imposed regulations in these regions. Consequently, when conducting the counterfactual exercise in the following section, I will lower the level of restrictions in the high income region to its own level in 2000. Thus, this counterfactual maps to a policy reforming land-use restrictions, rather than to removing innate limitations in a region's land, which is less feasible.

5 Quantitative Exercise

Having thus far exploited the firms' side of the model to obtain measures of land-use restrictions and productivity, I now analyze the full model focusing on the household decision and stationary distribution. Following a description of the calibration strategy, I study the baseline distribution of the model and the key mechanisms driving the results. Lastly, I perform the counterfactual exercise of lowering land-use restrictions in the high productivity region and investigate the implications of land-use restrictions.

5.1 Calibration

The model period is one year. Given the heterogeneity in the model, the number of regions is limited to 2 in order to preserve tractability. I set $N = \{0, 1\}$, where region 0 corresponds to California and region 1 corresponds to the rest of the United States. I focus on California for 2 reasons. Firstly, as observed in the previous section California epitomizes the 'good' regions of the U.S., having high incomes, house prices, and productivity, while also having very stringent land-use restrictions. Secondly, given the severity of the housing affordability crisis in California and the much publicized political debate around land-use restrictions in the state, the implications of loosening land-use restrictions in California are particularly relevant for policy.

The baseline model is calibrated to match the data as at 2014. The parameters of the model can be divided into two groups. The first consists of parameters that are assigned values established in the literature or given by data. The second consists of those that are calibrated in order to match the moments of the model with those in the data.

5.1.1 Assigned Parameters

The logarithm of the idiosyncratic ability process faced by agents follows an AR(1) process,

$$\log \epsilon_t = \rho \log \epsilon_{t-1} + e_t,$$

where $|\rho| < 1$ and $e_t \sim \mathcal{N}(0, \sigma_e^2)$. I approximate this process through a finite-state Markov process following Tauchen (1986). Table 1 below presents the list of assigned parameters along with their values.

Notably, the land share in the construction sector is chosen to be larger than the corresponding share in the production sector. The land share in the production sector is chosen based on findings from Davis and Heathcote (2007) who show that land accounted for 35-45% of the value of the aggregate housing stock between 1975 and 2006. The Cobb-Douglas utility function and preference weight on consumption is chosen to be consistent with papers such as Piazzesi et al. (2007) that show that the non-housing expenditure share does not vary significantly over time and lies approximately between 0.8 and 0.86 over their period of interest. The interest rate is a parameter since I do not close the asset market and abstract

Table 1: Assigned parameters

Parameters	Value	Description
Economy-wide parameters		
β	0.95	discount factor
α	0.9	labor share in production sector
ξ	0.6	labor share in construction sector
χ	0.84	preference weight on consumption
δ	0.02	depreciation rate
θ	0.8	maximum loan-to-value ratio
ρ	0.9	persistance of log ability process
r	0.02	exogenous interest rate
Regional parameters		
X_n	0.073 , 0.927	land share
τ_n	.0037 , .0099	land-use restrictions
A_n	10.1 , 7.57	regional productivity

from capital in the firm sectors. Consequently, agents can borrow and save at the exogenously given interest rate. The remainder of the economy-wide parameters are standard in the literature.

The regional measures of land-use restrictions and productivity come from identifying equations (8) and (9), while the regional endowment of urban land comes from USDA data as previously detailed in section 4.1.

5.1.2 Calibrated Parameters

The list of calibrated parameters and their targeted moments are summarized in table 2 below. The regional amenity value is chosen to match the population share of each region. The moving cost is chosen to match the migration rate in California. Note, since I am studying the steady-state of the model, the flow of agents into each region is equivalent to the outflow of agents from each region. However, given these two flows are not equivalent in the data, I compute the average between the in-migration rate and the out-migration in California and use this as the target moment. I focus only on migration to and from other states, excluding international migration. The subsistence level of housing in the utility function is chosen to match the ratio of the median home price to median income, while the variance of the logarithm of the ability process is chosen to match the ratio between the 75th and 25th percentiles of the income distribution.

Table 2: Calibrated parameters

Parameter	Value	Description	Target
z_n	0.39 , 0.1	amenity value	population share
κ	7.7	moving cost	migration rate
$\bar{h}$	0.48	subsistence level of housing	median $\frac{housevalue}{income}$
σ_e	0.22	s.d. of log ability process	inc p75/p25

5.2 Baseline Model

Calibrating California to have higher productivity, tighter land-use restrictions, and a higher amenity value, results in the following. The higher productivity in California contributes to a higher wage in the region. This higher wage coupled with the higher amenity value raises the demand for housing given the attractiveness of the region. However, the higher level of land-use restrictions reduces the capacity of the production sector and more importantly hinders the construction sector's ability to produce houses. Thus, the limited supply of housing leads to a significantly higher house price. The prohibitively high cost of housing keeps out individuals who would have otherwise moved to California, and this lower labor supply puts further upward pressure on the region's wages. This results in the equilibrium prices outlined in the table below.

Household Behavior. In order to clearly understand the behavior of the households in the model I simulate the sample path of a household for a given sequence of ability draws. The simulation is summarized in figure 5 below. The agent is stuck in region 1 at first, while she has low ability and net worth. Over time as she receives better ability draws she starts paying off her debt and increasing the quantity of housing she owns, thereby increasing her net worth. Contingent on sufficient net worth and a large enough ability draw, she uses her higher income and net worth to pay the moving cost, cover the higher housing cost, and move to region 0.

