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ABSTRACT

This paper studies the impact of state-level land-use restrictions on U.S. economic activity, focusing on how these restrictions have depressed macroeconomic activity since 2000. We use a variety of state-level data sources, together with a general equilibrium spatial model of the United States to systematically construct a panel dataset of state-level land-use restrictions between 1950 and 2014. We show that these restrictions have generally tightened over time, particularly in California and New York. We use the model to analyze how these restrictions affect economic activity and the allocation of workers and capital across states. Counterfactual experiments show that deregulating existing urban land from 2014 regulation levels back to 1980 levels would have increased US GDP and productivity roughly to their current trend levels. California, New York, and the Mid-Atlantic region expand the most in these counterfactuals, drawing population out of the South and the Rustbelt. General equilibrium effects, particularly the reallocation of capital across states, accounts for much of these gains.

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1 Introduction

The U.S. record of 250 years of roughly constant economic growth has gone hand-in-hand with enormous reallocation of population across U.S. regions. This includes the country's westward expansion into the Midwest and the Great Plains states in the 1800s, the urbanization of the U.S. in the 1800s and 1900s, and the remarkable expansion of California in mid and late 1900s.

To place California's population growth in context, we note that 18 states in 1900 were larger than California, including Alabama, Iowa, Kentucky, Georgia, and Mississippi. Illinois was roughly three times as large as California, Missouri was more than twice as large, and Kansas was roughly the same size at that time. By 1990, roughly 12 percent of the U.S. population resided in California, compared to less than 2 percent in 1900. And by 1990, California was as much as 11 times larger than some of the states that dominated California in 1900.

Recently, however, regional population reallocation patterns have declined, and California's share of the population stopped growing. Frey [2009] documents that the U.S. migration rate has declined by about 40 percent since the 1980s, and he shows that this decline in reallocation appears across all demographic groups.[1]

These changes in regional reallocation, and the sudden stop in the expansion of California's population share, have coincided with three other observations of interest. One is the decline in aggregate economic activity relative to historical trend that predates the Great Recession. This period of relatively low productivity growth and low output growth has been characterized by Decker et al. [2014] as a decline in "U.S. Dynamism," with much less factor reallocation.[2]

A second observation is that housing prices in California and other highly productive states rose considerably around the same time. Between 1940 and 1980, Census data show that California housing prices were on average around 35 percent higher than those in the rest of the country. But by 1990 the California housing price premium had risen to 262 percent.

[1] For additional discussion on the interstate migration slowdown, see Molloy et al. [2014] and Kaplan and Schulhofer-Wohl [2017].

[2] For additional discussion on the U.S. decline in churn and labor market dynamism, see Hyatt and Spletzer [2013], Karahan et al. [2015] (who focus on entrepreneurship), and Molloy et al. [2016].

A third observation is that state-level income convergence has slowed. Ganong and Shoag [2013] and Giannone [2017] show that income convergence across states, which we interpret as workers moving out of states with relatively poor job opportunities, to states with better job opportunities, began to slow in the 1980s. Moreover, the states with the highest housing prices, such as California, continue to have much higher worker productivity.

This paper interprets these observations as reflecting state-level land-use policies that have limited the available land for housing and commercial use, which in turn have raised land prices, slowed interstate migration, reduced factor reallocation, and depressed output and productivity relative to historical trends.

We construct a state-level growth model of the U.S. to analyze this issue. States in this model feature: (1) exogenous differences in land size, (2) exogenous differences in productivity levels, (3) exogenous differences in amenities, and (4) exogenous differences in land use-restriction policies that affect the amount of usable land, and which in turn affect the price of land and the productivity of capital and labor. Thus, states feature different attributes, and population will tend to move out of states with relatively poor productive opportunities and/or relatively poor amenities, to states with better productive opportunities and/or amenities.

This analysis models these state-specific policies as a factor that affects the percentage of the state's urban land stock that can be used for housing and for production of a consumption-investment good. This model policy variable stands in for the host of land-use regulations and restrictions that are used within states, including density restrictions, zoning restrictions, environmental restrictions, building restrictions, delays in obtaining building permits, and eminent domain and other policies that effectively take private property, all of which impact the opportunities or the incentives to develop land.

This analysis requires a systematic quantitative measure of land-use regulations over time and across states. To our knowledge, there is no such existing measure. Therefore, we construct a measure using the model and a variety of state-level data sources, including state-level labor productivity, housing prices, and employment shares. This allows us to use the model to infer a panel of the state-specific policy distortions, and also allows us to infer state-level TFP and state-level amenities.

We find that the model-inferred land-use distortions are quite highly correlated with other measures of state-level distortions, and we also find that the model-inferred state-level amenities are quite highly correlated with existing measures of quality-of-life measures across states. We find that California and New York have the highest TFP and also have the very restrictive land-use regulations, particularly in recent years. In contrast, we find that Texas has the least-restrictive level of land-use regulations among the states, which is consistent with prior evidence in Quigley and Rosenthal [2005].

We use the model to analyze the impact of these state-level distortions on output, productivity, labor, consumption, investment, and the allocation of the population across states. We conduct a number of counterfactual experiments that we call *deregulation experiments*, in which we reduce 2014 distortions to their levels in either an earlier year, or to a level based on the model-inferred 2014 Texas distortion level.

We find that even modest land-use deregulation leads to a substantial reallocation of population across the states, with California's population growing substantially. We also find that economy-wide TFP, output, consumption, and investment would be significantly higher as a consequence of deregulation. We find that U.S. labor productivity would be 12.4 percent higher and consumption would be 11.9 percent higher if all U.S. states moved halfway from their current land-use regulation levels to the current Texas level. Much of these gains reflect general equilibrium effects from the policy change. In particular, roughly half of the output and welfare increases reflect the substantial reallocation of capital across states.

The paper is organized as follows. Section 2 provides a literature review. Section 3 discusses the challenges to measure land restrictions over time and how our approach works. Section 4 presents the model economy. Section 5 summarizes the data. Section 6 discusses the quantitative approach and model calibration. Section 7 presents the counterfactual experiments. Section 8 conducts robustness exercises, and Section 9 concludes.

2 Literature Review

This paper, which focuses on the general equilibrium impact of land-use regulations on aggregate economic activity, is related to a number of papers that have separately studied the issues of land-use regulations, declining regional mobility, and rising housing and land prices. Brueckner [2009] and Gyourko and Molloy [2014] comprehensively summarize recent papers that study the link between government and private land-use regulations, house prices, and local labor markets. These summaries, however, point to the scarcity of general equilibrium assessments of land regulations, which is the focus of this paper.

Glaeser [2014] and Furman [2015] argue that land and housing regulations slow economic growth. Both papers synthesize existing work that provides a set of facts relating economic performance and regulation.

Hsieh and Moretti [2015] study how productivity differences across U.S. cities have contributed to aggregate economic activity. Our paper and Hsieh and Moretti [2015] study similar issues, but they are very complementary as there are several important differences in terms of focus, methodology, and the economic mechanisms that are operative.

The present paper develops a dynamic general equilibrium framework, in which land is a fixed factor in production to analyze how changes in regulations over time have affected aggregate productivity, real GDP, consumption, investment, employment, and the reallocation of the population. In contrast, Hsieh and Moretti [2015] analyze the contribution of each major city to US GDP at two points in time, and conduct counterfactuals based on time-invariant proxies for land-use regulation. Since they do not have time series on land-use regulations, they do not address the question of how changes in land-use regulations from 1950-2014 have impacted the U.S. economy. Hsieh and Moretti [2015] use a partial equilibrium model, which allows them to study some issues more easily than can be done in our framework, such as differentiated outputs and regional differences in production elasticities.

Another important difference between the two papers is the treatment of the housing market. Hsieh and Moretti [2015] assume an exogenous housing supply function. The general equilibrium model used in this paper requires that all markets, including the markets for land and for housing, clear. Market clearing in housing and land has important general equilibrium implications for quantifying changes in land-use regulations, because the incentives to relocate to particular regions will change as the prices in these markets change. In addition, our general equilibrium framework allows us to make welfare calculations of the costs of land regulation.

Our work is also related to recent work by Albouy and Stuart [2014], which builds a model of U.S. regions in which the substitution elasticity in non-tradable production is proportional to the Wharton Land Regulation Index. They study the cross-sectional determinants of labor allocation, including the role of regulations, taxes, amenities, and productivity. They find that amenities are the most important driver of population density across regions. While some features of these analyses are similar, there are some key differences, including our approach of explicitly modeling the labor-leisure choice, and the inclusion of markets for all traded goods. This allows us to identify a time series of land regulations and conduct welfare and policy analysis for the changes in land regulations observed since the 1950s.

There are several recent papers, including Davis et al. [2014] and Ahlfeldt et al. [2015], that have developed spatial general equilibrium models with land to estimate agglomeration effects. Our paper shares a similar economic environment to these papers, except for the treatment and measure of land and land-use regulations, and we use our model to address the recent US slowdown. This class of models, including our own, take land regulations as exogenous. Recent research by Bunten [2016] and Parkhomenko [2016], among others, has endogenized land-use regulations within political economy frameworks.

There is a literature on city-structure which studies the transmission of land regulations to land rents, which is a key mechanism in our paper. Building on Lucas and Rossi-Hansberg [2002], Chatterjee and Eyigungor [2017] show that land regulations can actually reduce land rents and house prices since restricting the number of people that can move to a location, through agglomeration effects, can severely reduce that region's productivity. The end result is that land regulations lead to a short-run increase in house prices, but a long run decline (depending on the degree of complementarity).

Our analysis is related to the business cycle accounting literature, e.g. Chari et al. [2007], and is related to more recent work by Ospina [2017] on regional business cycle accounting. Our analysis is also related to Caliendo et al. [2014] and others who have considered the impact of regional TFP shocks on aggregate output and welfare. In particular, land-use regulations in our framework is equivalent to a regional TFP distortion.

Our paper also contributes the literature that studies the U.S. growth slowdown. Gordon [2012], Garcia-Macia et al. [2016], Argente et al. [2017], and Moran and Queralto [2017] focus on the changing nature of innovation. Other papers study potential measurement issues, including McGrattan [2017] who focuses on mismeasurement of intangibles, and Byrne et al. [2016] who suggests that recent innovations that are complements to leisure, such as Facebook are not incorporated into GDP properly. Henriksen et al. [2016] focus on the role of demographics, Alon et al. [2017] focus on firm composition, and Boppart et al. [2017] argue that goods dropped from the CPI are actually being displaced by higher quality goods, and that after adjusting for this bias, real output growth is higher than that measured by the

BEA. Our paper contributes to this literature by quantifying the role of land-regulations and the regional allocation of workers for the US economic slowdown.

3 Challenges in Measuring Land-Use Regulations

A key input in any study of the impact of land use restrictions on economic activity is a consistent time series of these regulations that can be used in a quantitative analysis. This requirement has been a long-standing and significant impediment within the literature.

There are many different types of land-use restrictions that states and localities use, and many of these restrictions are complex and are thus difficult to capture as a simple quantitative measure of policy. For example, zoning restrictions affect the size and shape of buildings, setbacks from property lines, landscaping, height, number of units, parking requirements, ability to construct underground parking, and placement of utilities, among other requirements, including time-of-day restrictions on commercial activities. Moreover, zoning restrictions are often specific within specific neighborhoods, and can vary considerably across neighborhoods.

In some communities, particularly neighborhoods with high housing prices, development proposals must also pass architectural review board assessments before construction can begin. It is also very difficult to capture these costs within a land use restriction index, because these reviews are often subjective, and this subjectivity changes over time, depending on whether the committee composition is primarily pro-development members, or members who are more inclined to fight new development.

More broadly, environmental and other restrictions have become more commonplace in residential and commercial development. Building permits may be denied on the basis of the developments potential impact on wildlife and habitat, the possibility of previous historically relevant development, relics near the building site, the developments potential impact on water flow and erosion, and other possible environmental changes. Areas with high housing costs are also subject to requirements that developers set aside some of their land for either low-income housing, and/or for uses other than the proposed development.

Below, we review some of the approaches that have been used to measure land-use regulations, describe why these approaches cannot be used in this analysis, and we summarize our approach to constructing such a measure.

Ganong and Shoag [2013] use court cases involving land-use as a proxy for land-use regulations. They argue that declining migration rates and declining regional income convergence reflects regulations and rising house prices in high income regions.

Glaeser et al. [2005b] address the challenge of constructing a quantitative measure of land distortions by estimating the gap between home prices per square foot and estimates of the marginal cost of construction per square foot. This approach is best suited for multi-family dwellings, in which the land footprint of the building, and many planning and permitting costs, may be reasonably considered as a fixed cost relative to the marginal cost of adding units (floors) in the dwelling. This leads Glaeser et al. [2005a] to focus on New York (Manhattan), in which most dwellings are multi-family, multi-story units. Their study is at a point in time, and thus does not shed light on how land-use restrictions have changed over time. In addition, this approach cannot be implemented for our state-level analysis, as the construction cost estimates Glaeser et al. [2005b] use are for cities, rather than for states. Moreover, using these cost estimates would also require the following, none of which are available to our knowledge: (i) consistent measures of housing square footage over time by state, (ii) square-footage cost estimates for the 1950-2014 period, (iii) land costs, planning and preparation costs, and other costs that will be important for single family homes, as opposed to the multi-family dwellings studied by Glaeser et al. [2005b].

Glaeser and Ward [2009] develop another approach in which they fit a regression of home prices on measures of regulations that include wetlands restrictions, minimum lot size, and subdivision and septic regulations. They apply this approach to the city of Boston. It is infeasible to adopt this approach in our paper, given the large number of different regulations that exist across cities and that are not included in the regulation indices that they use, and given that systematic measures are not available for the entire period that we study, nor are they available at the state level.

Since there are no existing measures of a panel of land-use regulations, we construct such a panel measure for the 48 contiguous states over the 1950-2014 period. Our approach in constructing such a measure recognizes the many empirical and conceptual challenges associated with the task of compiling an index of land-use restrictions across states. We therefore pursue a very different strategy to construct an index by using a state-level optimal growth model, together with observations on state level productivities, employment shares, the stock of usable land, and housing prices, to infer a measure of land-use restrictions by state, and over time. The approach used in this paper shares a conceptual similarity with the Glaeser et al. [2005b] approach in that the size of the land-use restriction depends on housing prices and production costs. However, our method for assessing production costs is derived from a production function for housing, whereas Glaeser et al. [2005b] use square footage cost estimates. Below, we detail how we infer our measure of land-use regulations.

4 Model

This section develops a spatial growth model in which we explicitly model the stock of land within each state. Land has two uses in our model economy. Some land is used in production of the consumption-investment final good, and some land is used to produce housing services that are required for housing workers.

Land supply in each region is a fixed factor at any point in time. We model land-use regulations as changing the percentage of that land stock that actually can be employed in production or housing. More severe regulations reduce the fraction of land that can be used, and weaker regulations increase the fraction of land that can be used. These regulations can potentially vary over time and across states. Below, we show how the model and data allow us to infer a time series measure of land-use regulations by state from 1950-2014, which we then use to conduct counterfactual experiments. We analyze how recent changes in land-use regulations impact the distribution of employment across states as well the levels of output, productivity, investment, and consumption. We will conduct steady state analyses at different points in time.

4.1 Household Problem

Let $j \in \{1, \ldots, N\}$ index regions, and let $t = 0, 1, \ldots$ index time. All variables are expressed in per-capita terms. There is a stand-in household that owns the capital stock and the stock of usable land. The family chooses the number of workers in each region n_{jt}, how many units of housing to rent h_{jt}, how much capital to rent for final goods production k_{yjt}, housing production k_{hjt}, how land should be split between final goods production x_{yjt} and housing production x_{hjt}, the amount of capital to carry forward to next period k_{t+1}, consumption c_t, and investment, i_t. The stand-in household is constrained to rent as many housing structures as workers in a region.

The stand-in household has preferences over consumption c_t, aggregate hours worked ($n_t = \sum_j n_{jt}$) and region specific amenities a_{jt}, which are exogenous. We will consider two preference specifications. Our baseline utility function is separable between consumption, hours worked, and amenities, with one Frisch elasticity governing total labor supply (e.g. $U(c_t, n_{1t}, \ldots, n_{Nt}) = u(c_t, \sum_j n_{jt}) + \sum_j a_{jt} n_{jt}$, where we will assume $u(c_t, \sum_j n_{jt}) = \ln(c_t) - \frac{1}{1+\frac{1}{\gamma}}\Big(\sum_j n_{jt}\Big)^{1+\frac{1}{\gamma}}$ in our baseline calibration). In section 8.1, we consider alternate preferences which incorporate a region-specific disutility of work, which may be viewed as an additional congestion proxy over and above those arising from housing and land market clearing (e.g. $U(c_t, n_{1t}, \ldots, n_{Nt}) = \ln(c_t) - \big(\frac{1}{1+1/\gamma} n_{1t}^{1+1/\gamma} + \ldots + \frac{1}{1+1/\gamma} n_{Nt}^{1+1/\gamma}\big) + \sum_j a_{jt} n_{jt}$). We assume that amenities are additive and are proportional to labor supplied in a region.[3] The stock of usable land is given by x_{jt}, which is in fixed supply. Zoning laws and other land-use regulations are summarized by the parameters α_{hjt} and α_{yjt}. The α_{hjt} and α_{yjt} terms govern the fraction of land that can be used for housing and production, and therefore they are equivalent to the productivity of land.

There is a single consumption-investment good which is the numeraire. It is produced in each region and traded in a competitive market. Housing rental units are traded competitively within a region, and p_{jt} is the rental price of housing in region j at date t. Land is traded competitively within a region and the rental rate of land in region j and date t is q_{jt}. Capital and labor are freely mobile across regions. The stand-in household owns the production firms and housing rental firms in all regions. The profits from final goods and housing rental production are given by π_{hjt} and π_{yjt}, though they will be zero in equilibrium.

The household maximizes the following objective function,

$$\max_{\{k_{yjt}, k_{hjt}, n_{jt}, x_{hjt}, x_{yjt}, h_{jt}\}, k_{t+1}} \sum_{t=0}^{\infty} \beta^t \Big\{ u(c_t, n_t) + \sum_j a_{jt} n_{jt} \Big\}, \tag{1}$$

subject to the budget constraint,

$$c_t + i_t + \sum_j p_{jt} h_{jt} = \sum_j (w_{jt} n_j + q_{jt} x_{jt} + \pi_{yjt} + \pi_{hjt}) + r_t k_t \tag{2}$$

[3] This is fairly standard in the literature, e.g. Diamond [2016]. The impact of population density on a location's amenity level remains an open question (see Couture [2013]).

the law of motion for investment, i_t, in physical capital,

$$i_t = k_{t+1} - (1-\delta)k_t, \tag{3}$$

the regional capital constraint,

$$k_t = \sum_{j=1}^{N} k_{jt} = \sum_{j=1}^{N} k_{yjt} + \sum_{j=1}^{N} k_{hjt} \tag{4}$$

the regional worker constraint,

$$n_t = \sum_{j=1}^{N} n_{jt} \tag{5}$$

the housing constraint,

$$h_{jt} \geq n_{jt} \tag{6}$$

and the land constraint,

$$x_{jt} = x_{yjt} + x_{hjt}. \tag{7}$$

4.2 Final Goods Production

In each region, a representative firm produces the consumption-investment good, by combining land, x_{yjt}, labor, n_{jt}, and capital, k_{yjt}. We consider two forms of the final goods production technology. One is neoclassical, and the other features an agglomeration externality that exogenously affects productivity. In this latter case, productivity is given by $A_{jt}\bar{A}(\tilde{y}_{jt})$, where $\tilde{y}_{j,t}$ is output net of agglomeration effects (e.g. see Benhabib and Farmer [1996]).[4]

Production is given by:

$$y_{jt} = A_{jt}\bar{A}(\tilde{y}_{jt})F(k_{yjt}, n_{jt}, \alpha_{yjt}x_{yjt})$$
$$\tilde{y}_{jt} = F(k_{yjt}, n_{jt}, \alpha_{yjt}x_{yjt})$$

[4] Other studies in the literature have used the Ciccone and Hall [1996] agglomeration specification, which is over population density, but since our model includes capital, it is difficult to reconcile their estimates with the parameters in our model. We note that their density externality approximately corresponds to an externality on labor productivity, which is similar to our specification. For microeconomic foundations for agglomeration and increasing returns at the regional level, see Duranton and Puga [2004] and Couture [2015].

Firms rent capital, rent land, and hire workers in order to maximize profits:

$$\pi_{yjt} = \max_{k_{yjt}, n_{jt}, x_{yjt}} A_{jt}\bar{A}(\tilde{y}_{jt})F(k_{yjt}, n_{jt}, \alpha_{yjt}x_{yjt}) - r_t k_{yjt} - w_{jt}n_{jt} - q_{jt}x_{yjt}$$

4.3 Housing Rental Units

Housing rental units are produced by combining capital with land according to:

$$h_{jt} = g(\alpha_{hjt}x_{hjt}, k_{hjt})$$

Rental housing firms maximize profits by renting land and structures to combine with land:

$$\pi_{hjt} = \max_{k_{hjt}, x_{hjt}} p_{jt}g(\alpha_{hjt}x_{hjt}, k_{hjt}) - r_t k_{hjt} - q_{jt}x_{hjt}$$

The rental price of a home is $\frac{r_t}{g_k(\alpha_{hjt}x_{hjt}, k_{hjt})} = p_{jt}$. The value of a house ($P_{jt}$), is given by the discounted sum of rental payments, $P_{jt} = \sum_t \beta^t \frac{u_{ct}}{u_{c0}} p_{jt}$.

4.4 Equilibrium Definition

A competitive equilibrium consists of policy functions, $\{n_{jt}, h_{jt}, x_{hjt}, k_{yjt}, k_{hjt}, k_{t+1}, c_t\}_{t=0}^{\infty}$, prices $\{w_{jt}, r_t, q_{jt}, p_{jt}\}_{t=0}^{\infty}$, profits $\{\pi_{yjt}, \pi_{hjt}\}_{t=0}^{\infty}$, and exogenous land, land constraints, total factor productivity, and amenities, $\{x_{jt}, \alpha_{hjt}, \alpha_{yjt}, A_{jt}, a_{jt}\}_{t=0}^{\infty}$, for each $j = 1, \ldots, N$, such that:

1. Given prices, profits, and land-use regulations, the household policy functions maximize utility.
2. Given prices, and land-use regulations, firms in the final goods and residential service sector maximize profits.
3. Capital, land, housing and labor markets clear in each region.

4.5 Discussion of Model Mechanisms

Housing rental rates, wages, and land prices may vary across regions. Ceteris paribus, competition for the fixed supply of land in each location means that housing and land prices will be higher in more densely-populated regions. This congestion that reflects land scarcity prevents corner solutions in which all agents locate in either the most productive region, or in the region with the highest level of amenities.

Land-use regulations, α_{yjt} and α_{hjt}, distort both productivity and the atemporal condition that governs the efficient allocation of time between labor and leisure. Land-use regulations also impact the rental rate of housing units in a region. Since there must be as many houses as individuals in a region, tighter land-use regulations reduce employment levels, ceteris paribus. The first order condition for labor in region j is given by,

$$-\frac{u_{njt}}{u_{ct}} = w_{jt} - p_{jt} + \underbrace{\frac{a_{jt}}{u_{ct}}}_{Amenities}$$

Since land is a fixed factor, rental rates for housing, p_{jt}, differ across regions.

Amenities enter the labor-leisure first order condition, and thus will generate equilibrium wage dispersion. But even without amenities ($a_{jt} = 0$), the model generates wage dispersion in which house price variation across regions induces compensating wage differentials. Specifically, w_{jt} differs across regions, and will tend to be higher in regions with higher housing prices. This positive relationship between house prices and wages is a robust empirical feature of U.S. data (e.g. Ganong and Shoag [2013]).

4.6 Identification of State-level Regulations, Amenities, and Total Factor Productivity

There are three assumptions that allow us to easily identify the state-level unobservables: land-use regulations, amenities, and TFP. These assumptions are (i) symmetric restrictions on land-use in both the housing and commercial sectors, (ii) amenities are additively separable, and (iii) production in both sectors is Cobb-Douglas.

The second and third assumptions are fairly standard in the literature (e.g. Diamond [2016] and references therein). To motivate the first assumption, we use the Wharton Land

Regulation Index (WRI) data collected by Gyourko et al. [2008] to show that residential land-use restrictions are positively correlated with the presence of commercial land-use restrictions. This means that locations that severely restrict residential land use also tend to severely restrict commercial land use. Specifically, the correlation between residential density restrictions and constrained land supply for commercial use is about 0.55, and the correlation between minimum lot size and constrained land supply for commercial use is about 0.35. Note that these relationships may even be stronger than suggested by the size of the correlations, given the discrete nature of the answers to the WRI survey. In addition, residential zoning indirectly affects commercial activity in a location through restrictions on the hours that a business can operate, through noise restrictions, environmental restrictions, and parking restrictions, and through other factors that raise business costs. More broadly, given a fixed supply of land, residential zoning necessarily impacts commercial or other land uses. Thus, local zoning means higher land prices as land users compete for a smaller effective supply of land.

4.7 Identification of Land-Use Regulations

Identifying the land-use regulation parameter is very simple for the symmetric case in which $\alpha_j = \alpha_{hj} = \alpha_{yj}$.[5] We identify the land regulation parameter, α_j, using data on land acreage, house prices, employment, and output (we omit time subscripts for simplicity). The expression for α_j is given below:[6]

$$\alpha_j = \frac{(1-\xi)}{x_j}\left(\frac{n_j}{k_{hj}}\right)^{\frac{\xi}{1-\xi}}[(1-\xi)n_j + (1-\theta-\chi)\frac{y_j}{p_j}] \tag{8}$$

Heuristically, changes in land-use regulations will be associated with the following changes in the data. For a fixed amount of land x_j, an increase in population density, ceteris paribus, suggests weaker land-use regulations. Similarly, an increase in output of the consumption-investment good, ceteris paribus, suggests lower land-use regulations.

In the above expression, the values for x_j, n_j, p_j and y_j are observed, and the share parameters are calibrated from national accounts. The remaining value of k_{hj} is implied by time series on p_j, n_j, and the parameter values. Since the housing production technology

[5] In Appendix C we separately identify α_{hj}.

[6] We thank Chris Tonetti for suggesting and solving this problem.

is Cobb-Douglas, the share of payments to housing capital is given by, $\frac{rk_{hj}}{p_j h_j} = \xi$. Combined with the constraint on housing, $h_j = n_j$, we can solve for $k_{hj} = \frac{\xi p_j n_j}{r}$ (note that in steady state r is pinned down by the discount factor and depreciation rate). Therefore under these functional form assumptions, the value of α_j is identified.

4.8 Identification of Amenities

The amenity term is pinned down by regional employment shares. Heuristically, this follows from the fact that the atemporal first order condition that governs household time allocation is a function of regional employment allocations, regional labor productivity, and regional home prices. Thus, the regional amenity is residualy determined to generate the observed employment shares, given observed regional house prices and labor productivity.

Formally, we use data on p_j, n_j, y_j, and x_j to determine k_{hj} (as shown in Section 4.7), k_{yj} (which is identified from the first order condition for k_{yj} in final goods, $\frac{rk_{yj}}{y_j} = \theta$), w_j (which is obtained using first order condition for n_j in final goods, $\frac{w_j n_j}{y_j} = \chi$), and c (which comes from the finals goods resource constraint, $\sum_j (k_{yj} + k_{hj}) = k$, $y = \sum y_j$, and in steady state $i = \delta k$, $c = y - i$). We then use the house price data, p_j, and values of the model-determined variables to solve for amenities, a_j, using the atemporal first order condition as follows:

$$a_j = -u_{nj} - u_c w_j + u_c p_j \tag{9}$$

4.9 Identification of TFP

State labor productivity is observed, but the absence of state-level capital stock data means that TFP cannot be calculated using the standard approach. While it is not necessary to assume symmetric land regulations (and in Section 8.4 we relax this assumption), to identify total factor productivity of each state in our benchmark specification, we assume that regulations in the residential sector and commercial sector are the same, i.e. $\alpha_j = \alpha_{hj} = \alpha_{yj}$. Observations on p_j, n_j, y_j, and x_j in conjunction with equilibrium conditions allow us to solve for α_j and k_{yj}. We use the no-arbitrage condition for land to solve for $q_j = \frac{1}{x_j}[(1-\xi)p_j n_j + (1-\theta-\chi)y_j]$, which is solely a function of observables. The land price then implies the split of land between sectors, $x_{yj} = \frac{(1-\theta-\chi)y_j}{q_j}$. Now using $(x_{yj}, \alpha_j, n_j, k_{yj}, y_j)$, we can recover total factor productivity A_j:

$$A_j = \frac{y_j}{k_{yj}^{\theta} n_j^{\chi} (\alpha_j x_{yj})^{1-\theta-\chi}} \tag{10}$$

5 Data

The data are from a variety of sources. Regional employment and population are drawn from the BLS and the Census, respectively, and were generously provided to us by Steven Yamarik, which were originally used in Yamarik [2013]. The regional data for price deflators, output per worker, house prices, and urban land acreage, are drawn from a number of different sources, which are described below.

Turner et al. [2007] provide an updated set of regional deflators based on the methodology of Berry et al. [2000]. Berry et al. [2000] estimate consistent state-level deflators using family budget sets collected by the BLS. Since their data ends in 2000, we extend this series to 2014 using the following procedure. We regress the Turner et al. [2007] time series of the state deflators on a set of regional CPI variables interacted with a full set of state indicators for the 13 years in which both data series overlap (1987-2000). During the overlap period, the R^2 is approximately .990. Given this very close fit between the regional CPI and the state CPI, we then project the time series forward using the regional CPI variables to obtain state-level deflators. The base year of the deflator is 2000.

We obtain state-level output per worker between 1950 and 2000 from Turner et al. [2007]. We extend the series to 2014 using BEA measures of state output, and then we deflate this series using our consistent state-level deflators.

For home price data, we use the Census of Housing's median single-family house price across states from 1940-2000. Since the Census of Housing has been discontinued, we extend these data after 2000 using the American Community Survey's 100 percent sample. Specifically, we use these data from 2014 to compute a consistent measure of median single-family house prices across states.[7] We deflate house prices by the regional price deflators to obtain the real cost of housing from 1950-2014 across all US states.

For urban land acreage, we use the USDA Economic Research Services (ERS) data, which

[7] We impose the same conditions, including the fact that the house must be owner occupied, single-family, on a plot of land less than 10 acres, with no business or medical office on the property.

is available from 1945-1997. Following 1997, we use data from the 2010 decennial census, along with USDA-ERS total acreage estimates for 2002 and 2007 to construct consistent estimates of land from 1998 to 2014.[8]

Appendix A provides additional information on the data sources and data construction.

6 Quantitative Approach

The quantitative approach focuses on the long-run evolution of aggregate variables and regional employment shares. We therefore calculate steady states of the model beginning in 1950, continuing at 10 year intervals up to 2000, and then again in 2014. Future research will consider transition paths between steady states, though this approach requires constructing expectations about the evolution of land-use regulations, amenities, and productivity in each of the regions.

6.1 Model Calibration and Experimental Design

We separately model each of the 48 continental U.S. states. We omit Alaska and Hawaii, given that both achieved statehood after 1950, and given that they are not part of the continental U.S. In each region, land masses x_{jt} are equal to the acres of urban land in region j, divided by the US population.[9] For ease of exposition, we construct eight regions which aggregate the 48 continental U.S. states. California is one region, given our specific interest in this state. New York is another individual region, given its size and given the view in the literature that New York has very tight land-use regulations (Glaeser et al. [2005a]). Texas is the third region, given its size and recent growth, and because Texas is considered to

[8]The USDA-ERS provides imputed urban acreage estimates for 2002 and 2007. As they note, however, their imputation method makes the data points in 2002 and 2007 inconsistent with their estimates in 1997. To fix this issue, we use the 2010 decennial census which includes urban land share estimates. We multiply total land acreage by state from the USDA-ERS (total land has been roughly constant for the last 60 years across states and is not subject to imputation inconsistencies) by the Census' estimates of the percent of total land that is urban, by state. This yields a consistent estimate of urban land acreage by state from 1950-2010. We linearly interpolate between the observation dates in the USDA-ERS urban land series. In the case of the final year, our 2010 urban acreage estimate, without additional adjustment, is used for our 2014 steady state.

[9]Since the resulting acreage per person is quite small in magnitude, and the actual units of x are arbitrary (acres vs. hectares), we multiply by 100 to maintain reasonably scaled units.

have fewer land-use regulations than many other states (e.g. Quigley and Rosenthal [2005]).