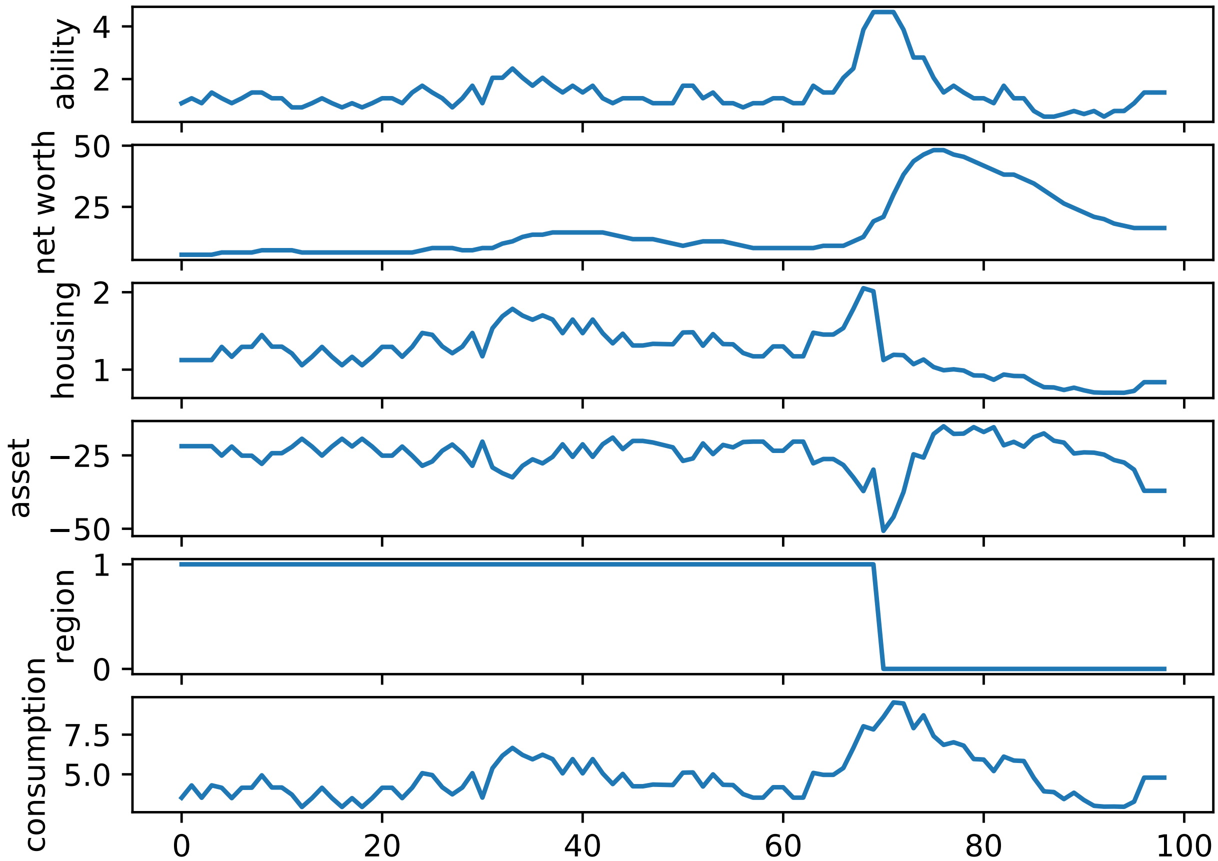


Figure 5: Household Simulation. First 2000 periods have been dropped.

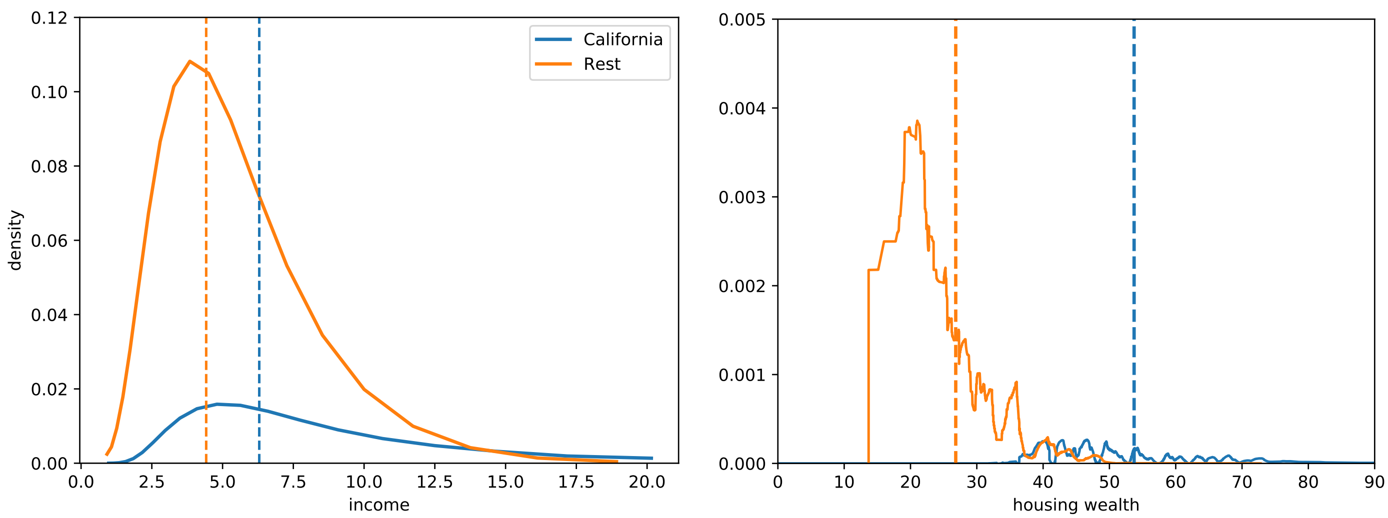
The equilibrium prices in each region, given in table 3, clearly illustrate the trade-off, between a higher wage and a higher house price, faced by the agent as she contemplates moving to region 0. When the agent moves, she sells her larger but less valuable house in region 1 and is forced to buy a much smaller house in region 0, given the significantly higher price of housing. In order to absorb this housing cost and the cost of moving, she borrows against her house. This is seen in the sharp drop in her asset position. The agent stays in region 0 while her draws are sufficiently high and takes on debt to smooth against low ability draws. Eventually, as she receives a sequence of low ability draws and runs down her net worth she will move back to region 1.

Table 3: Regional Prices

Price	Region 0	Region 1
w	4.43	4.16
P	63.78	24.32

As evident from this simulation there are two sources of sorting in this environment. Firstly, since an agent's income is given by the product of her ability and the regional wage, ϵw_n, the increase in income from moving from region 1 to 0 is higher for higher ability agents. Thus, agents sorts on ability. Secondly, since only high net worth agents are able to absorb the moving cost and afford the significantly higher house price in region 0, agents also sort on net worth.

Figure 6: Income and Housing Wealth Distribution



Notes: The dotted lines plot the mean income (left panel) and mean house value (right panel) in each region.

Stationary Distribution. Studying the stationary distribution of the economy, depicted in figure 6, the income and house value gaps between the two regions are clearly observable. The higher income in California comes from the fact that the region has both, a higher equilibrium wage and a population that is on average more skilled than those in the rest of the country. Consistent with the data, the model generates a proportionately larger house value gap. Note, the higher house values in California come purely from the higher per unit house price in the region, as in fact the average house in California is smaller than the average house in the rest of the country.

While I have not explicitly targeted the income and house value gaps between regions, the model generated gaps match the differentials observed in the data well. This is evident from table 4. Notably, the model captures the fact that the house value gap is significantly larger than the income gap. However, the model slightly underestimates the house value gap, while slightly overestimating the income gap.

Table 4: Untargeted Moments

	Data	Model
income gap	1.13	1.42
house value gap	2.19	2.00

5.3 Counterfactual Exercise

In order to analyze the quantitative implications of land-use restrictions, I now study the key counterfactual exercise of this paper. I lower the level of restrictions in California (raise τ_0) to its level in 2000, holding all else including the amenity values, productivities, and the level of restrictions in the rest of the U.S., at their 2014 levels. The values of τ are outlined in table 5, and this exercise represents a loosening of restrictions in California by 21%.