We aggregate the remaining continental states into five geographic regions. When we aggregate, we use employment weighted averages. The *South* region includes Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, the Carolinas, and Tennessee. The *Rust Belt* includes the states typically cited in that group, with the exception of New York. The *Rust Belt* consists of Illinois, Indiana, Michigan, Ohio, Pennsylvania, Wisconsin, West Virginia (see Alder et al. [2014]). The *New England-mid-Atlantic region* includes Connecticut, Delaware, Massachusetts, Maryland, Maine, New Hampshire, New Jersey, Rhode Island, Virginia, and Vermont. The *Midwest* region includes Iowa, Kansas, Minnesota, Missouri, Nebraska, Oklahoma, and the Dakotas, and the *Northwest-Mountain* region includes Arizona, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington, and Wyoming.

For expositional purposes, the aggregate U.S. economy therefore consists of the 3 states cited above, plus the five regions.

Our benchmark preference specification modifies standard balanced growth preferences to include additive amenities as follows:

$$\ln(c_t) - \frac{1}{1+\frac{1}{\gamma}}\Big(\sum_j n_{jt}\Big)^{1+\frac{1}{\gamma}} + \sum_{jt} a_{jt} n_{jt} \tag{11}$$

The technology for producing the consumption/investment good is given as follows:

$$y_{it} = \tilde{y}_{jt}^{\lambda} A_{jt} k_{yjt}^{\theta} n_{jt}^{\chi} (\alpha_{yjt} x_{yjt})^{1-\theta-\chi} \tag{12}$$

The technology for producing housing is:

$$h_{jt} = k_{hjt}^{\xi} (\alpha_{hjt} x_{hjt})^{1-\xi} \tag{13}$$

We use fairly standard values for the discount factor, $\beta = .9614$, the depreciation rate, $\delta = .1$ (Hansen [1985]), and the labor supply elasticity parameter, $\gamma = 2$ (e.g. Keane and Rogerson [2012]).

We choose a labor share of 0.66 for the production of the consumption/investment good.

We choose a land share of five percent in this technology, based on Valentinyi and Herrendorf [2008]. Physical capital share is 0.29. In terms of the share parameters in the production of housing, we choose a land share of 0.38, based on Davis and Heathcote [2007].[10]

We consider two values for the production externality parameter, λ: zero (a purely neoclassical model), and 0.03. This latter value is a conservative choice relative to Ciccone and Hall [1996], who choose a value that is about 0.06. Related work by Davis et al. [2014] estimates an agglomeration parameter of .02 based on county level data, which is very similar to our choice.[11]

For the other model parameters $\{a_j, A_j, \alpha_{hj}, \alpha_{yj}\}$, we maintain the assumption that $\alpha_j = \alpha_{hj} = \alpha_{yj}$ (see Section 4.6), and we use equilibrium conditions and observed values of n_j, y_j, x_j, and p_j to infer (i) land regulations α_j using equation (8), (ii) the state level amenities using equation (9), and (iii) TFP using equation (10).

Table 1 illustrates the model's fit relative to the data as well as the model's parameter values. The model exactly matches the specified moments. We discuss the interpretation of the estimated parameters in the next section. Appendix B includes the parameter values for all 48 states.

[10] This is the raw average across MSAs and across time, from 1984-Q4-2016-Q1.

[11] Ciccone and Hall [1996] and Davis et al. [2014] specify their production externalities slightly differently, but both of their approaches are similar to a simple specification of an exponent on aggregate output, which is used in this study.

Table 1: Parameter Values and Model vs. Data Moments (CA, NY, and TX)

	Model	Data	Parameter	Value	Parameter Name
Labor Productivity in CA ($\frac{y_{CA}}{n_{CA}}$)	10.380	10.380	$A_{CA,2014}$	4.806	TFP
Employment in CA (n_{CA})	0.067	0.067	$a_{CA,2014}$	-0.668	Amenity
House Prices in CA (p_{CA})	27.633	27.633	$\alpha_{CA,2014}$	0.005	Land Regulation
Land Per Capita in CA (x_{CA})	2.084	2.084	$x_{CA,2014}$	2.084	Acres per 100 Individuals in US
Labor Productivity in NY	11.824	11.824	$A_{NY,2014}$	5.000	
Employment in NY	0.039	0.039	$a_{NY,2014}$	-0.989	
House Prices in NY	19.417	19.417	$\alpha_{NY,2014}$	0.015	
Land Per Capita in NY	1.037	1.037	$x_{NY,2014}$	1.037	
Labor Productivity in TX	9.943	9.943	$A_{TX,2014}$	4.099	
Employment in TX	0.050	0.050	$a_{TX,2014}$	-0.771	
House Prices in TX	10.230	10.230	$\alpha_{TX,2014}$	0.042	
Land Per Capita in TX	1.874	1.874	$x_{TX,2014}$	1.874	

Figure 1: Measures of Land-Use Regulations ($\alpha_{jt}^{1-\xi}$)

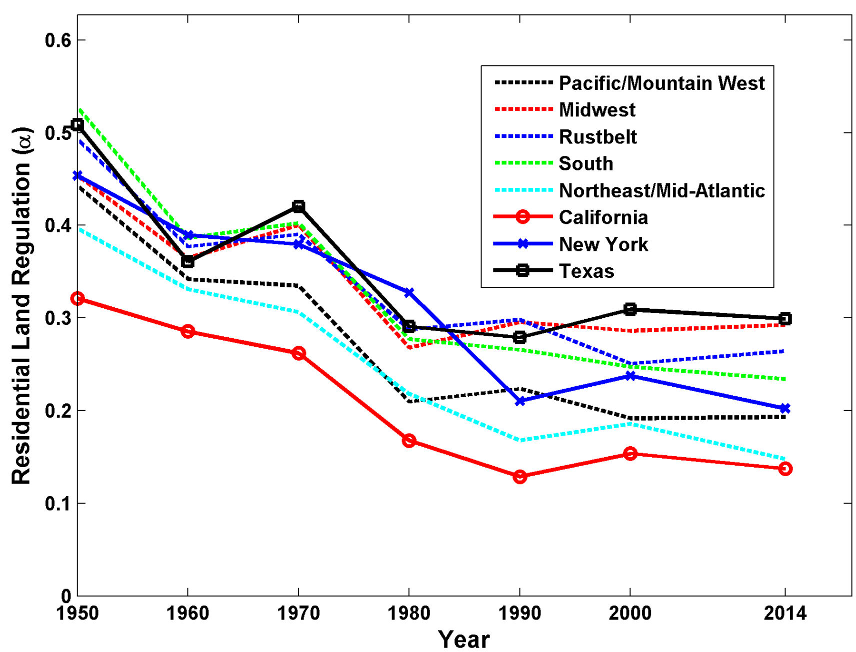


Figure 2: Measures of Amenities (a_{jt})

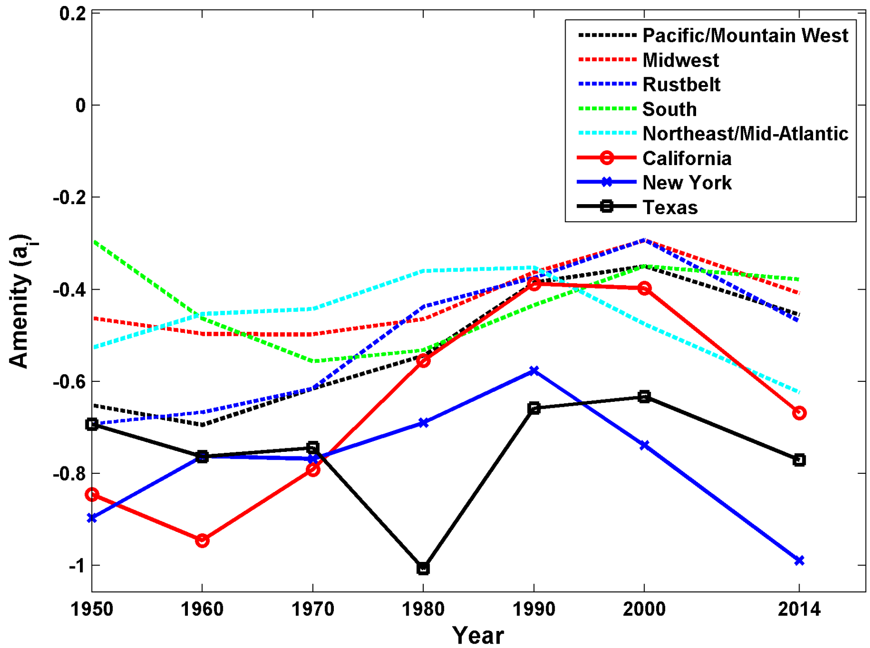
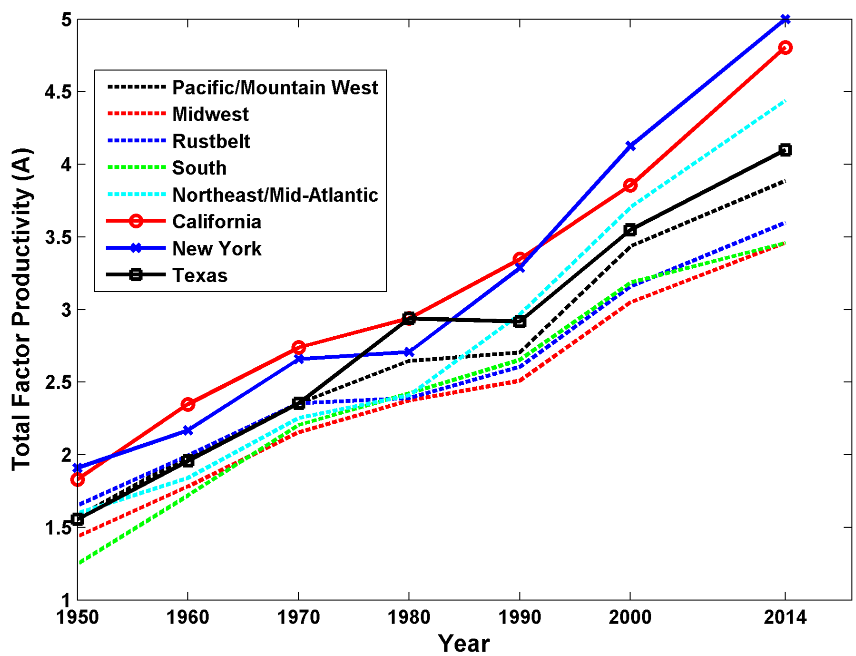


Figure 3: TFP Across Regions (A_{jt})



6.2 Model-Inferred State-Level TFP, Policies, and Amenities

Figures 1, 2, and 3 show the model-inferred regional land-use regulations, amenities, and total factor productivities. The model exhibits considerable cross-state variation in TFP throughout the postwar period. There is roughly a 40 percent gap between the most productive states in 1950 (New York and California) and the least productive states (the southern states). By 2014, the 40 percent productivity gap persists between the most productive states (New York and California) and the least productive states (the Midwest and the South).

There is also very little change in the rank-ordering of TFP in these regions over time, with California and New York at the top, the South and Midwest at the bottom, and Texas and the Northwest-Mountain region typically in the middle. This finding suggests that the slowdown in U.S. "economic dynamism" that Decker et al. [2014] describe may systematically and significantly be associated with California and New York.

The regulatory constraints figure displays the land-use distortions by region and over time. The figure shows generally *increasing* distortions over time (recall that lower α_j implies a tighter set of land regulations). This reflects the fact that housing prices have increased over time, particularly in California and New York. Texas has the lowest level of land-use regulations, and there is almost no change in the Texas land-use distortion after 1980. As in the case of TFP, there is relatively little change in the rank ordering of the land-use regulations over time.

The amenity figure shows a large decline in New York after 1990, rising amenities in California up to around 1990 which is then followed by a large decline, and relatively stable amenities in Texas.

6.3 Evaluating Model-Inferred Amenities, Policy Distortions, and TFP

This section compares the model-inferred values of amenities, distortions and TFP to empirical comparisons and/or analogues.[12]

Since there are no standard measures of the capital stock at the state level, we construct an aggregated model TFP, $\frac{Y}{K^{1/3}L^{2/3}}$ (which we call the Solow residual or measured TFP), and

[12] Appendix D compares the model wage predictions to the data.

compare this model object to aggregate TFP in the data.[13] Table 2 compares the growth rate of model TFP for six periods to Fernald et al. [2012] measures of TFP for these same periods. The table shows that the model TFP growth rate is quite similar to those of Fernald et al. [2012]. In particular, both model and data have a relatively high growth rate in the 1950s and 1960s, the growth rate falls significantly in the 1970s and 1980s, rises in the 1990s, and then declines again after 2000.

Table 2: Comparison of Model Solow Residual to Fernald et al. Solow Residual

	1950-1960	1960-1970	1970-1980	1980-1990	1990-2000	2000-2014
Model Solow Residual Growth Rate	1.75	1.76	0.33	0.89	1.77	0.91
Fernald Solow Residual Growth Rate	2.12	1.81	0.86	0.50	1.12	0.87

Table 3 compares our measure of land-regulation distortions, α_j, to existing measures of distortions. It is common in the literature to use the Wharton Land Regulation Index (WRI) as a cross-sectional measure of land-use distortions. This index is based on a principal component analysis of answers to survey questions in Gyourko et al. [2008]. This survey was sent to city managers across the country. To facilitate ease of comparison, we rank states by their degree of regulations according to the WRI, with a rank of 1 equaling the least regulated state, and a rank of 48 indicating the most regulated state. We do the same in the model, ranking states based on α_j, with a rank of 1 equaling the least regulated state, and a rank of 48 indicating the most regulated state. Large positive correlations between these two rankings suggest that the measures are closely aligned. Table 3 shows that our measure of distortions is highly correlated with the overall Wharton index (correlation(Rank(α_j), Rank(WRI)) = 0.82), as well as the Density Restriction Index (DRI) (correlation(Rank(α_j), Rank(DRI)) = 0.33) the Supply Restriction Index (SRI) (correlation(Rank(α_j), Rank(SRI)) = 0.29).

Recall that we imposed the same distortion in housing production and in non-residential production ($\alpha_{hj} = \alpha_{yj} = \alpha_j$). We therefore also compare our model distortion to the Pacific Research Institute's private business regulation index (Winegarden [2015]). This index is constructed conceptually along the same lines as the World Bank's *Doing Business Index*, which ranks countries on the basis of policies and institutions that impact the costs of starting a new business, and the profitability of running a business. Specifically, the PRI's

[13] Y is aggregate output, K is aggregate capital, and L is aggregate labor.

index is based on a state's disability system, unemployment insurance system, minimum wage, Workman's Compensation system, occupational licensing requirements, whether it is a right-to-work state, state energy regulations, the state tort system, and whether the state has a system of regulatory flexibility, in which a state has a formal protocol for a business to appeal for regulatory relief. The PRI ranks range from the least regulated with a rank of 1, to the most regulated states with a rank of 48. We similarly rank regions in our model, by degree of regulation, α_j. The last column of Table 3 shows that the correlation between the model's regulatory rank and the PRI business regulation rank is 0.60. We therefore conclude from these comparisons that our model-inferred distortions in 2014 are quite closely aligned with existing measures of residential land-use regulations and measures of state-level business regulations.

Table 3: Comparison of Model Land-Use Regulations to Wharton and Business Regulation Indices

	Regulation Indices			
	Wharton Land Regulation Rank*	Density Restriction Rank*	Supply Restriction Rank*	PRI Business Regulation Rank*
Correlation between Model Land-Use Regulation Rank* and Regulatory Index Rank*	0.82	0.33	0.29	0.60

**Rank equal to 1 indicates least regulated region, Rank equal to 48 indicates most regulated region.*

The final model-inferred parameter is the amenity term. Table 4 compares the state amenity terms to quality of life indices constructed by Gabriel et al. [2003] and Albouy [2008]. Their ranking convention is such that Rank 1 is the best place to live, and Rank 50 is the worst. We similarly rank our states based on the value of the model inferred amenity, a_{jt}. Table 4 reports the correlation of our amenity rankings with the amenity rankings of Gabriel et al. [2003] and Albouy [2008]. Our model amenity rank aligns best with the amenity series in Albouy [2008], exhibiting a rank correlation of 0.56. Our model exhibits weaker rank correlations between the 1980 measure of amenities in Gabriel et al. [2003]. However, our amenity series has a positive correlation of 0.30 with Gabriel et al. [2003]'s ranking in 1990. Our amenity index is based on a set of general equilibrium conditions that take into account capital across regions, land across regions, and the labor-leisure choices of agents, making our amenity estimates unique and potentially important for the literature which attempts to measure quality of life across states.

Table 4: Comparison of Model's Amenities to Quality of Life Indices

	Albouy Rank*	**Quality of Life Indices** Gabriel et al. 1980 Rank*	Gabriel et al. 1990 Rank*
Correlation between Model Amenity Rank* and Quality of Life Index Rank*	0.56	0.03	0.30

**Rank equal to 1 indicates best place to live, Rank equal to 48 indicates worst place to live.*

7 Counterfactual Experiments

This section conducts the counterfactual experiments. Our approach treats the α_{jt} terms as land-use policy differences across states that could be changed by policymakers. We therefore conduct experiments in which either some or all of these land-use policy terms change. The experiment is to deregulate *existing* urban land while keeping the mass of urban land constant. This is an important distinction relative to the existing literature, which does not utilize measures of actual land acreage.

One set of experiments rolls back regulations to a previous point in time. For these experiments, we take the 2014 model steady state and we change the $\alpha_{j,2014}$ terms to the state's 1980 regulation levels and their 2000 regulation levels. We then compare the differences in macroeconomic performance, welfare and the allocation of the population across states for these deregulations.

The second set of experiments changes the α_{jt} terms for all states other than Texas to levels that are based on 2014 Texas levels. We choose Texas because it has the weakest land-use regulations among the states in this analysis. This finding is also consistent with the fact that large metropolitan areas of Texas, including Houston, have no zoning laws, and the fact that Texas is identified as the least regulated state according to measures of supply and density restrictions.[14] In these experiments, states adopt policies that move their land-use regulation level either 50 percent or 25 percent closer to the Texas 2014 land-use regulation level.

We conduct the following sequence of experiments, which we refer to as *deregulation experiments*: (1) changing just the California $\alpha_{CA,2014}$ term, (2) changing the $\alpha_{CA,2014}$ and

[14] "The Department of Planning and Development regulates land development in Houston and within its extraterritorial jurisdiction (ETJ). The city of Houston does not have zoning but development is governed by codes that address how property can be subdivided. The City codes do not address land-use." http://www.houstontx.gov/planning/DevelopRegs/ .

$\alpha_{NY,2014}$ terms for California and in New York, respectively, and (3) changing the $\alpha_{j,2014}$ terms in all states/regions. We do this for both the neoclassical model (no externality) and the model with the productive externality that has an elasticity of $\lambda = 0.03$. Table 5 summarizes the $\alpha_{j,2014}$ terms in each of the main experiments. The full set of estimated α_{jt} values in the deregulation experiments are listed in Appendix B.

Table 5: Values of land regulations in 2014 (α_j) by experiment.

	Pacific/Mtn West	Midwest	Rustbelt	South	NE/Mid-Atlantic	CA	NY	TX
Baseline $\alpha_{j,2014}$	0.013	0.039	0.030	0.022	0.007	0.005	0.015	0.042
Deregulate CA to 2000 $\alpha_{j,2014}$	0.013	0.039	0.030	0.022	0.007	0.007	0.015	0.042
Deregulate CA to 1980 $\alpha_{j,2014}$	0.013	0.039	0.030	0.022	0.007	0.009	0.015	0.042
Deregulate CA & NY to 2000 $\alpha_{j,2014}$	0.013	0.039	0.030	0.022	0.007	0.007	0.023	0.042
Deregulate CA & NY to 1980 $\alpha_{j,2014}$	0.013	0.039	0.030	0.022	0.007	0.009	0.053	0.042
Deregulate All to 2000 $\alpha_{j,2014}$	0.013	0.037	0.027	0.025	0.012	0.007	0.023	0.046
Deregulate All to 1980 $\alpha_{j,2014}$	0.017	0.034	0.039	0.034	0.019	0.009	0.053	0.039
Deregulate 25% to TX $\alpha_{j,2014}$	0.020	0.040	0.033	0.027	0.015	0.014	0.022	0.042
Deregulate 50% to Texas $\alpha_{j,2014}$	0.027	0.040	0.036	0.032	0.024	0.024	0.028	0.042

Table 6 summarizes the results of these experiments.[15] The entries in this table are expressed relative to the baseline 2014 results. Specifically, the table entries for row x show the ratio $\frac{x_{2014,counterfactual}}{x_{2014,baseline}}$. Deregulating only California to its 1980 level and leaving the land-use regulation level of all other states unchanged, raises output, investment, TFP, and consumption by about 1.5 percent, and increases California's population by about 6.0 million workers.[16] The reallocation of workers to California comes from every other region, particularly the Rust Belt and the South which each lose about 1 percent of aggregate employment. The larger employment losses for these regions primarily reflect the fact that these regions are relatively large, rather than being more severely impacted by the California policy change.

Figure 4 shows the impact of this California deregulation. Panel (A) shows how the deregulation impacts employment shares across regions. Panel (B) illustrates the impact of deregulation on measured TFP and output growth from 2000-2014. As Panel (B) illustrates, deregulating California to 1980s levels would increase aggregate TFP and output growth rates by 0.1 percentage points per year between 2000 and 2014.

The first two columns of Table 7 show the results of the same experiment in the economy

[15] For a complete set of responses by aggregate variables, see Appendix F.

[16] Employment per capita in California goes from 6.7% to 10.7% (note that this is distinct from the plotted change in employment share since aggregate employment is falling). There are roughly 150m workers in the US in 2014, so the approximate employment gain to CA is 6 million workers (=150*(.107-.067)).

with the productivity externality. The impact of the same California land-use deregulation is roughly one-fourth to one-half larger in this economy. In particular, the Solow residual (defined in Section 6.3 as $Y/(K^{1/3}L^{2/3})$) increases by 2% with the externality, rather than 1.4% without the externality.

The next experiment deregulates California and New York. Column 5 of Table 6 shows that deregulating these states to their 1980 levels increases labor productivity by about seven percent and output per capita by about four percent in the neoclassical economy. Figure 5 graphs these results. Panel (A) shows that the Rustbelt and South lose the most population, followed by the New-England and Mid-Atlantic regions. Panel (B) of Figure 5 shows that TFP and output growth rise each year by about 0.35 and .25 percentage points, respectively, between 2000 and 2014.

Table 7 shows that these gains from deregulating New York and California also would increase by more than 50 percent in the economy with the productivity externality relative to the neoclassical economy. Note that these hypothetical increases would eliminate much of the current gap between current and trend productivity and current and trend output (see for instance, Prescott [2017]).

Column 7 of Tables 6 and 7 illustrates that deregulating all of the regions to 1980 levels would raise labor productivity by about 10 percent, and consumption by about 9 percent in the neoclassical economy, and would raise labor productivity by about 16 percent, and consumption by about 11 percent in the economy with the externality. Figure 6 shows these gains. Panel (A) shows that the region gaining the most population is the New-England/Mid-Atlantic region because their land-use restrictions tightened the most during this time period. New York and California would gain significantly as well. Panel (B) shows that TFP growth would increase by nearly 0.5 percentage points per year from 2000 to 2014. This would bring TFP growth in line with historic TFP growth rates over previous decades in the US (e.g. see Table 2). Panels (C) and (D) illustrate the impact of deregulation on the time path of consumption and measured TFP, respectively.

The final experiment deregulates all states from their current levels to 50 percent and 25 percent of the 2014 Texas level of land-use regulations. The gains are substantial. Column 9 of Table 6 shows that welfare rises by 10 percent of lifetime consumption, and output rises by a similar amount. TFP increases by nearly 8 percentage points over the 2000-2014 period. Panel (B) of Figure 7 shows that TFP growth and output growth would increase by nearly 0.7 percentage points per annum between 2000 and 2014 under Texas-level land-use regulations. Relative to Fernald et al. [2012]'s estimates of TFP growth, deregulation would increase measured TFP growth from about .9 percent per annum between 2000 and 2014 to roughly 1.6 percent per annum.[17] This is very close to the annual growth rates of TFP during the 1950s, 1960s, and 1990s (see Table 2).

There are two synergistic forces driving these economic expansions from land-use deregulation. One is that deregulation expands the effective supply of usable land, which in turn expands housing supply, reduces home prices, and thus reduces the marginal cost of working, ceteris paribus. The second is that deregulation also expands the effective supply of usable land in production of the consumption-investment good. This is isomorphic to proportionally raising productivity of the capital-labor aggregate in that location. This also increases the incentive to locate in the region that experiences the largest reduction in land-use restrictions.

It is striking that aggregate labor input declines following land-use deregulation, despite the fact that deregulating land reduces the cost of labor. Ceteris paribus, this suggests that aggregate employment should expand, not decline, in response to land deregulation. The primary reason why aggregate labor declines is due to substitution of land for labor in some production locations. Specifically, workers and capital are relocated to the regions with the largest deregulations. As workers leave the declining locations, land in these locations is in relatively abundant supply. With fewer workers, land devoted to residential production falls in the declining locations, and land is more intensively used in production of the final good in these locations. Thus, the labor-land ratio declines in the regions losing population, which enables society to produce more of the final good while also raising leisure.

[17]The Fernald et al measure of TFP growth is about .9 percent per annum between 2000 and 2014 (see Table 2).

Table 6: Baseline Deregulation Experiments. Variables expressed relative to baseline values $\frac{x_{2014,counterfactual}}{x_{2014,baseline}}$. Welfare expressed as fraction of lifetime consumption.

	(1) Baseline	(2) Dereg. CA to 2000	(3) Dereg. CA to 1980	(4) Dereg. CA & NY to 2000	(5) Dereg. CA & NY to 1980	(6) Dereg. All to 2000	(7) Dereg. All to 1980	(8) Dereg. 25% to TX	(9) Dereg. 50% to TX
Relative Consumption	1.000	1.007	1.013	1.014	1.045	1.033	1.090	1.071	1.119
Relative Output	1.000	1.007	1.015	1.013	1.037	1.029	1.072	1.062	1.101
Relative Measured Solow Residual	1.000	1.007	1.014	1.016	1.050	1.030	1.069	1.054	1.085
Relative Labor Productivity	1.000	1.011	1.021	1.023	1.073	1.044	1.100	1.079	1.124
Relative Investment	1.000	1.008	1.015	1.012	1.032	1.026	1.060	1.057	1.089
Relative Labor	1.000	0.997	0.994	0.990	0.967	0.986	0.974	0.984	0.979
Cons. Equiv. Welfare Gain (percentage points)	0	0.633	1.253	1.106	3.250	2.760	7.341	6.210	10.317

Table 7: Deregulation Experiments with Agglomeration, $\lambda = 0.03$. Variables expressed relative to baseline values $\frac{x_{2014,counterfactual}}{x_{2014,baseline}}$.

	(1) Baseline	(2) Dereg. CA to 2000	(3) Dereg. CA to 1980	(4) Dereg. CA & NY to 2000	(5) Dereg. CA & NY to 1980	(6) Dereg. All to 2000	(7) Dereg. All to 1980	(8) Dereg. 25% to TX	(9) Dereg. 50% to TX
Relative Consumption	1.000	1.007	1.015	1.017	1.063	1.040	1.112	1.082	1.144
Relative Output	1.000	1.010	1.021	1.017	1.059	1.040	1.102	1.086	1.142
Relative Measured Solow Residual	1.000	1.010	1.020	1.023	1.087	1.043	1.106	1.080	1.127
Relative Labor Productivity	1.000	1.015	1.032	1.035	1.131	1.066	1.160	1.123	1.195
Relative Investment	1.000	1.011	1.024	1.018	1.057	1.040	1.096	1.089	1.141
Relative Labor	1.000	0.995	0.989	0.983	0.936	0.976	0.950	0.967	0.956
Cons. Equiv. Welfare Gain (percentage points)	0	0.746	1.558	1.322	4.559	3.399	9.396	7.672	13.125

Figure 4: Deregulating California to 1980s and 2000s Levels.