Table 5: Change in restrictions

	California	Rest
baseline τ	.0037	.0099
counterfactual τ	.0047	.0099

The lower level of restrictions in California has two direct effects. First, local wages rise since the marginal product of labor in increasing in τ. Second, the increased usability of land increases the housing stock in the region and reduces house prices. This results in a large movement of people into California from the rest of the country. As evidenced by table

6, the rest of the U.S. also enjoys a higher wage, due to a lower labor supply, and benefits from lower house prices, resulting from a decrease in the demand for housing.

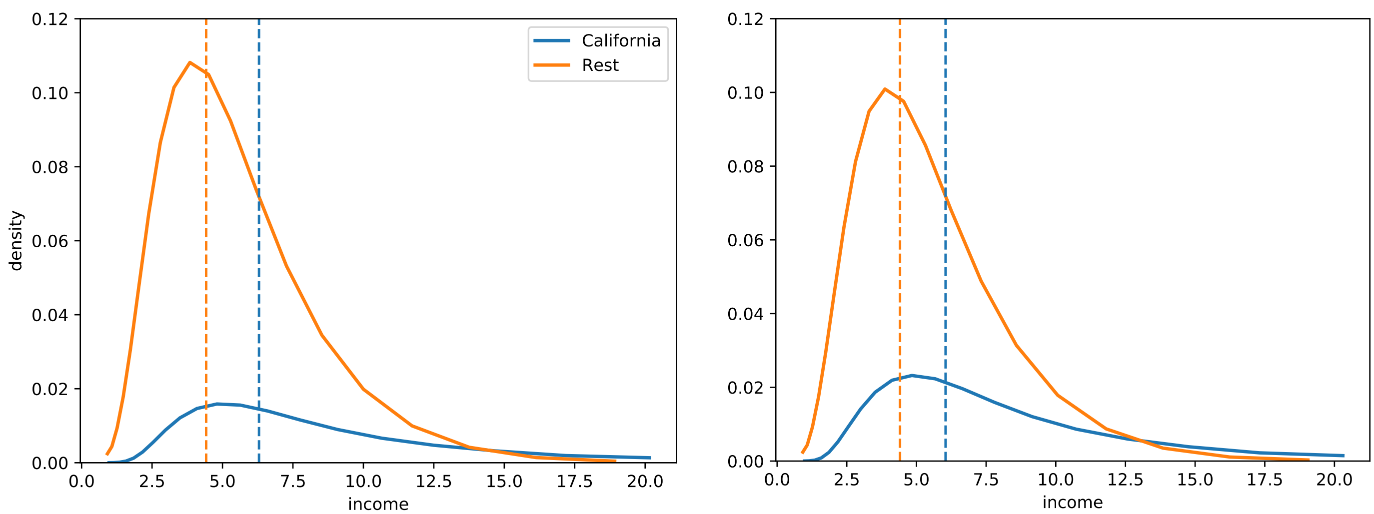
Table 6: Implications of lower restrictions

Variable	Baseline		Counterfactual	
	Cal	Rest	Cal	Rest
w	4.433	4.162	4.466	4.190
P	63.78	24.32	62.37	23.82
population share	12.9%	87.1%	18.9%	81.1%
regional output	1.154	3.940	1.367	3.770
aggregate output	5.094		5.127	

Figure 7: Income Distribution

(a) Baseline

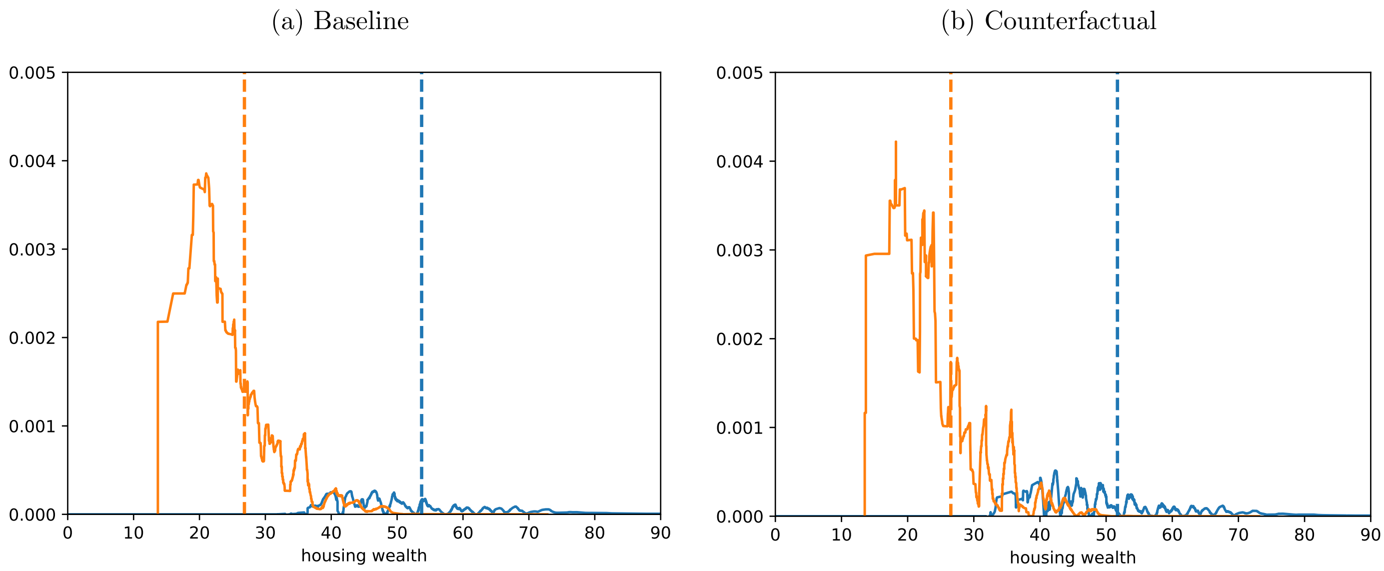
(b) Counterfactual



Notes: The dotted lines plot the mean income.

Figure 7 compares the income distribution in the counterfactual model to that in the baseline model. While the population change in each region is clearly evident, the skill composition of workers also changes. The new residents of California are on average less skilled than those previously in the region. This further lowers the average income in the region. As evidenced by table 7, the combination of converging regional wages and a lower skill composition in California, lead to a fall in the income gap between the regions by 3.69%, when compared to the baseline.

Figure 8: Housing Wealth Distribution



Notes: The dotted lines plot the mean housing wealth.

Figure 8 compares the housing wealth distributions in both cases. We see that the new entrants to California on average own significantly smaller houses than those previously in the region. Thus, the inflow of agents into California also reduces the mean level of housing wealth in the region and consequently, lowers the housing wealth gap between the regions.