(A) Change in Employment Shares

(B) Change in Output Growth

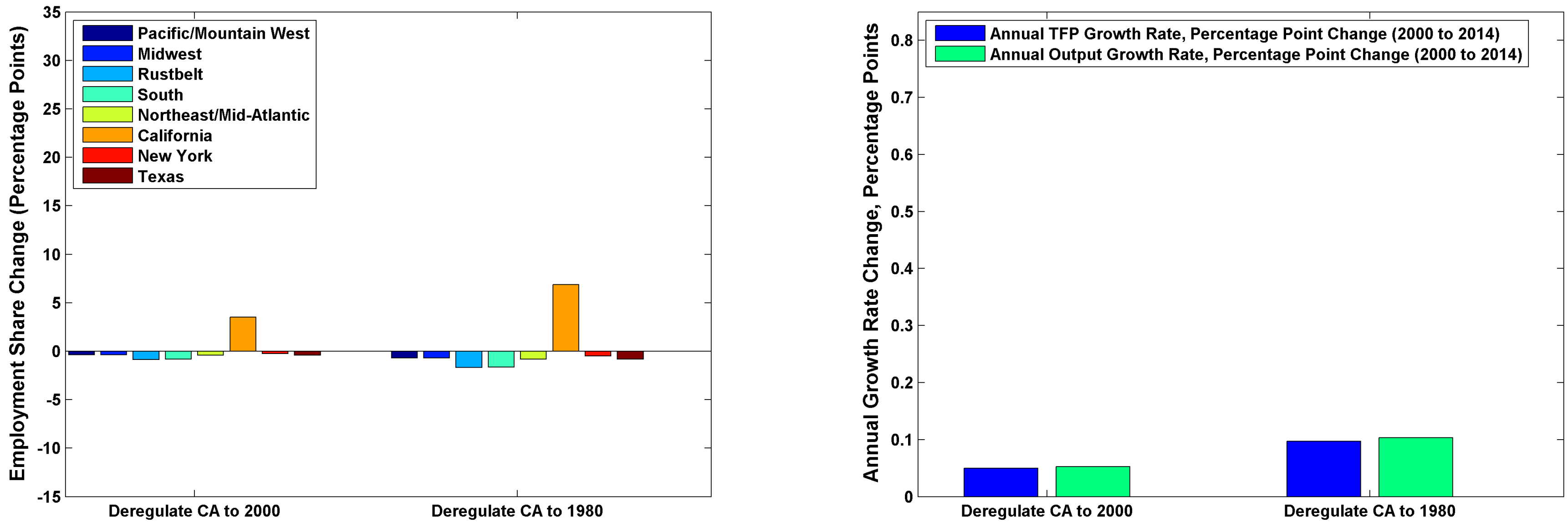


Figure 5: Deregulating CA and NY to 1980 and 2000 Levels

(A) Change in Employment Shares

(B) Change in Output Growth

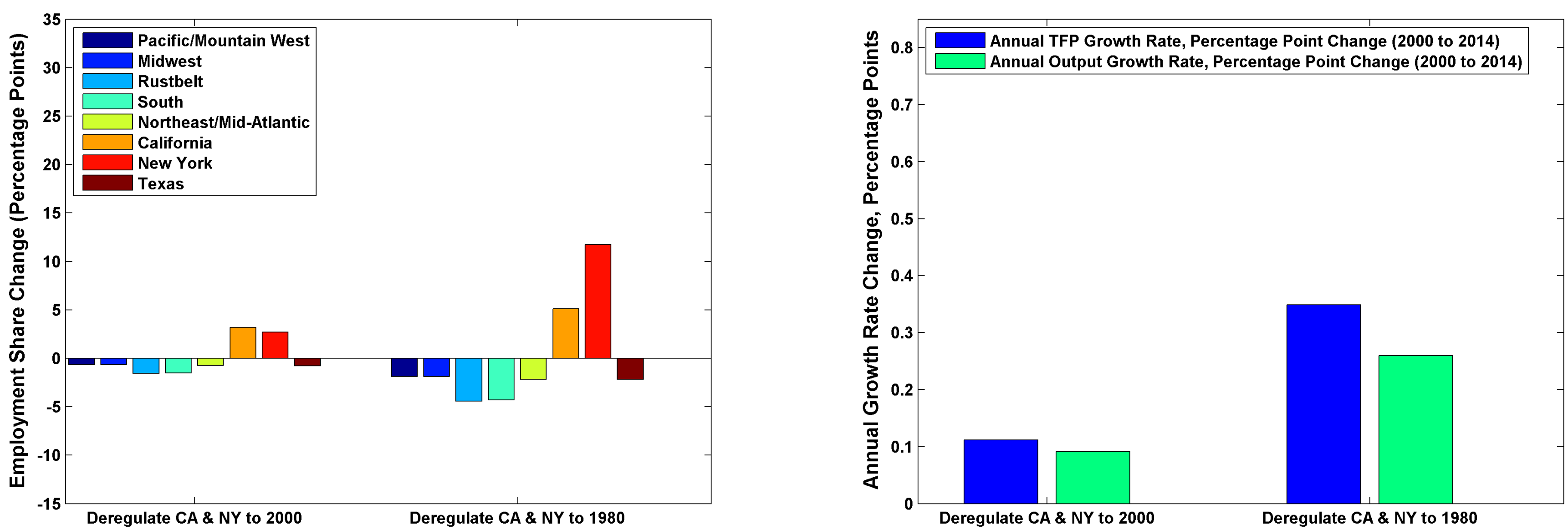


Figure 6: Deregulating All States to 1980 and 2000 Levels

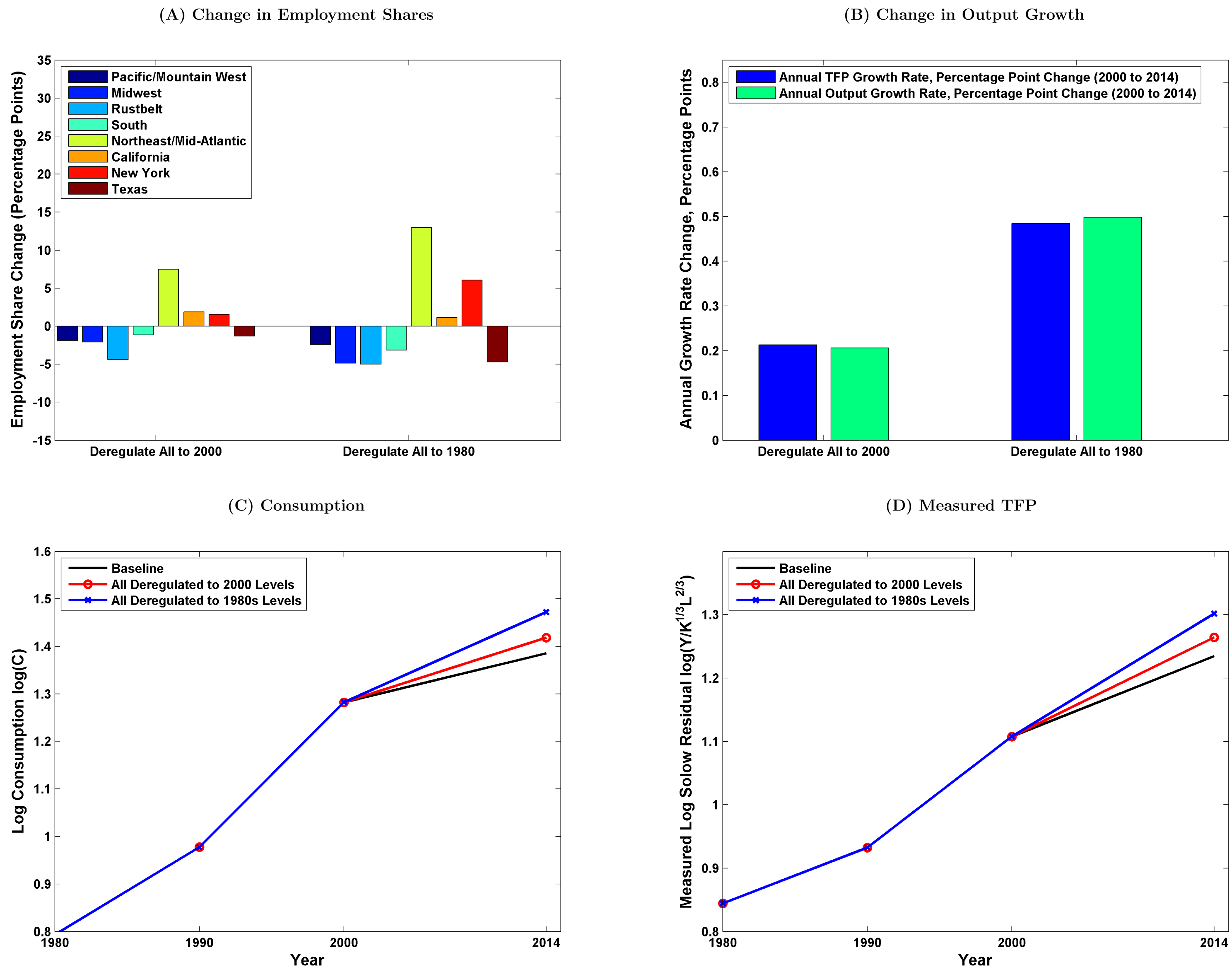
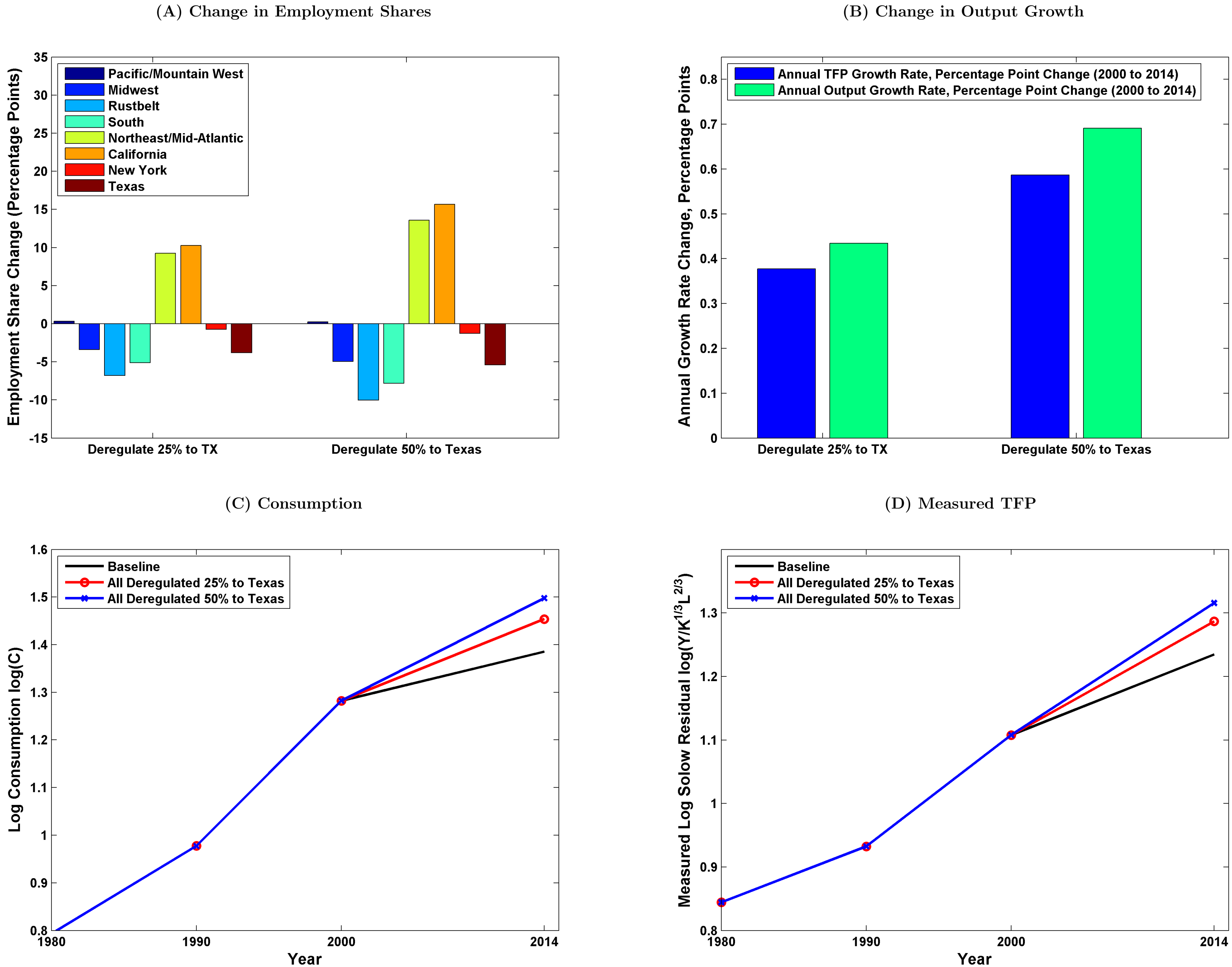


Figure 7: Deregulating All States Halfway to Texas Levels



8 Robustness

This section explores a number of robustness checks for our benchmark model. We explore (i) alternate preferences in Section 8.1, (ii) the sources of gains from deregulation in Section 8.2, (iii) alternate land shares in Section 8.3, (iv) unregulated commercial land in Section 8.4, and (v) covariance between amenities and regulation in Section 8.5.

8.1 Alternate Preferences

This section considers an alternative utility function in which the curvature of the disutility of labor applies specifically at the state level. Thus, there is no longer perfect substitutability of labor (in utility) across locations.

With this alternative specification, the household's problem becomes:

$$\max_{\{k_{yjt},k_{hjt},n_{jt},x_{hjt},x_{yjt},h_{jt}\},k_{t+1}} \sum_{t=0}^{\infty} \beta^t \Big\{ u(c_t, n_{1t}, \ldots, n_{Nt}) + \sum_j a_{jt} n_{jt} \Big\},$$

subject to the constraints given by equations (2) to (7). The utility function has the following functional form:

$$u(c_t, n_{1t}, \ldots, n_{Nt}) = ln(c_t) - \Big(\frac{1}{1+1/\gamma} n_{1t}^{1+1/\gamma} + \ldots + \frac{1}{1+1/\gamma} n_{Nt}^{1+1/\gamma} \Big) \tag{14}$$

This specification may be viewed as an additional source of congestion. To see this, consider a family that is evaluating different locations for workers. With the benchmark utility specification, the family considered regional amenities, productivity, and housing prices in its worker location choice, and was otherwise indifferent between regional locations. With this alternative specification, the family's choice not only involves the region's amenities, productivity, and housing prices, but also involves how many existing workers are in a region. This alternative specification thus reduces the incentives to move a large number of workers to any single region, and instead tends to equalize the number of workers across regions, ceteris paribus. For this experiment, we use a region specific Frisch elasticity equal to 2.

Table 8 illustrates the impact of land-use deregulation with the alternative utility function in equation 14. The additional source of congestion modestly reduces the productivity, output, and welfare gains from deregulation, in most instances. In particular the welfare gain from deregulating all regions halfway to Texas levels is 9.8 percent, compared to the baseline gain of 10.3 percent.

Table 8: Alternative Utility Function Experiments. Variables expressed relative to baseline values $\frac{x_{2014,counterfactual}}{x_{2014,baseline}}$. Welfare expressed as fraction of lifetime consumption.

	(1) Baseline	(2) Dereg. CA to 2000	(3) Dereg. CA to 1980	(4) Dereg. CA & NY to 2000	(5) Dereg. CA & NY to 1980	(6) Dereg. All to 2000	(7) Dereg. All to 1980	(8) Dereg. 25% to TX	(9) Dereg. 50% to Texas
Relative Consumption	1.000	1.005	1.010	1.011	1.030	1.028	1.076	1.062	1.101
Relative Output	1.000	1.004	1.008	1.008	1.020	1.021	1.054	1.047	1.074
Relative Measured Solow Residual	1.000	1.005	1.010	1.012	1.035	1.025	1.057	1.044	1.069
Relative Labor Productivity	1.000	1.008	1.014	1.017	1.050	1.036	1.080	1.062	1.097
Relative Investment	1.000	1.004	1.007	1.006	1.013	1.017	1.041	1.037	1.058
Relative Labor	1.000	0.997	0.994	0.991	0.971	0.986	0.976	0.986	0.979
Cons. Equiv. Welfare Gain (percentage points)	0	0.795	1.499	1.455	3.902	2.852	7.002	6.143	9.799

8.2 Understanding the Gains from Deregulation

This section interprets the gains from deregulation by conducting deregulations in which one or more input factors are fixed at their initial steady state values. These experiments shed light on the relative importance of changes in the various factors of production, and the change in regulations per se.

Table 9 illustrates output gains from deregulation, holding one or more inputs fixed. The first row of Table 9 allows all inputs to vary, and thus presents the maximum output gain from deregulation for all experiments. The second row fixes labor, capital, and the allocation of land between residential and business sectors, and thus shows the gains from just changing the value of the land-use regulation parameter. Across all experiments, the change from just the land-use parameter is roughly 20 percent of the total change. The third row is from the model steady state in which the allocation of land between housing and final goods production changes in response to the change in the land-use parameter. The gains from this experiment are roughly 30 percent of the total gain. The fourth row additionally allows capital to adjust, but keeps the amount of labor in each state fixed. With fixed labor, the output gains from deregulation are about 35 percent of the total change. The final row allows labor to adjust, but holds the total amount of capital in each state fixed (although within the state, capital can be reallocated between the housing and consumption-investment good sectors). When labor can adjust, but capital is fixed, the output gains from deregulation are about 45 percent of the total change. These results indicate that both the capital and labor margins are important in land-use deregulation, and that their complementarity is central for understanding the size of the gains from deregulation.

Table 9: Decomposition of Gains from Deregulation

	Deregulate All to 2000	Deregulate All to 1980	Deregulate 25% to TX	Deregulate 50% to Texas
All Inputs Vary	1.029	1.072	1.062	1.101
Only Land Regulation Changes (x,k,n) are fixed	1.006	1.017	1.014	1.023
Land regulation and x change, (k,n) fixed	1.008	1.022	1.019	1.030
Land regulation and (x,k) change, n fixed	1.009	1.026	1.021	1.035
Land regulation and (x,n) change, k fixed	1.012	1.031	1.028	1.044

8.3 Alternate Land Share of Final Goods Sector

The baseline specification calibrates the land share in the production of the consumption-investment good to five percent. However, as Davis et al. [2014] and Valentinyi and Herrendorf [2008] note, there is some uncertainty regarding the size of this share. This section therefore evaluates the sensitivity of the results to changes in this share. Tables 10 and 11 illustrate the results for two cases, one in which the land share is equal to 10% of final goods production, and the other in which the land share is equal to just 3%. Tables 10 shows that the welfare gains and output gains from deregulating halfway to the Texas level increase by approximately 7 percentage points with a 10% land share in final goods production. Table 11 illustrates that if land share is approximately halved to 3% in the final goods sector, output gains and welfare gains both fall to roughly 7%.[18].

[18]In Appendix E, we compute the housing supply elasticity and show that it is in within a range typically reported by the empirical literature under the assumption of a 5% land share

Table 10: 10% Land Share of Final Goods Sector. Variables expressed relative to baseline values $\frac{x_{2014,counterfactual}}{x_{2014,baseline}}$. Welfare expressed as fraction of lifetime consumption.

	(1) Baseline	(2) Dereg. CA to 2000	(3) Dereg. CA to 1980	(4) Dereg. CA & NY to 2000	(5) Dereg. CA & NY to 1980	(6) Dereg. All to 2000	(7) Dereg. All to 1980	(8) Dereg. 25% to TX	(9) Dereg. 50% to Texas
Relative Consumption	1	1.0093	1.0177	1.0196	1.0616	1.0481	1.1298	1.1137	1.191
Relative Output	1	1.0098	1.0186	1.0179	1.0526	1.043	1.1094	1.1019	1.1671
Relative Measured Solow Residual	1	1.0084	1.0159	1.0191	1.0604	1.0397	1.0955	1.0807	1.129
Relative Labor Productivity	1	1.0129	1.0243	1.0281	1.088	1.058	1.1377	1.1184	1.1892
Relative Investment	1	1.0103	1.0193	1.0165	1.045	1.0388	1.0922	1.092	1.147
Relative Labor	1	0.99698	0.99441	0.9901	0.96743	0.98589	0.97517	0.9853	0.98148
Cons. Equiv. Welfare Gain (percentage points)	0	0.89339	1.6915	1.6403	4.8826	4.1892	11.2107	10.3381	17.2662

Table 11: 3% Land Share of Final Goods Sector. Variables expressed relative to baseline values $\frac{x_{2014,counterfactual}}{x_{2014,baseline}}$. Welfare expressed as fraction of lifetime consumption.

	(1) Baseline	(2) Dereg. CA to 2000	(3) Dereg. CA to 1980	(4) Dereg. CA & NY to 2000	(5) Dereg. CA & NY to 1980	(6) Dereg. All to 2000	(7) Dereg. All to 1980	(8) Dereg. 25% to TX	(9) Dereg. 50% to Texas
Relative Consumption	1	1.0055	1.0113	1.0117	1.0376	1.0269	1.0731	1.0517	1.0873
Relative Output	1	1.0062	1.0127	1.0105	1.0298	1.0228	1.0547	1.0448	1.0723
Relative Measured Solow Residual	1	1.0062	1.0126	1.014	1.0448	1.0256	1.0578	1.0416	1.0656
Relative Labor Productivity	1	1.0095	1.0193	1.0208	1.0657	1.0375	1.0828	1.0612	1.0959
Relative Investment	1	1.0067	1.0135	1.0098	1.0256	1.0205	1.0448	1.0411	1.0643
Relative Labor	1	0.99677	0.99351	0.98989	0.96628	0.98585	0.97405	0.98461	0.97849
Cons. Equiv. Welfare Gain (percentage points)	0	0.51806	1.0602	0.86953	2.5339	2.1297	5.6513	4.4179	7.3592

8.4 Unregulated Land Use in the Final Goods Sector

The baseline model treats land-use regulations symmetrically for both residential and commercial development. We view this as a reasonable specification, given that various data sources show that residential land-use regulations are highly correlated with commercial land-use and business regulations. However, to understand the specific role of these regulations in terms of residential and commercial effects, we conduct the analysis in the extreme case in which commercial land use is completely deregulated. This means that the $\alpha_{yj} = 1 \quad \forall j$.

Table 12 shows the gains from deregulation under this specification. In this case, deregulation means regulatory changes only for residential development. Following deregulation of just the housing sector, welfare gains still reach 2.7 percent of lifetime consumption and output gains exceed 1.5 percent. These statistics are respectively about 1/4 to 1/6 as large as the benchmark case in which both sectors are initially regulated, and are then deregulated. Table 13 illustrates the same experiment, allowing for agglomeration with a three percent production elasticity. The welfare gains are about 3.3 percent, which is about 1/3 as large as in the benchmark experiment with no agglomeration.

Table 12: Undistorted Final Goods Sector: $\alpha_{yj} = 1 \quad \forall j$. Variables expressed relative to baseline values $\frac{x_{2014,counterfactual}}{x_{2014,baseline}}$. Welfare expressed as fraction of lifetime consumption.

	(1) Baseline	(2) Dereg. CA to 2000	(3) Dereg. CA to 1980	(4) Dereg. CA & NY to 2000	(5) Dereg. CA & NY to 1980	(6) Dereg. All to 2000	(7) Dereg. All to 1980	(8) Dereg. 25% to TX	(9) Dereg. 50% to Texas
Relative Consumption	1	1.0031	1.0058	1.0058	1.014	1.0128	1.0297	1.0268	1.041
Relative Output	1	1.0022	1.0039	1.0032	1.0065	1.0062	1.011	1.012	1.0166
Relative Measured Solow Residual	1	1.0023	1.0041	1.0048	1.0115	1.0081	1.0139	1.0117	1.016
Relative Labor Productivity	1	1.0031	1.0056	1.0064	1.0149	1.0102	1.0151	1.0131	1.0165
Relative Investment	1	1.0016	1.0027	1.0016	1.002	1.0022	0.99958	1.0029	1.0017
Relative Labor	1	0.99906	0.99835	0.99684	0.99172	0.99609	0.99597	0.99894	1.0001
Cons. Equiv. Welfare Gain (percentage points)	0	0.23878	0.43543	0.35922	0.78829	0.81617	1.8182	1.8203	2.723

8.5 Correlated Land-Use Regulations and Amenities

In the baseline counterfactuals, we changed the land-use regulation parameters, but kept the other parameters fixed. This section conducts counterfactuals in which the amenity pa-

Table 13: Agglomeration and Undistorted Final Goods Sector: $\alpha_{yj} = 1 \quad \forall j,\ \lambda = 0.03$. Variables expressed relative to baseline values $\frac{x_{2014,counterfactual}}{x_{2014,baseline}}$. Welfare expressed as fraction of lifetime consumption.

	(1) Baseline	(2) Dereg. CA to 2000	(3) Dereg. CA to 1980	(4) Dereg. CA & NY to 2000	(5) Dereg. CA & NY to 1980	(6) Dereg. All to 2000	(7) Dereg. All to 1980	(8) Dereg. 25% to TX	(9) Dereg. 50% to Texas
Relative Consumption	1	1.0033	1.0063	1.0066	1.0175	1.0144	1.0345	1.0298	1.0468
Relative Output	1	1.0032	1.0059	1.0047	1.0106	1.0094	1.0177	1.0189	1.0273
Relative Measured Solow Residual	1	1.0034	1.0064	1.0074	1.0195	1.0128	1.0239	1.02	1.0288
Relative Labor Productivity	1	1.0051	1.0095	1.0106	1.0273	1.0177	1.0308	1.0269	1.0374
Relative Investment	1	1.0031	1.0056	1.0036	1.0063	1.0064	1.0075	1.0123	1.0154
Relative Labor	1	0.99807	0.99642	0.99424	0.98374	0.9919	0.98734	0.99227	0.99032
Cons. Equiv. Welfare Gain (percentage points)	0	0.27831	0.52456	0.42098	0.98534	0.97371	2.2104	2.1836	3.3536

rameters change when land-use regulation changes. Our approach is to assess the statistical relationship between the model land-use regulation terms and the model amenities from the benchmark model, and then use this relationship to change amenities when we change the land-use regulations.

We pooled the benchmark steady state values from 1950 to 2014. After controlling for state level TFP and available land, we estimate the following relationship between amenities and state regulations:

$$a_{jt} = -1.323\alpha_{jt} + \hat{\gamma} X_{jt} + \hat{u}_{jt} \tag{15}$$

$$(0.262) \tag{16}$$

The point estimate on α_{jt} is significant at the 1 percent level. In Table 14, when we deregulate the economy, we impose that $\Delta a_{jt} = -1.323\Delta\alpha_{jt}$. This relationship suggests that amenities may decline in regions that deregulate land use. However, the impact of this alternative specification is not very large. Table 14 shows that the output gains and welfare gains remain quite large, reaching 9 percent for the case in which states are deregulated halfway to the Texas level.

Table 14: Covariance of Land Regulation and Amenities. Variables expressed relative to baseline values $\frac{x_{2014,counterfactual}}{x_{2014,baseline}}$. Welfare expressed as fraction of lifetime consumption.

	(1) Baseline	(2) Dereg. CA to 2000	(3) Dereg. CA to 1980	(4) Dereg. CA & NY to 2000	(5) Dereg. CA & NY to 1980	(6) Dereg. All to 2000	(7) Dereg. All to 1980	(8) Dereg. 25% to TX	(9) Dereg. 50% to Texas
Relative Consumption	1	1.0065	1.0128	1.0132	1.0377	1.031	1.079	1.0662	1.1082
Relative Output	1	1.007	1.0137	1.0117	1.0296	1.0263	1.0606	1.0566	1.0884
Relative Measured Solow Residual	1	1.0067	1.0131	1.0146	1.0422	1.0285	1.0661	1.0528	1.0831
Relative Labor Productivity	1	1.0102	1.02	1.0216	1.0614	1.0416	1.095	1.0772	1.1209
Relative Investment	1	1.0074	1.0142	1.0107	1.0247	1.0234	1.0493	1.0507	1.0762
Relative Labor	1	0.99681	0.99379	0.99034	0.97008	0.98528	0.96857	0.98083	0.97101
Cons. Equiv. Welfare Gain (percentage points)	0	0.60642	1.1871	1.0143	2.6187	2.49	6.1022	5.6173	8.9873

9 Conclusion

Historically, U.S. economic growth has gone hand-in-hand with the regional reallocation of labor and capital. The pace of resource reallocation, however, has slowed considerably. This decline has roughly coincided with lower productivity and output growth, as well as growing home price premia in high income states, including California and New York.

This paper develops a theory of these observations based on land-use regulations. We analyzed how policies that restrict land-use have affected resource reallocation, aggregate output and productivity, and regional employment shares.

We constructed a multi-region model economy in which regions differ by their productivity, their amenities, their urban land stock, and land-use regulations. We develop a procedure that uses the model together with data on land acreage, regional employment shares, and regional labor productivities to identify time series of regional TFP, amenities, and to systematically construct a time series of land-use regulations, which has been missing from the literature. Our model-inferred TFP, amenities, and land-use regulations compare fairly closely with independent measures of state-level regulations and quality of life measures.

We find that reforming land-use regulations would generate substantial reallocation of labor and capital across U.S. regions, and would significantly increase investment, output, productivity, and welfare. The results indicate that too few people are located in the highly productive states of California and New York. In particular, we find that deregulating just California and New York back to their 1980 land-use regulation levels would raise aggregate productivity by as much as 7 percent and consumption by as much as 5 percent. The results suggest that relaxing land-use restrictions may contribute significantly to higher aggregate economic performance.

In future work, we plan to explore the impact of land-use regulation on the wages and mobility of workers with varying degrees of skills. There are large regional differences in skill-levels and industry composition that may dampen or amplify the welfare gains from deregulation. We also plan to study transition dynamics following deregulation to shed light on the speed with which we may expect to see productivity and welfare gains from land-use deregulation and labor reallocation.

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A Data Appendix

Table 15 describes our data sources. To construct the CPI measures used to deflate nominal time series, we project Turner et al. [2007] onto Regional BLS CPI series for the Northeast, Midwest, South, and West which are available from 1987 onward. Let $P_{Turner,i}$ denote the Turner et al. [2007] price index for state i (where i is the state FIPS number). Let $P_{BLS,j}$ be the BLS price index for region $j \in \{west, midwest, northeast, south\} \equiv \mathcal{R}$. We regress $P_{Turneral,i} = \sum_{i=1}^{56} I(FIPS = i) + \sum_{j \in \mathcal{R}} P_{BLS,j} + \sum_{j \in \mathcal{R}} \sum_{i=1}^{56} I(FIPS = i) \times P_{BLS,j} + e_{it}$, which yields a goodness of fit of .99 for the time period in which the series overlap (1987 to 2000). We then project forward. Figure 8 illustrates our projected CPI.

To correct for the USDA's imputation bias of urban land discussed in the text, we take the 2010 Decennial Census estimate of fraction of urban land by state, $U_{i,2010}(\%)$, and multiply by total land from the USDA in 2007, $T_{i,2007}$, (total land is not subject to the imputation bias and 2007 is the latest public estimate) to compute a consistent time series estimate for urban land in state i in 2010 (Urban Land State i 2010=$U_{i,2010}(\%) \times T_{i,2007}$). Figure 9 illustrates the estimated urban land acreage series and compares it to the imputation biased version from the USDA. We linearly interpolate between 1997, the last available unbiased estimate of urban land from the USDA, and our consistent 2010 estimate of urban land to recover urban land in 2000. For urban land in 2014, we use our consistent estimate of urban land in 2010, unadjusted.

Table 15: Data Sources

Time Series	Source	Years	Units	Additional Notes
Employment	BLS	1950-2014	Thousands	Latest version provided by Yamarik.
Population	Census	1950-2014	Thousands	Latest version provided by Yamarik.
Regional Price Deflator	Turner et al	1950-2000	Base year 2000	Latest version provided by Tamura.
Projected Price Deflator	Project Turner et al on BLS Regional CPIs (Northeast, Midwest, South, West), R2 is .990 for 1987-2000. Project forward.	2000-2014	Base year 2000	
Real Output per worker	Turner et al	1950-2000	Real $2000	Latest version provided by Tamura.
Real Output per worker	BEA, deflated by Projected CPI	2000-2014	Real $2000	
Median Single Family House Prices	US Census of Housing	1950-2000	Nominal	https://www.census.gov/hhes/www/housing/census/historic/values.html
Median Single Family House Prices	ACS	2014	Nominal	Consistent restrictions: non-commercial, owner occupied, on land less than 10 acres.
Urban Land Acreage	USDA-ERS	1945-1997	Acres	https://www.ers.usda.gov/data-products/major-land-uses/
Urban Land Acreage	Decennial Census Urban Land Percent Multiplied by USDA-ERS Total State Land Acreage	2014	Acres	https://www.census.gov/geo/reference/ua/urban-rural-2010.html

Figure 8: Regional Deflator Projection based on BLS Regional CPIs for Midwest, Northeast, West and South (Wyoming)

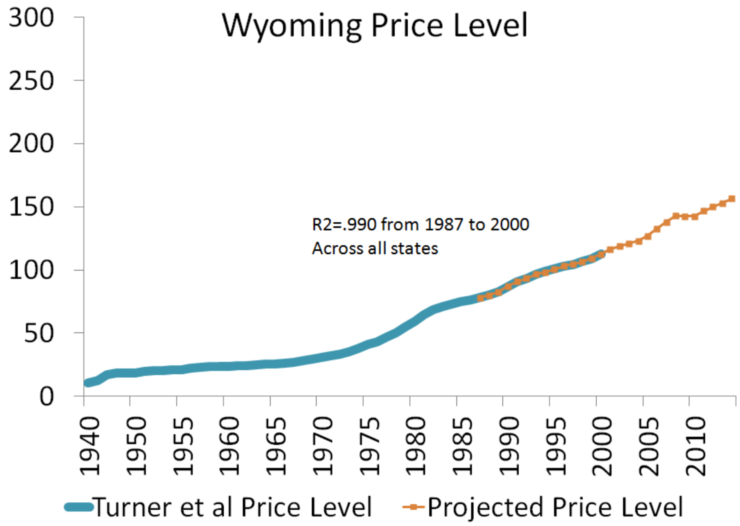
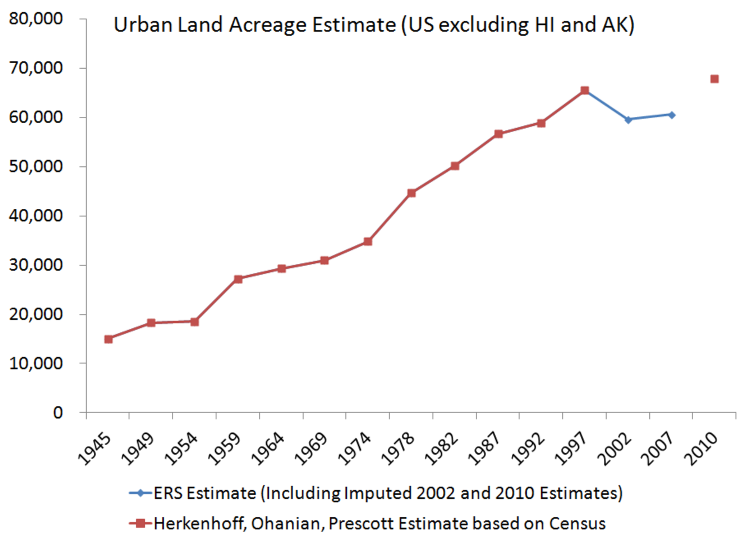


Figure 9: Urban Land Estimates based on 2010 Census Urban Land Shares



B List of All Parameters

Tables 16 to 18 describe the full set of parameters, moments, and model generated moments for the 2014 steady state calibration without agglomeration. Tables 19 to 22 include the time series of all parameters in the 1950, 1960, 1970, 1980, 1990, 2000, and 2014 steady states without agglomeration. Tables 23 to 26 include the values of $\alpha_{j,2014}$ in each of the experiments. This is a disaggregated version of Table 5.

Table 16: Moments and parameters for 2014 Steady State, $\lambda = 0$.