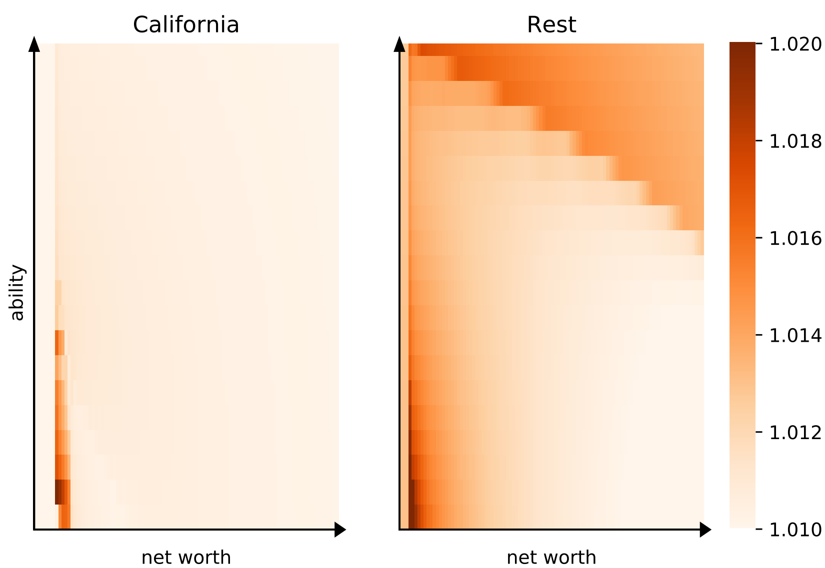
Table 7: Regional Gaps

	Baseline	Counterfactual	% change
population in Cal	12.9%	18.8%	$\uparrow$ 45.0%
income gap	1.42	1.37	$\downarrow$ 3.69%
housing wealth gap	2.00	1.95	$\downarrow$ 2.66%

As noted in table 6, the counterfactual economy also enjoys higher aggregate output. This comes about via two channels. The first comes through the reallocation of labor, as a larger share of the population now lives and works in the more productive region. The second comes from the fact that lowering restrictions effectively increases a factor of production, subsequently enabling the consumption goods producing firm to produce more from a given unit of land while also enjoy a lower rental cost of land.

In order to study the welfare implications of the lower land-use restrictions, I compute the consumption equivalent welfare gain between the baseline economy and the counterfactual economy. Figure 9 plots the welfare gain across the state space. First, we see that welfare is higher in the counterfactual economy at each point in the state space. Second, we notice that the region of the state space with the largest gain is the section made up of higher ability and higher net worth individuals in the rest of the U.S. This group of agents represents those outside of California who were closest to the minimum ability and net worth thresholds required to move in, in the baseline economy. As a result of the lower restrictions and the subsequently more affordable housing in California, these agents can now move in and enjoy an increase in their income in the counterfactual economy. The mean welfare gain for an agent is 1.4%.

Figure 9: Welfare Gain



Notes: the figure shows the permanent increase in consumption (lifetime) required by an agent in the baseline economy to be indifferent between the baseline economy and the counterfactual economy. For example, a value of 1.02 implies that an agent at a given point in the state space requires a 2% increase in consumption in each period in the baseline economy, to be as well off as she would be in the same state in the counterfactual economy.

5.4 Residential Land-Use vs. Commercial Land-Use

Thus far, I have considered a policy that lowers restrictions uniformly across all available land. While such a policy has significant implications, the type of land that is restricted is also an important consideration. A policy that lowers residential land-use restrictions can lead to vastly differing consequences in comparison to a policy that lowers restrictions on commercial land. To isolate these different effects, I perform two additional counterfactual exercises, which are described below.

(i) **Counterfactual 2:** I lower the level of residential land-use restrictions in California back to its level in 2000, keeping restrictions on commercial land at its 2014 level.

(ii) **Counterfactual 3:** I lower the level of commercial land-use restrictions in California back to its level in 2000, keeping restrictions on residential land at its 2014 level.

Residential land-use restrictions correspond to τ_{nh} in the construction firm's problem while commercial land-use restrictions correspond to τ_{ny} in the production firm's problem. Table 8 outlines the level of restrictions on each type of land in California, in each of the aforementioned counterfactual exercises as well in the baseline economy and initial counterfactual exercise described in section 5.3.

Table 8: Land-use restrictions on each type of land in California

	τ_h	τ_y
baseline	.0037	.0037
counterfactual 1	.0047	.0047
counterfactual 2	.0047	.0037
counterfactual 3	.0037	.0047

Notes: land-use restrictions across both types of land are kept constant at 0.0099 for the rest of U.S. in all cases. Smaller values of τ_h and τ_y represent more stringent land-use restrictions on residential land and commercial land respectively.

As evidenced by table 9, loosening land-use restrictions in California leads to a large flow of agents into the state, regardless of the type of restrictions that are lowered. However, the two policy alternatives considered have differing impacts on the wage and house price in California. When residential land-use restrictions are lowered, as in counterfactual 2,

Table 9: Implications of lower restrictions

Variable	Baseline		Counterfactual 1		Counterfactual 2		Counterfactual 3	
	Cal	Rest	Cal	Rest	Cal	Rest	Cal	Rest
w	4.433	4.162	4.466	4.190	4.407	4.207	4.543	4.194
P	63.78	24.32	62.37	23.82	59.16	23.55	65.04	23.77
population share	12.9%	87.1%	18.9%	81.1%	18.5%	81.5%	17.6%	82.4%
aggregate output	5.094		5.127		4.767		4.835	
income gap	1.42		1.37		1.34		1.43	
housing wealth gap	2.00		1.95		1.88		2.03	
mean welfare gain	-		1.48%		2.32%		1.65%	

Notes: the welfare gain represents the mean permanent increase in lifetime consumption required by agent in the baseline economy to be indifferent between the baseline economy and the relevant counterfactual economy.

increased construction raises the supply of housing and lowers house prices in California. The more affordable housing results in a large flow of agents into California, thereby raising labor supply and lowering the wage in the region. Consequently, we have lower wages and house prices relative to the baseline economy as well as a narrowing of both the income gap and housing wealth gap between the two regions.

This is not the case in the third counterfactual experiment. When commercial land-use restrictions are lowered, the production sector in California can produce more units of the consumption good on a given unit of land. This raises the marginal product of labor and puts upward pressure on wages. The higher regional wage attracts agents who previously lived outside of California, and the influx of new workers puts downward pressure on California's wage. However, unlike in counterfactual 2, the increase in demand for labor exceeds the increase in supply of labor leading to a higher overall wage. The increase in demand for housing coming for the new migrants to California results in a higher house price in the region as well. Subsequently, we now have a wider income gap and house price gap across the two regions.

The increase in the effective productivity of the goods producing sector also results in aggregate output being higher under a policy that lowers commercial land-use restrictions, relative to the policy that lowers residential land-use restrictions. Welfare gains however, are larger under a policy that lowers residential land-use restrictions.

6 Alternative Factors and Extensions

In addition to the main exercise described in the previous section, the heterogeneity and depth of the model allow me to also study the role of other factors that might affect labor mobility. In this section of the paper I evaluate these factors and discuss additional features yet to be incorporated into the model, but worth considering.

6.1 Borrowing Constraints

Given the large cost associated with purchasing a house, the ability to borrow against it is important for households considering migrating to a high house price region. In order to test whether borrowing constraints play an important role in preventing labor mobility, I solve my model for various levels of the maximum loan-to-value ratio θ, and study the counterfactual distributions. The results of an extreme case, where agents are allowed to borrow up to 99% of the value of their house are highlighted in the table below.

Table 10: Looser borrowing constraints

Variable	$\theta = 0.8$		$\theta = 0.99$	
	Cal	Rest	Cal	Rest
w	4.433	4.162	4.455	4.170
P	63.78	24.32	62.86	24.19
population share	12.9%	87.1%	14.9%	85.1%
income gap	1.42		1.43	
housing wealth gap	2.00		1.93	

I find that improved access to credit does lead to a shift of the population towards California. However, despite the large loosening of the borrowing constraint, the results of this exercise are quantitatively small when compared to the results following a loosening of land-use restrictions.

This is because conditional on the large house price differentials observed in the data, expanding the availability of credit does not significantly impact the agent's migration choice. The agents compare the benefit of the high wage in California to the high housing cost in the region. Although, they do not have to pay a significant down payment when moving to California and purchasing an expensive house, borrowing up to the value of their house would mean they have to role over their debt each period and pay interest, which closely maps to renting their house. This effective 'rental rate' is still significantly higher in California, consequently reducing the extent to which poorer agents in the rest of the country wish to move into California.

I do not explicitly allow households to rent a house in the baseline model. This seems extremely limiting given that it is significantly less costly to rent a house rather than put a down payment on a house when moving into a high income region. However, since removing the down payment requirement does not significantly change the agents' migration choice or aggregate prices, I can conclude that the option to rent does not change the main results of this paper. Hence, in order to preserve the tractability of the model I abstract from a rental choice.

6.2 Moving Costs

A large strand of the migration literature requires a massive fixed cost of moving in order to match the migration patterns and population shares observed in the data. In this model there is an additional implicit cost associated with moving to the high income region. Agents must sell their less valuable house and purchase a higher priced house in the high income region. Given the significant house price differential, this implicit cost of moving is large. Consequently, this model does not need a large fixed cost of moving in order to reconcile the data. In fact, solving the baseline model for various values of the moving cost, I find that while the moving cost does slightly impact the migration rate in the steady-state, it does not significantly affect the population share in each region.

6.3 Model Extensions

Agglomeration Economies. When conducting the counterfactual exercise of lowering restrictions, I keep regional productivities fixed at their baseline values. This assumes that productivity does not vary with the population mass in a region. However, a more recent strand of the urban literature has highlighted the role of agglomeration economies, whereby regional productivity is increasing in population mass. Allowing for this would in fact increase the impact of land-use restrictions, as lowering restrictions would raise a region's population share which now would also increase its productivity. Consequently, the impact of land-use restrictions as described in this model can be looked at as capturing a lower bound.

Congestion. One limitation of the model proposed is that it does not allow for the positive externalities that may arise from restricting land-use. In reducing a region's population and housing densities, tighter restrictions may in fact raise the amenity value associated with a region through its impact on congestion. Residents of a region could benefit through such channels as the preservation of unbuilt greenery or less crowded schools for their children. In order to capture these effects, I can expand the model to allow the amenity value of region to be a function of its population density. I am currently performing this exercise for various parameterizations and the results are forthcoming.

Transition Path. At present, the analysis in this paper is limited to a stationary setting and the implications of lowering restrictions are studied by comparing steady-states. Investigating the transition path between these steady-states could shed light on the time it takes to reach a new steady-state following a policy change as well as the welfare implications along the transition. Further, although credit constraints and fixed costs of moving play only a limited role in the stationary equilibrium, they may have significant implications for the transition path. Consequently, I believe this is a fruitful dimension in which to expand this paper and I hope to have an analysis of the transition path in a later version of this paper.

7 Conclusion

In this paper I study the interaction between land-use restrictions, house prices, and labor mobility. To do so, I develop a multi-region model of heterogeneous agents, migration, and housing, where land-use restrictions limit the productivity of land and restrict housing supply. Exploiting the structure of the model and observable data, I document that regions with stringent land-use restrictions tend to have higher incomes, house prices, and productivities, than those with lower restrictions. I also find that most states have experienced a tightening of restrictions over time and that the states experiencing the largest increase in restrictions were those that were most regulated to begin with.

Using this measure to calibrate the full model, I show that regional differences in land-use restrictions and productivities can explain the income and house price differentials observed in the data. I find that lowering land-use restrictions in the most restricted regions significantly changes the allocation of labor across states, with more people moving to high income areas with better opportunities. This movement of labor in turn leads to a fall the income and housing wealth gaps between regions. Studying the welfare implications of lowering land-use restrictions in California, I find that while welfare is increased at each point in the state space, the largest gains are concentrated amongst the higher ability and higher net worth individuals in the rest of the U.S.

These results are particularly insightful for policy given the housing affordability crisis currently being experienced in California. In fact, the state has already begun attempts to loosen restrictive land-use regulations and increase the density of housing. An example is Senate Bill 50, introduced in December 2018. This bill aims to "upzone" much of the state's land which is presently zoned for single-family housing, as well as increase the density of housing near transit hubs. Given the severity of the affordability crisis and the limited research focusing on land-use restrictions and regional differences in quantitative general equilibrium frameworks, I believe further research on this topic could lead to invaluable contributions.

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Appendices

A Derivation of identifying equations

The derivation of identifying equations (8) and (9) is as follows.

- From the production firm's first order conditions obtain $L_{ny} = \frac{\alpha Y_n}{w_n}$ and $X_{ny} = \frac{(1-\alpha)Y_n}{q_n}$.
- From the construction firm's first order conditions obtain $L_{nh} = \frac{\xi P_n h_n}{w_n}$ and $X_{nh} = \frac{(1-\xi)P_n h_n}{q_n}$.
- Using the Cobb-Douglas function for the construction technology $G_n = L_{nh}^{\xi}(\tau_n X_{nh})^{1-\xi}$, solve for τ_n to obtain,

$$\tau_n = \left[\frac{G_n}{(L_{nh})^{\xi}}\right]^{\frac{1}{1-\xi}} \frac{1}{X_{nh}}.$$

- Plugging in $X_{nh} = \frac{(1-\xi)P_n G_n}{q_n}$, obtain

$$\begin{aligned}\tau_n &= \left[\frac{G_n}{(L_{nh})^{\xi}}\right]^{\frac{1}{1-\xi}} \frac{q_n}{(1-\xi)P_n G_n}, \\ &= \frac{1}{1-\xi}\left[\frac{G_n}{L_{nh}}\right]^{\frac{\xi}{1-\xi}} \frac{q_n}{P_n}.\end{aligned}$$