	Model	**Data**	**Parameter**	**Value**
Labor Productivity in AL	7.0525	7.0525	$A_{AL,2014}$	3.2475
Employment in AL	0.008251	0.008251	$a_{AL,2014}$	-0.29827
House Prices in AL	9.7668	9.7668	$\alpha_{AL,2014}$	0.024592
Land Per Capita in AL	0.45978	0.45978	$x_{AL,2014}$	0.45978
Labor Productivity in AZ	7.8342	7.8342	$A_{AZ,2014}$	3.6621
Employment in AZ	0.011019	0.011019	$a_{AZ,2014}$	-0.38118
House Prices in AZ	14.364	14.364	$\alpha_{AZ,2014}$	0.015033
Land Per Capita in AZ	0.44324	0.44324	$x_{AZ,2014}$	0.44324
Labor Productivity in AR	6.9941	6.9941	$A_{AR,2014}$	3.1696
Employment in AR	0.0051	0.0051	$a_{AR,2014}$	-0.3017
House Prices in AR	8.466	8.466	$\alpha_{AR,2014}$	0.040913
Land Per Capita in AR	0.23755	0.23755	$x_{AR,2014}$	0.23755
Labor Productivity in CA	10.3801	10.3801	$A_{CA,2014}$	4.8058
Employment in CA	0.067122	0.067122	$a_{CA,2014}$	-0.66826
House Prices in CA	27.6327	27.6327	$\alpha_{CA,2014}$	0.005362
Land Per Capita in CA	2.0835	2.0835	$x_{CA,2014}$	2.0835
Labor Productivity in CO	8.8999	8.8999	$A_{CO,2014}$	4.1236
Employment in CO	0.010558	0.010558	$a_{CO,2014}$	-0.51385
House Prices in CO	18.6732	18.6732	$\alpha_{CO,2014}$	0.011411
Land Per Capita in CO	0.33515	0.33515	$x_{CO,2014}$	0.33515
Labor Productivity in CT	11.3084	11.3084	$A_{CT,2014}$	4.9091
Employment in CT	0.007148	0.007148	$a_{CT,2014}$	-0.88681
House Prices in CT	21.1341	21.1341	$\alpha_{CT,2014}$	0.00489
Land Per Capita in CT	0.46502	0.46502	$x_{CT,2014}$	0.46502
Labor Productivity in DE	10.6419	10.6419	$A_{DE,2014}$	4.6108
Employment in DE	0.001878	0.001878	$a_{DE,2014}$	-0.81024
House Prices in DE	17.8004	17.8004	$\alpha_{DE,2014}$	0.010533
Land Per Capita in DE	0.08066	0.08066	$x_{DE,2014}$	0.08066
Labor Productivity in FL	7.5835	7.5835	$A_{FL,2014}$	3.5309
Employment in FL	0.03357	0.03357	$a_{FL,2014}$	-0.35532
House Prices in FL	12.8163	12.8163	$\alpha_{FL,2014}$	0.015775
Land Per Capita in FL	1.6342	1.6342	$x_{FL,2014}$	1.6342
Labor Productivity in GA	8.114	8.114	$A_{GA,2014}$	3.6045
Employment in GA	0.017829	0.017829	$a_{GA,2014}$	-0.46436
House Prices in GA	10.6803	10.6803	$\alpha_{GA,2014}$	0.022018
Land Per Capita in GA	0.99416	0.99416	$x_{GA,2014}$	0.99416
Labor Productivity in ID	6.9123	6.9123	$A_{ID,2014}$	3.2977
Employment in ID	0.002811	0.002811	$a_{ID,2014}$	-0.25131
House Prices in ID	12.1376	12.1375	$\alpha_{ID,2014}$	0.021204
Land Per Capita in ID	0.10849	0.10849	$x_{ID,2014}$	0.10849
Labor Productivity in IL	8.8695	8.8695	$A_{IL,2014}$	3.8911
Employment in IL	0.025195	0.025195	$a_{IL,2014}$	-0.57363
House Prices in IL	12.2217	12.2217	$\alpha_{IL,2014}$	0.025454
Land Per Capita in IL	0.94415	0.94415	$x_{IL,2014}$	0.94415
Labor Productivity in IN	7.6135	7.6135	$A_{IN,2014}$	3.3657
Employment in IN	0.012786	0.012786	$a_{IN,2014}$	-0.40132
House Prices in IN	8.7298	8.7298	$\alpha_{IN,2014}$	0.041241
Land Per Capita in IN	0.5848	0.5848	$x_{IN,2014}$	0.5848
Labor Productivity in IA	7.685	7.685	$A_{IA,2014}$	3.3884
Employment in IA	0.006642	0.006642	$a_{IA,2014}$	-0.41276
House Prices in IA	8.7659	8.7659	$\alpha_{IA,2014}$	0.059451
Land Per Capita in IA	0.21013	0.21013	$x_{IA,2014}$	0.21013
Labor Productivity in KS	7.4273	7.4273	$A_{KS,2014}$	3.3301
Employment in KS	0.005975	0.005975	$a_{KS,2014}$	-0.3667
House Prices in KS	9.1166	9.1166	$\alpha_{KS,2014}$	0.044064
Land Per Capita in KS	0.22666	0.22666	$x_{KS,2014}$	0.22666
Labor Productivity in KY	6.9975	6.9975	$A_{KY,2014}$	3.1994
Employment in KY	0.007971	0.007971	$a_{KY,2014}$	-0.29619
House Prices in KY	9.0692	9.0692	$\alpha_{KY,2014}$	0.040094
Land Per Capita in KY	0.32225	0.32225	$x_{KY,2014}$	0.32225
Labor Productivity in LA	8.6477	8.6477	$A_{LA,2014}$	3.7548
Employment in LA	0.008498	0.008498	$a_{LA,2014}$	-0.55348
House Prices in LA	10.5826	10.5826	$\alpha_{LA,2014}$	0.025438
Land Per Capita in LA	0.4388	0.4388	$x_{LA,2014}$	0.4388

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Table 17: Moments and parameters for 2014 Steady State, $\lambda = 0$, *continued.*

	Model	Data	Parameter	Value
Labor Productivity in ME	7.0252	7.0252	$A_{ME,2014}$	3.391
Employment in ME	0.002593	0.002593	$a_{ME,2014}$	-0.25292
House Prices in ME	13.8332	13.8332	$\alpha_{ME,2014}$	0.01772
Land Per Capita in ME	0.08994	0.08994	$x_{ME,2014}$	0.08994
Labor Productivity in MD	9.5046	9.5046	$A_{MD,2014}$	4.3966
Employment in MD	0.011236	0.011236	$a_{MD,2014}$	-0.58169
House Prices in MD	21.8589	21.8589	$\alpha_{MD,2014}$	0.006213
Land Per Capita in MD	0.47954	0.47954	$x_{MD,2014}$	0.47954
Labor Productivity in MA	10.2659	10.2659	$A_{MA,2014}$	4.7359
Employment in MA	0.014645	0.014645	$a_{MA,2014}$	-0.6645
House Prices in MA	26.1294	26.1294	$\alpha_{MA,2014}$	0.003696
Land Per Capita in MA	0.74088	0.74088	$x_{MA,2014}$	0.74088
Labor Productivity in MI	7.485	7.485	$A_{MI,2014}$	3.3281
Employment in MI	0.017932	0.017932	$a_{MI,2014}$	-0.3801
House Prices in MI	8.7298	8.7298	$\alpha_{MI,2014}$	0.037832
Land Per Capita in MI	0.88285	0.88285	$x_{MI,2014}$	0.88285
Labor Productivity in MN	7.8911	7.8911	$A_{MN,2014}$	3.6434
Employment in MN	0.01207	0.01207	$a_{MN,2014}$	-0.40101
House Prices in MN	13.3242	13.3242	$\alpha_{MN,2014}$	0.022344
Land Per Capita in MN	0.3896	0.3896	$x_{MN,2014}$	0.3896
Labor Productivity in MS	6.4702	6.4702	$A_{MS,2014}$	3.0064
Employment in MS	0.004803	0.004803	$a_{MS,2014}$	-0.21613
House Prices in MS	8.3715	8.3715	$\alpha_{MS,2014}$	0.036284
Land Per Capita in MS	0.24481	0.24481	$x_{MS,2014}$	0.24481
Labor Productivity in MO	7.2558	7.2558	$A_{MO,2014}$	3.3113
Employment in MO	0.01173	0.01173	$a_{MO,2014}$	-0.33132
House Prices in MO	9.8179	9.8179	$\alpha_{MO,2014}$	0.03387
Land Per Capita in MO	0.47833	0.47833	$x_{MO,2014}$	0.47833
Labor Productivity in MT	7.0345	7.0345	$A_{MT,2014}$	3.4108
Employment in MT	0.001947	0.001947	$a_{MT,2014}$	-0.24912
House Prices in MT	14.364	14.364	$\alpha_{MT,2014}$	0.015953
Land Per Capita in MT	0.06897	0.06897	$x_{MT,2014}$	0.06897
Labor Productivity in NE	7.8576	7.8576	$A_{NE,2014}$	3.4562
Employment in NE	0.004262	0.004262	$a_{NE,2014}$	-0.43774
House Prices in NE	9.1166	9.1166	$\alpha_{NE,2014}$	0.06177
Land Per Capita in NE	0.12019	0.12019	$x_{NE,2014}$	0.12019
Labor Productivity in NV	7.9062	7.9062	$A_{NV,2014}$	3.6842
Employment in NV	0.005214	0.005214	$a_{NV,2014}$	-0.39305
House Prices in NV	14.364	14.364	$\alpha_{NV,2014}$	0.022089
Land Per Capita in NV	0.14358	0.14358	$x_{NV,2014}$	0.14358
Labor Productivity in NH	8.4412	8.4412	$A_{NH,2014}$	3.997
Employment in NH	0.002779	0.002779	$a_{NH,2014}$	-0.43269
House Prices in NH	19.2128	19.2128	$\alpha_{NH,2014}$	0.006321
Land Per Capita in NH	0.14479	0.14479	$x_{NH,2014}$	0.14479
Labor Productivity in NJ	10.6594	10.6594	$A_{NJ,2014}$	4.8131
Employment in NJ	0.016999	0.016999	$a_{NJ,2014}$	-0.7462
House Prices in NJ	24.4654	24.4654	$\alpha_{NJ,2014}$	0.005127
Land Per Capita in NJ	0.73241	0.73241	$x_{NJ,2014}$	0.73241
Labor Productivity in NM	8.295	8.295	$A_{NM,2014}$	3.7366
Employment in NM	0.003519	0.003519	$a_{NM,2014}$	-0.47529
House Prices in NM	12.5685	12.5685	$\alpha_{NM,2014}$	0.0151
Land Per Capita in NM	0.19883	0.19883	$x_{NM,2014}$	0.19883
Labor Productivity in NY	11.8242	11.8242	$A_{NY,2014}$	4.9997
Employment in NY	0.038973	0.038973	$a_{NY,2014}$	-0.98923
House Prices in NY	19.417	19.417	$\alpha_{NY,2014}$	0.014937
Land Per Capita in NY	1.0369	1.0369	$x_{NY,2014}$	1.0369
Labor Productivity in NC	8.1392	8.1392	$A_{NC,2014}$	3.6575
Employment in NC	0.01777	0.01777	$a_{NC,2014}$	-0.45781
House Prices in NC	11.7483	11.7483	$\alpha_{NC,2014}$	0.018411
Land Per Capita in NC	0.95061	0.95061	$x_{NC,2014}$	0.95061
Labor Productivity in ND	9.0122	9.0122	$A_{ND,2014}$	3.9041
Employment in ND	0.00198	0.00198	$a_{ND,2014}$	-0.60373
House Prices in ND	11.5711	11.5711	$\alpha_{ND,2014}$	0.05668
Land Per Capita in ND	0.03831	0.03831	$x_{ND,2014}$	0.03831

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Table 18: Moments and parameters for 2014 Steady State, $\lambda = 0$, *continued*.

	Model	**Data**	**Parameter**	**Value**
Labor Productivity in OH	7.7472	7.7472	$A_{OH,2014}$	3.4222
Employment in OH	0.02287	0.02287	$a_{OH,2014}$	-0.41988
House Prices in OH	9.079	9.079	$\alpha_{OH,2014}$	0.037927
Land Per Capita in OH	1.0498	1.0498	$x_{OH,2014}$	1.0498
Labor Productivity in OK	8.2963	8.2963	$A_{OK,2014}$	3.5668
Employment in OK	0.007095	0.007095	$a_{OK,2014}$	-0.51317
House Prices in OK	8.8188	8.8188	$\alpha_{OK,2014}$	0.046927
Land Per Capita in OK	0.29684	0.29684	$x_{OK,2014}$	0.29684
Labor Productivity in OR	8.1709	8.1709	$A_{OR,2014}$	3.8576
Employment in OR	0.007385	0.007385	$a_{OR,2014}$	-0.40757
House Prices in OR	17.2704	17.2704	$\alpha_{OR,2014}$	0.011113
Land Per Capita in OR	0.27224	0.27224	$x_{OR,2014}$	0.27224
Labor Productivity in PA	9.1942	9.1942	$A_{PA,2014}$	4.0406
Employment in PA	0.024841	0.024841	$a_{PA,2014}$	-0.61348
House Prices in PA	13.5919	13.5919	$\alpha_{PA,2014}$	0.016806
Land Per Capita in PA	1.1289	1.1289	$x_{PA,2014}$	1.1289
Labor Productivity in RI	8.6783	8.6783	$A_{RI,2014}$	4.0489
Employment in RI	0.002048	0.002048	$a_{RI,2014}$	-0.47955
House Prices in RI	18.4443	18.4443	$\alpha_{RI,2014}$	0.007331
Land Per Capita in RI	0.10244	0.10244	$x_{RI,2014}$	0.10244
Labor Productivity in SC	6.9708	6.9708	$A_{SC,2014}$	3.2608
Employment in SC	0.00836	0.00836	$a_{SC,2014}$	-0.27561
House Prices in SC	10.6803	10.6803	$\alpha_{SC,2014}$	0.018611
Land Per Capita in SC	0.49607	0.49607	$x_{SC,2014}$	0.49607
Labor Productivity in SD	7.5507	7.5507	$A_{SD,2014}$	3.4152
Employment in SD	0.001817	0.001817	$a_{SD,2014}$	-0.3765
House Prices in SD	10.1685	10.1685	$\alpha_{SD,2014}$	0.054079
Land Per Capita in SD	0.04396	0.04396	$x_{SD,2014}$	0.04396
Labor Productivity in TN	7.4128	7.4128	$A_{TN,2014}$	3.3867
Employment in TN	0.012079	0.012079	$a_{TN,2014}$	-0.35076
House Prices in TN	10.4644	10.4644	$\alpha_{TN,2014}$	0.0227
Land Per Capita in TN	0.64288	0.64288	$x_{TN,2014}$	0.64288
Labor Productivity in TX	9.9432	9.9432	$A_{TX,2014}$	4.0988
Employment in TX	0.049554	0.049554	$a_{TX,2014}$	-0.77093
House Prices in TX	10.2298	10.2298	$\alpha_{TX,2014}$	0.041778
Land Per Capita in TX	1.8738	1.8738	$x_{TX,2014}$	1.8738
Labor Productivity in UT	7.5879	7.5879	$A_{UT,2014}$	3.6501
Employment in UT	0.005697	0.005697	$a_{UT,2014}$	-0.31959
House Prices in UT	16.4467	16.4467	$\alpha_{UT,2014}$	0.013716
Land Per Capita in UT	0.18149	0.18149	$x_{UT,2014}$	0.18149
Labor Productivity in VT	7.2559	7.2559	$A_{VT,2014}$	3.5125
Employment in VT	0.00133	0.00133	$a_{VT,2014}$	-0.27557
House Prices in VT	15.3703	15.3703	$\alpha_{VT,2014}$	0.01699
Land Per Capita in VT	0.03872	0.03872	$x_{VT,2014}$	0.03872
Labor Productivity in VA	8.6814	8.6814	$A_{VA,2014}$	4.0203
Employment in VA	0.016192	0.016192	$a_{VA,2014}$	-0.49011
House Prices in VA	17.4444	17.4444	$\alpha_{VA,2014}$	0.010732
Land Per Capita in VA	0.62715	0.62715	$x_{VA,2014}$	0.62715
Labor Productivity in WA	9.5183	9.5183	$A_{WA,2014}$	4.3099
Employment in WA	0.013196	0.013196	$a_{WA,2014}$	-0.61617
House Prices in WA	18.652	18.652	$\alpha_{WA,2014}$	0.008866
Land Per Capita in WA	0.56343	0.56343	$x_{WA,2014}$	0.56343
Labor Productivity in WV	6.9248	6.9248	$A_{WV,2014}$	3.135
Employment in WV	0.003271	0.003271	$a_{WV,2014}$	-0.29304
House Prices in WV	8.1882	8.1882	$\alpha_{WV,2014}$	0.044628
Land Per Capita in WV	0.15003	0.15003	$x_{WV,2014}$	0.15003
Labor Productivity in WI	7.1617	7.1617	$A_{WI,2014}$	3.3392
Employment in WI	0.012206	0.012206	$a_{WI,2014}$	-0.30216
House Prices in WI	11.1742	11.1742	$\alpha_{WI,2014}$	0.028848
Land Per Capita in WI	0.42872	0.42872	$x_{WI,2014}$	0.42872
Labor Productivity in WY	10.3177	10.3178	$A_{WY,2014}$	4.3919
Employment in WY	0.001255	0.001255	$a_{WY,2014}$	-0.79124
House Prices in WY	14.364	14.364	$\alpha_{WY,2014}$	0.020584
Land Per Capita in WY	0.04436	0.04436	$x_{WY,2014}$	0.04436
Employment Per Capita	0.59	0.59		