- Adding the two expressions $X_{ny} = \frac{(1-\alpha)Y_n}{q_n}$ and $X_{nh} = \frac{(1-\xi)P_n G_n}{q_n}$, and solving for q_n, obtain $q_n = \frac{1}{X_n}[(1-\xi)P_n G_n + (1-\alpha)Y_n]$. Plugging this into the above expression for τ_n, obtain

$$\begin{aligned}\tau_n &= \frac{1}{X_n(1-\xi)}\left[\frac{G_n}{L_{nh}}\right]^{\frac{\xi}{1-\xi}} \frac{(1-\xi)P_n G_n + (1-\alpha)Y_n}{P_n}, \\ &= \frac{1}{X_n(1-\xi)}\left[\frac{G_n}{L_{nh}}\right]^{\frac{\xi}{1-\xi}} \left[(1-\xi)G_n + \frac{(1-\alpha)Y_n}{P_n}\right].\end{aligned}$$

- Substituting for L_{nh}, obtain

$$\tau_n = \frac{1}{X_n(1-\xi)}\left[\frac{w_n}{\xi P_n}\right]^{\frac{\xi}{1-\xi}} \left[(1-\xi)G_n + \frac{(1-\alpha)Y_n}{P_n}\right].$$

- Lastly, using the equilibrium condition that $G_n = \delta H_n$ we have equation (8),

$$\tau_n \;\; = \;\; \frac{1}{X_n(1-\xi)}\left[\frac{w_n}{\xi P_n}\right]^{\frac{\xi}{1-\xi}}\left[(1-\xi)\delta H_n + \frac{(1-\alpha)Y_n}{P_n}\right].$$

Consequently, we have τ_n as a function of X_n, w_n, P_n, H_n, and Y_n, all of which are observable. Using data on these variables, I can back out a time series of land-use restrictions for each region. With τ_n in hand, I invert the production technology to obtain the model implied productivity A_n in each region,

$$A_n = \frac{Y_n}{L_{ny}^{\alpha}(\tau_n X_{ny})^{1-\alpha}},$$

where L_{ny}, X_{ny}, τ_n are functions of the observables described above.

B Construction of adjusted wages

From the Census and ACS I obtain microdata on wages as well the individual's level of education, industry of employment, and state of residence. With this is hand, I run the following regression for each year,

$$\log(w_i) = \alpha + \beta_1' \; educ_i + \beta_2' \; ind_i + \gamma' \; state_i + \epsilon_i, \tag{10}$$

where $educ_i$ is a categorical variable for individual $i's$ educational attainment which can take three values depending on whether the individual,

i did not complete high school,

ii completed high school and some college, or

iii completed at least 4 years of college.

ind_i is a categorical variable for individual $i's$ industry of employment which can take seven values, and $state_i$ is a categorical variable for the individual's state of residence. Note, all coefficient's are statistically significant at the 1% level. I then use the coefficients to fix the educational attainment and industry composition in all states. That is, I compute

$$e\bar{d}uc = \sum_{j=1}^{3} \hat{\beta}_{1,j} \; educ\_share_j,$$

where j indexes the education bin, and $educ\_share_j$ is the share of the U.S. population that have the level of educational attainment associated with education bin j. Similarly, I compute

$$\bar{ind} = \sum_{j=1}^{7} \hat{\beta}_{2,j} \; ind\_share_j,$$

where j indexes the industry bin, and ind_share_j is the share of the U.S. population that are employed in the industry associated with industry bin j. I then compute the state level adjusted log wage as follows,

$$\hat{\log}(w_s) = \alpha + \bar{educ} + \bar{ind} + \gamma_s,$$

and finally take the exponential of $\log(w_s)$ to obtain the adjusted state level wage. Consequently, all of the cross-sectional variation in adjusted state wages are coming from the state fixed effect. I repeat this exercise for each year to obtain a panel of adjusted state wages.

C Model implied measures

C.1 Full list of model implied measures

The table below presents the full list of model implied land-use restrictions and regional productivities for the panel of U.S. states. The last column for each measure describes the percentage change in the measure from 2000 to 2014. Note, τ represents the inverse of land-use restrictions and so a lower value of τ implies a higher degree of land-use restrictions. The states of Alaska and Hawaii, as well as the District of Columbia have been excluded.

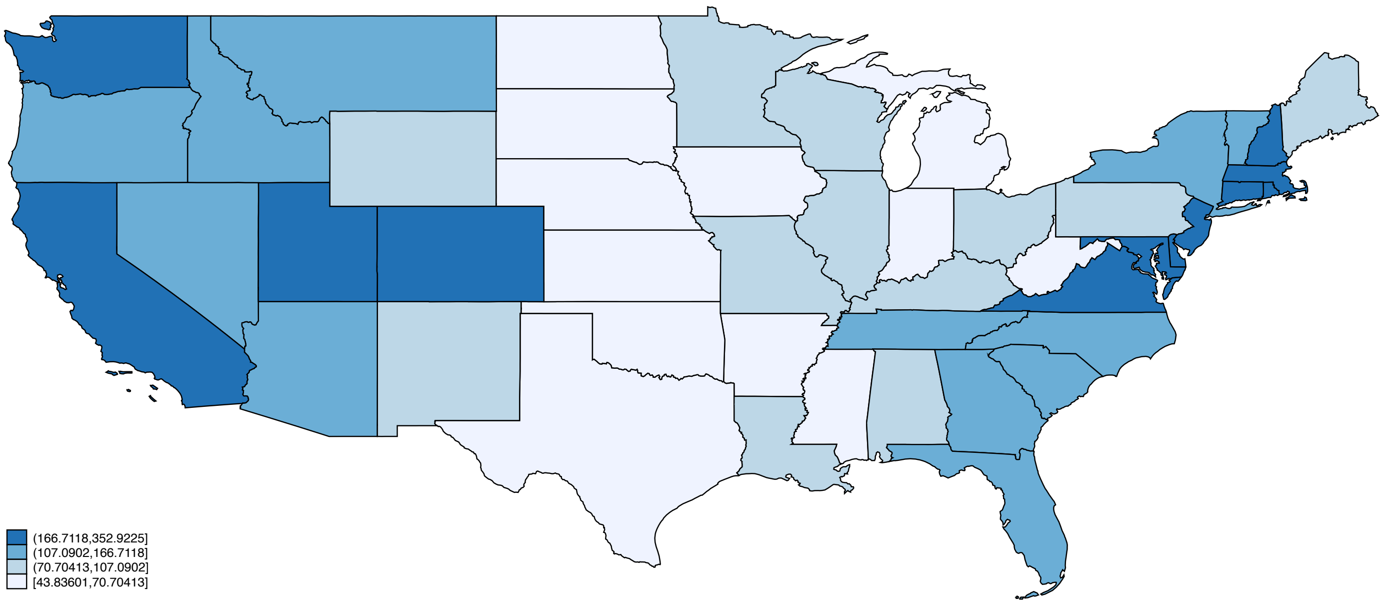
Table 11: Model implied measures of land-use restrictions and productivity

State	τ				Regional productivity			
	2000	2010	2014	%Δ	2000	2010	2014	%Δ
Alabama	.0101	.0095	.01	-1.31	6.06	6.85	6.58	8.58
Arizona	.009	.0091	.0082	-9.52	6.92	7.81	7.6	9.9
Arkansas	.0182	.0161	.0172	-5.31	5.31	6.13	5.92	11.42
California	.0047	.0039	.0037	-21.56	8.94	10.23	10.1	12.97
Colorado	.0063	.0059	.0058	-6.52	7.67	8.69	8.56	11.57
Connecticut	.0061	.003	.004	-34.42	8.9	10.58	10.05	12.93
Delaware	.0101	.0042	.0049	-51.84	7.68	9.03	8.49	10.46
Florida	.0095	.0071	.0075	-20.51	6.79	7.54	7.25	6.78
Georgia	.0086	.007	.0072	-16.55	6.88	7.37	7.1	3.07
Idaho	.0097	.008	.0093	-4.39	6.38	7.07	6.71	5.18
Illinois	.0101	.0091	.0122	20.89	7.63	8.12	7.68	.63
Indiana	.0145	.012	.0145	.29	6.63	6.88	6.56	-1.05
Iowa	.0158	.016	.0187	17.91	5.95	6.6	6.52	9.5
Kansas	.0125	.0147	.0167	33.71	6.2	6.59	6.51	5.02
Kentucky	.018	.0133	.0136	-24.49	6.13	6.73	6.59	7.42
Louisiana	.0131	.0101	.0102	-22.18	6.03	7.06	6.98	15.66
Maine	.0076	.0107	.0134	76.49	6.4	7.25	6.94	8.3
Maryland	.0067	.0041	.0045	-31.65	8.43	10.48	10.02	18.79
Massachusetts	.0047	.0025	.0028	-39.24	8.71	10.45	10.28	18.11
Michigan	.0134	.0126	.0153	14.58	7.33	7.17	6.83	-6.81
Minnesota	.0075	.0079	.0095	27.52	7.32	8.05	7.82	6.74
Mississippi	.014	.015	.0157	11.84	5.56	6.09	5.86	5.4
Missouri	.0133	.0116	.0137	3.14	6.23	6.81	6.58	5.5
Montana	.0081	.0075	.0075	-7.62	5.88	7.02	7	19.12
Nebraska	.0154	.0172	.0187	21.63	5.93	6.47	6.39	7.87
Nevada	.0073	.0116	.0085	16.16	7.74	8.32	8.05	3.92

New Hampshire	.0063	.0036	.0043	-32.48	7.51	9.12	8.78	16.89
New Jersey	.0062	.0032	.0044	-29.21	9.16	10.86	10.1	10.32
New Mexico	.0091	.0081	.0101	10.86	6.12	7.25	6.76	10.33
New York	.0114	.0068	.0083	-26.62	8.15	9.49	9.04	10.92
North Carolina	.0088	.0072	.0069	-21.2	6.64	7.2	6.98	5.17
North Dakota	.0226	.0232	.0199	-11.89	5.43	6.29	7.29	34.22
Ohio	.0109	.0105	.0138	26.12	7	7.24	6.87	-1.87
Oklahoma	.013	.0187	.0228	75.96	5.6	6.2	6.1	8.82
Oregon	.0065	.005	.0062	-4.81	7.58	8.51	8.26	9.01
Pennsylvania	.0163	.0093	.0104	-36.14	6.63	7.59	7.47	12.55
Rhode Island	.0077	.0044	.005	-34.84	7.52	9.28	8.78	16.7
South Carolina	.0096	.007	.0071	-26.11	6.2	6.95	6.63	6.88
South Dakota	.0169	.0164	.0164	-3.34	5.42	6.18	6.18	13.92
Tennessee	.0075	.0079	.008	6.51	6.56	6.95	6.72	2.5
Texas	.0166	.0152	.015	-9.74	6.37	7.18	7.15	12.3
Utah	.0063	.0049	.0049	-23.38	7.19	8.12	8.11	12.75
Vermont	.0122	.0085	.0093	-24.23	6.37	7.69	7.62	19.53
Virginia	.008	.0052	.0053	-34.11	7.51	9.3	9.2	22.6
Washington	.0061	.0043	.0056	-8.78	8.01	9.45	9.14	14.16
West Virginia	.0214	.0211	.0216	.71	5.7	6.27	6.21	9.04
Wisconsin	.0118	.0086	.0101	-15.02	6.84	7.56	7.24	5.97
Wyoming	.0102	.0098	.0094	-8.49	6.19	8.11	7.89	27.49

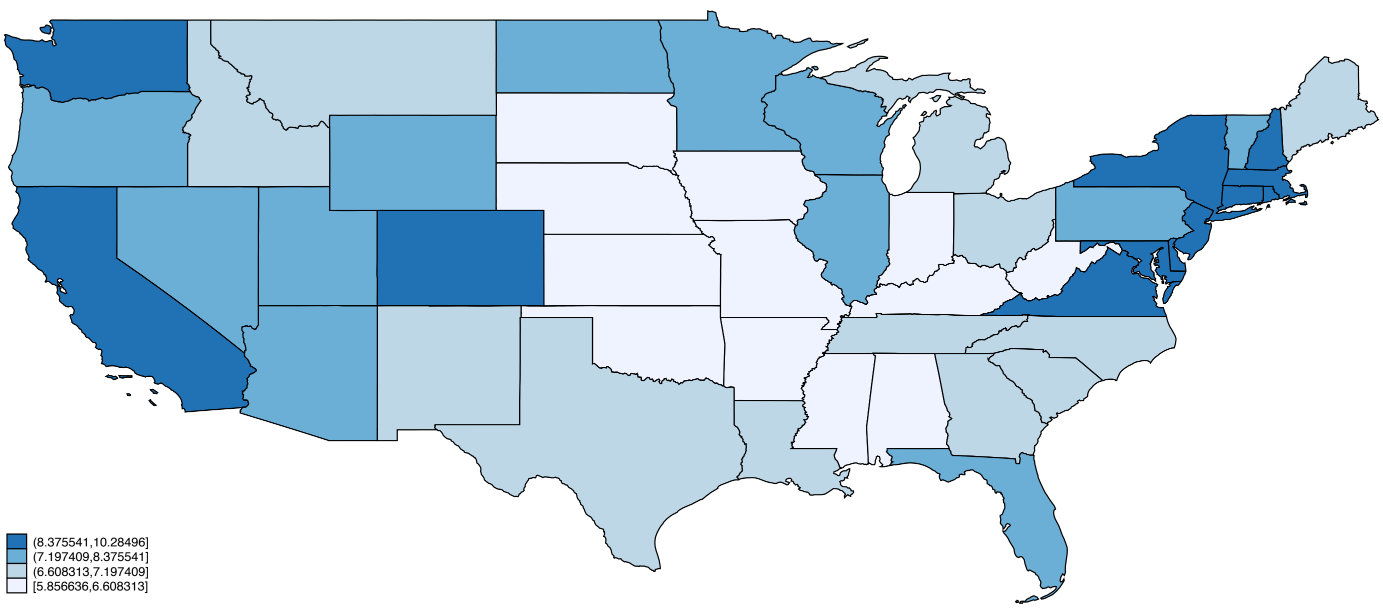
C.2 Spatial variation on a map of the U.S

Figure 10: Model implied land-use restrictions



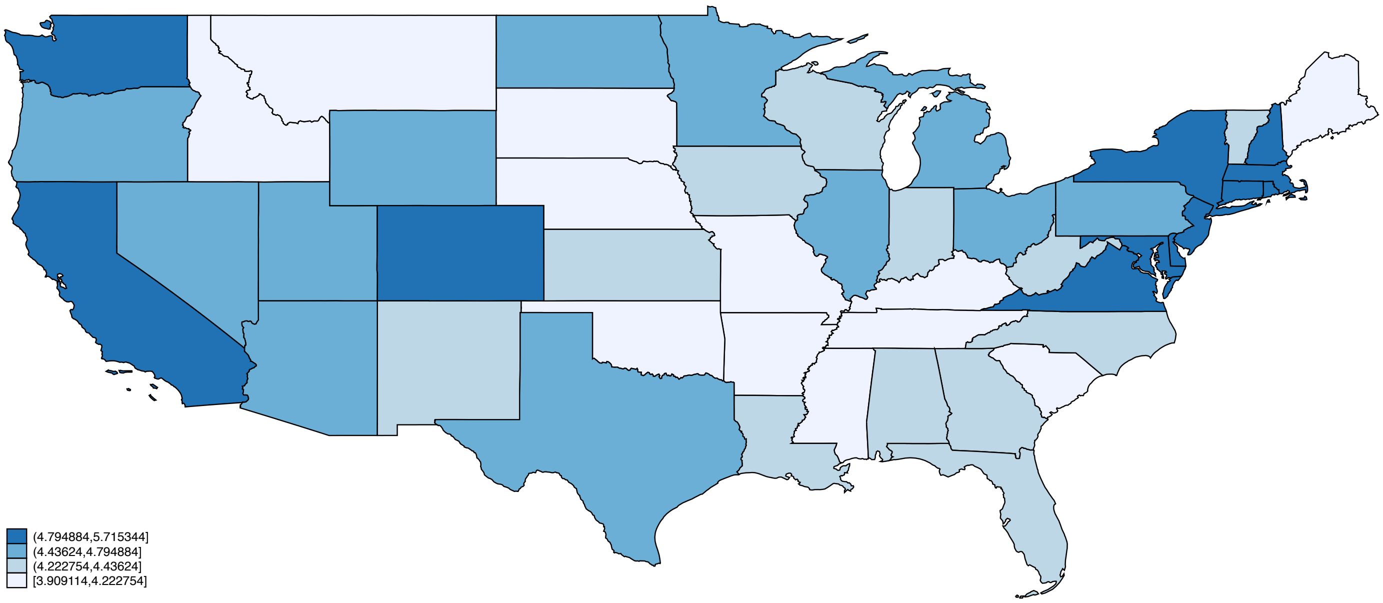
Notes: the figure depicts the measure of land-use restrictions, which is defined as $\frac{1}{\tau}$, across the states that comprise the continental U.S., for the year 2014.

Figure 11: Model implied productivities



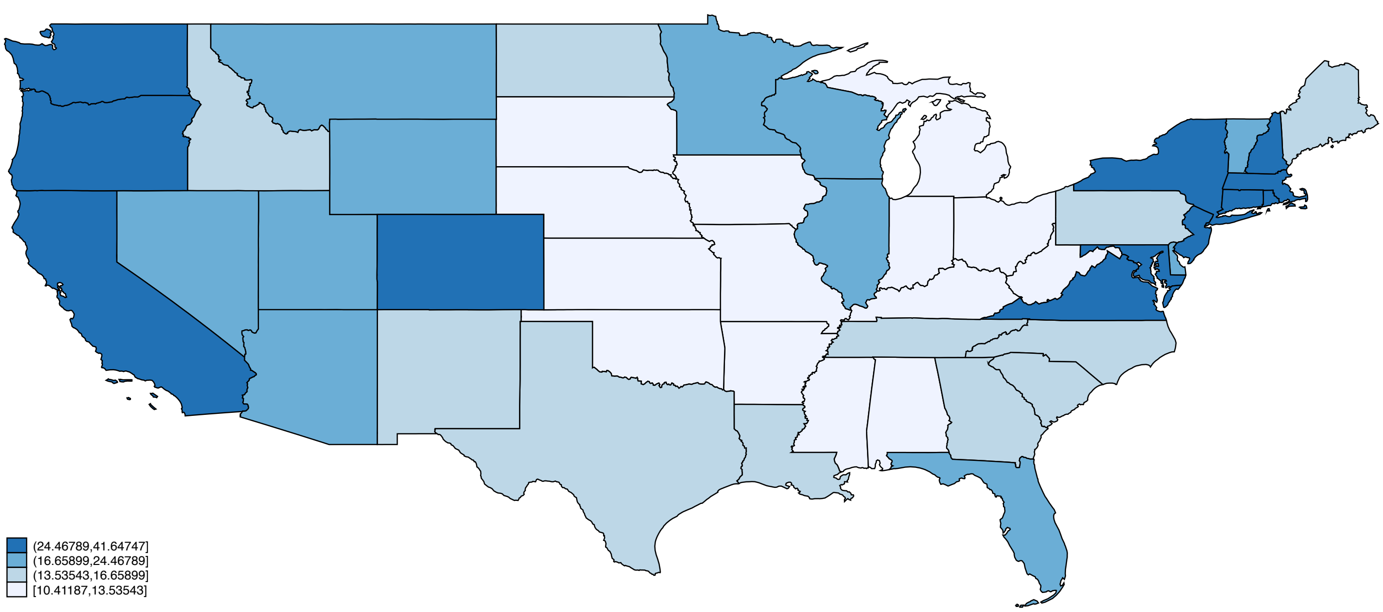
Notes: the figure depicts the measure of regional productivities across the states that comprise the continental U.S., for the year 2014.

Figure 12: Adjusted real wages



Notes: the figure depicts the adjusted real wage in $10,000s (as discussed in appendix B) across the states that comprise the continental U.S., for the year 2014.

Figure 13: Real house values



Notes: the figure depicts the median house value in $10,000s, across the states that comprise the continental U.S., for the year 2014.