Table 19: Time Series of Estimated Parameters, TFP

	1950	1960	1970	1980	1990	2000	2014
A_{AL}	1.1441	1.6453	2.044	2.2909	2.5595	2.9335	3.2475
A_{AZ}	1.4601	1.9086	2.378	2.5486	2.6814	3.3906	3.6621
A_{AR}	1.0455	1.526	2.0159	2.1715	2.3525	2.9478	3.1696
A_{CA}	1.8292	2.3477	2.7384	2.9389	3.347	3.8559	4.8058
A_{CO}	1.4683	1.8826	2.2356	2.6611	2.8538	3.8581	4.1236
A_{CT}	1.7416	1.8829	2.2811	2.4945	3.1634	3.9705	4.9091
A_{DE}	1.9332	2.3419	2.7037	2.7861	3.4766	4.4446	4.6108
A_{FL}	1.4641	1.9178	2.3571	2.5045	2.6785	3.1768	3.5309
A_{GA}	1.1986	1.679	2.1543	2.3415	2.7601	3.369	3.6045
A_{ID}	1.402	1.7056	2.1056	2.3742	2.4623	2.9218	3.2977
A_{IL}	1.765	2.1948	2.562	2.6021	2.8997	3.5286	3.8911
A_{IN}	1.5502	1.913	2.2092	2.2264	2.4514	2.9906	3.3657
A_{IA}	1.4118	1.7218	2.1345	2.3323	2.3711	2.98	3.3884
A_{KS}	1.4189	1.6964	2.0041	2.3165	2.4768	3.0322	3.3301
A_{KY}	1.2904	1.7675	2.3246	2.3291	2.5646	3.2034	3.1994
A_{LA}	1.566	2.1896	2.6443	3.3167	3.1778	3.3618	3.7548
A_{ME}	1.2827	1.4799	1.8082	1.9948	2.2366	2.5216	3.391
A_{MD}	1.5893	1.945	2.3775	2.459	3.004	3.4653	4.3966
A_{MA}	1.6386	1.7742	2.1503	2.3063	2.9422	3.9457	4.7359
A_{MI}	1.7296	2.0535	2.4903	2.3401	2.5669	3.1764	3.3281
A_{MN}	1.5011	1.8496	2.3066	2.4018	2.6723	3.4185	3.6434
A_{MS}	0.93675	1.4498	1.9675	2.1827	2.2855	2.7406	3.0064
A_{MO}	1.4844	1.8455	2.2085	2.2608	2.5194	2.9398	3.3113
A_{MT}	1.4828	1.8132	2.1103	2.4807	2.334	2.6502	3.4108
A_{NE}	1.4325	1.7684	2.1136	2.313	2.5174	3.0375	3.4562
A_{NV}	1.8014	2.2827	2.7656	2.8515	3.1669	3.6227	3.6842
A_{NH}	1.3192	1.5027	1.8476	2.0562	2.4016	3.022	3.997
A_{NJ}	1.718	1.977	2.3915	2.5173	3.2153	4.0134	4.8131
A_{NM}	1.5595	2.0791	2.2696	2.7405	2.6104	3.0009	3.7366
A_{NY}	1.9099	2.1674	2.6582	2.7081	3.2867	4.1271	4.9997
A_{NC}	1.1908	1.6069	2.1537	2.2373	2.6524	3.3708	3.6575
A_{ND}	1.242	1.6116	1.9689	2.4622	2.2995	2.7972	3.9041
A_{OH}	1.6737	2.0917	2.4102	2.4005	2.6219	3.0929	3.4222
A_{OK}	1.3836	1.8286	2.1347	2.7281	2.5576	2.89	3.5668
A_{OR}	1.5629	1.9883	2.3588	2.4884	2.385	3.215	3.8576
A_{PA}	1.5916	1.7928	2.147	2.3088	2.5067	3.0604	4.0406
A_{RI}	1.6228	1.6215	1.9222	2.0944	2.5604	2.9902	4.0489
A_{SC}	1.0804	1.4442	1.9441	2.1878	2.5118	2.9114	3.2608
A_{SD}	1.2737	1.5759	1.8656	2.0844	2.2987	2.9074	3.4152
A_{TN}	1.2366	1.6478	2.1386	2.3278	2.6765	3.2783	3.3867
A_{TX}	1.5538	1.9577	2.3543	2.9387	2.9173	3.5496	4.0988
A_{UT}	1.5978	1.9706	2.1759	2.5476	2.629	3.2625	3.6501
A_{VT}	1.3223	1.5014	2.0217	2.0034	2.3325	2.6773	3.5125
A_{VA}	1.3705	1.7975	2.2792	2.515	2.9872	3.6172	4.0203
A_{WA}	1.6729	2.1083	2.519	2.6931	2.7876	3.6525	4.3099
A_{WV}	1.5166	1.9	2.3508	2.4934	2.4095	2.6326	3.135
A_{WI}	1.5234	1.9241	2.2406	2.3393	2.4774	3.0489	3.3392
A_{WY}	1.7971	2.2283	2.5876	3.8695	3.3054	3.4578	4.3919

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Table 20: Time Series of Estimated Parameters, Amenity (greater values indicate greater amenities)

	1950	1960	1970	1980	1990	2000	2014
a_{AL}	-0.19825	-0.39848	-0.43577	-0.4592	-0.41365	-0.24021	-0.29827
a_{AZ}	-0.54706	-0.63513	-0.6623	-0.48509	-0.34448	-0.38232	-0.38118
a_{AR}	-0.08578	-0.34172	-0.45597	-0.38845	-0.30687	-0.29853	-0.3017
a_{CA}	-0.84578	-0.94574	-0.79134	-0.55488	-0.38759	-0.39754	-0.66826
a_{CO}	-0.48203	-0.5592	-0.50164	-0.50338	-0.45847	-0.5188	-0.51385
a_{CT}	-0.53457	-0.40507	-0.37087	-0.32312	-0.32029	-0.58491	-0.88681
a_{DE}	-1.0444	-1.0709	-0.93659	-0.77917	-0.86032	-1.0129	-0.81024
a_{FL}	-0.49921	-0.57464	-0.64949	-0.51767	-0.36869	-0.30959	-0.35532
a_{GA}	-0.21422	-0.38865	-0.46595	-0.45994	-0.46212	-0.40372	-0.46436
a_{ID}	-0.46794	-0.41509	-0.45683	-0.41811	-0.30535	-0.16067	-0.25131
a_{IL}	-0.79335	-0.79157	-0.72151	-0.53077	-0.50371	-0.43304	-0.57363
a_{IN}	-0.63347	-0.63212	-0.53651	-0.35812	-0.32491	-0.23993	-0.40132
a_{IA}	-0.41569	-0.43513	-0.47473	-0.42252	-0.32149	-0.27775	-0.41276
a_{KS}	-0.48388	-0.4297	-0.40038	-0.43749	-0.35885	-0.30501	-0.3667
a_{KY}	-0.34867	-0.53386	-0.69883	-0.48995	-0.43995	-0.39588	-0.29619
a_{LA}	-0.76466	-0.96608	-0.95828	-1.3354	-0.88391	-0.50151	-0.55348
a_{ME}	-0.31287	-0.21633	-0.20893	-0.15108	-0.02739	0.034307	-0.25292
a_{MD}	-0.59327	-0.60274	-0.57541	-0.36061	-0.41871	-0.34963	-0.58169
a_{MA}	-0.53725	-0.37233	-0.34602	-0.31037	-0.221	-0.51626	-0.6645
a_{MI}	-0.81461	-0.72615	-0.7093	-0.43771	-0.36984	-0.27591	-0.3801
a_{MN}	-0.45027	-0.47482	-0.53558	-0.36692	-0.37499	-0.39517	-0.40101
a_{MS}	0.055621	-0.20567	-0.39183	-0.39204	-0.25938	-0.18059	-0.21613
a_{MO}	-0.51356	-0.53991	-0.53188	-0.40047	-0.34254	-0.22611	-0.33132
a_{MT}	-0.59039	-0.52912	-0.46389	-0.5018	-0.22037	-0.03202	-0.24912
a_{NE}	-0.47142	-0.50998	-0.49618	-0.43232	-0.40259	-0.29065	-0.43774
a_{NV}	-0.86884	-0.93752	-0.89535	-0.62966	-0.6269	-0.45344	-0.39305
a_{NH}	-0.27354	-0.17557	-0.16537	-0.1131	0.019974	-0.13707	-0.43269
a_{NJ}	-0.60496	-0.53089	-0.50024	-0.38865	-0.40372	-0.59904	-0.7462
a_{NM}	-0.71366	-0.86299	-0.64679	-0.74757	-0.34599	-0.19957	-0.47529
a_{NY}	-0.89685	-0.76268	-0.76835	-0.68967	-0.57735	-0.739	-0.98923
a_{NC}	-0.22474	-0.36857	-0.51435	-0.37874	-0.41236	-0.41503	-0.45781
a_{ND}	-0.24034	-0.3136	-0.34349	-0.50269	-0.23434	-0.20173	-0.60373
a_{OH}	-0.67981	-0.717	-0.62944	-0.431	-0.39374	-0.26681	-0.41988
a_{OK}	-0.48116	-0.64756	-0.55306	-0.84793	-0.45367	-0.27263	-0.51317
a_{OR}	-0.62005	-0.69704	-0.61819	-0.39492	-0.22342	-0.19213	-0.40757
a_{PA}	-0.62558	-0.50933	-0.4953	-0.40427	-0.29334	-0.27106	-0.61348
a_{RI}	-0.48111	-0.25229	-0.19404	-0.15286	-0.06845	-0.12061	-0.47955
a_{SC}	-0.06498	-0.20584	-0.3126	-0.34559	-0.33419	-0.19215	-0.27561
a_{SD}	-0.28259	-0.31187	-0.29064	-0.25114	-0.27115	-0.24607	-0.3765
a_{TN}	-0.27432	-0.41429	-0.51788	-0.47291	-0.4731	-0.41637	-0.35076
a_{TX}	-0.69347	-0.76375	-0.74421	-1.0073	-0.65854	-0.63344	-0.77093
a_{UT}	-0.654	-0.65247	-0.45742	-0.46291	-0.36656	-0.23456	-0.31959
a_{VT}	-0.27289	-0.2076	-0.31761	-0.11978	-0.05862	-0.01181	-0.27557
a_{VA}	-0.36891	-0.47342	-0.52101	-0.49851	-0.52709	-0.50408	-0.49011
a_{WA}	-0.76234	-0.79104	-0.69101	-0.54253	-0.38694	-0.39408	-0.61617
a_{WV}	-0.65551	-0.74426	-0.75909	-0.57759	-0.34159	-0.11238	-0.29304
a_{WI}	-0.48709	-0.55	-0.47731	-0.34513	-0.29167	-0.21384	-0.30216
a_{WY}	-1.001	-0.98343	-0.90103	-1.6941	-0.95888	-0.51283	-0.79124

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Table 21: Time Series of Estimated Parameters, Land Regulation (greater values indicate *less* regulation)

	1950	1960	1970	1980	1990	2000	2014
α_{AL}	0.20211	0.06114	0.090578	0.026379	0.02534	0.023629	0.024592
α_{AZ}	0.18867	0.046464	0.047246	0.011889	0.012155	0.014734	0.015033
α_{AR}	0.23724	0.13237	0.12744	0.042337	0.041495	0.043292	0.040913
α_{CA}	0.050369	0.03692	0.029427	0.009102	0.004528	0.007215	0.005362
α_{CO}	0.15392	0.077042	0.064041	0.01552	0.018483	0.011312	0.011411
α_{CT}	0.040581	0.034512	0.026539	0.011252	0.004584	0.007771	0.00489
α_{DE}	0.18704	0.081107	0.087685	0.039444	0.021027	0.023173	0.010533
α_{FL}	0.062003	0.039387	0.05465	0.020036	0.019159	0.020835	0.015775
α_{GA}	0.16911	0.061625	0.06969	0.033171	0.024458	0.018812	0.022018
α_{ID}	0.16391	0.072753	0.086808	0.032188	0.039109	0.023409	0.021204
α_{IL}	0.14415	0.062988	0.064725	0.029634	0.030162	0.020445	0.025454
α_{IN}	0.23137	0.10559	0.09956	0.044447	0.05445	0.031213	0.041241
α_{IA}	0.080272	0.05906	0.085494	0.031192	0.063681	0.046575	0.059451
α_{KS}	0.1732	0.098543	0.105	0.04119	0.050252	0.043544	0.044064
α_{KY}	0.29225	0.12964	0.14387	0.061022	0.068092	0.044007	0.040094
α_{LA}	0.20267	0.06852	0.098269	0.047996	0.045169	0.03512	0.025438
α_{ME}	0.21503	0.091368	0.078662	0.012391	0.008786	0.017946	0.01772
α_{MD}	0.19179	0.083278	0.062744	0.01617	0.010836	0.012034	0.006213
α_{MA}	0.096171	0.058252	0.044301	0.022836	0.006118	0.0073	0.003696
α_{MI}	0.14161	0.064427	0.065199	0.044614	0.046428	0.021241	0.037832
α_{MN}	0.061801	0.032546	0.048533	0.013854	0.021609	0.020419	0.022344
α_{MS}	0.2059	0.088387	0.11067	0.047138	0.046461	0.043056	0.036284
α_{MO}	0.17331	0.087835	0.092344	0.044731	0.038422	0.034713	0.03387
α_{MT}	0.24317	0.099378	0.1229	0.035349	0.04001	0.02444	0.015953
α_{NE}	0.15401	0.12588	0.16033	0.058693	0.087506	0.053959	0.06177
α_{NV}	0.049323	0.044976	0.029772	0.011371	0.010171	0.0125	0.022089
α_{NH}	0.13181	0.079758	0.04545	0.010994	0.005363	0.010799	0.006321
α_{NJ}	0.045344	0.035842	0.031653	0.016691	0.006548	0.010389	0.005127
α_{NM}	0.090017	0.064053	0.078232	0.022741	0.016167	0.014151	0.0151
α_{NY}	0.12499	0.083703	0.078101	0.052873	0.016526	0.02275	0.014937
α_{NC}	0.27653	0.13164	0.13107	0.046373	0.036896	0.02182	0.018411
α_{ND}	0.1535	0.084298	0.12191	0.041765	0.067585	0.07307	0.05668
α_{OH}	0.11878	0.05066	0.060595	0.030146	0.037859	0.02587	0.037927
α_{OK}	0.2355	0.0941	0.11509	0.031003	0.032946	0.041377	0.046927
α_{OR}	0.13893	0.072194	0.067887	0.019439	0.039598	0.012401	0.011113
α_{PA}	0.20142	0.12973	0.1504	0.050308	0.041526	0.031235	0.016806
α_{RI}	0.068296	0.064532	0.049568	0.025564	0.008602	0.012756	0.007331
α_{SC}	0.17478	0.11093	0.088671	0.036914	0.031492	0.021986	0.018611
α_{SD}	0.11872	0.091559	0.13494	0.048318	0.081953	0.064264	0.054079
α_{TN}	0.27164	0.11842	0.10726	0.03559	0.032554	0.027724	0.0227
α_{TX}	0.1686	0.068334	0.10213	0.038712	0.034729	0.045522	0.041778
α_{UT}	0.045679	0.036556	0.05024	0.012247	0.021344	0.012106	0.013716
α_{VT}	0.098584	0.094771	0.10382	0.034752	0.019169	0.02455	0.01699
α_{VA}	0.14339	0.064677	0.054602	0.0231	0.018585	0.019434	0.010732
α_{WA}	0.11438	0.052656	0.037945	0.015375	0.016979	0.008722	0.008866
α_{WV}	0.35781	0.21182	0.27661	0.069771	0.091234	0.052553	0.044628
α_{WI}	0.083451	0.041678	0.055377	0.02515	0.040202	0.025305	0.028848
α_{WY}	0.14669	0.083011	0.10138	0.029469	0.034899	0.025626	0.020584

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Table 22: Time Series of Estimated Parameters, Urban Land per 100 US Individuals

	1950	1960	1970	1980	1990	2000	2014
x_{AL}	0.41659	0.66681	0.48422	0.88318	0.95208	0.69782	0.45978
x_{AZ}	0.07353	0.27771	0.31717	0.52937	0.68734	0.63337	0.44324
x_{AR}	0.18686	0.2441	0.25561	0.35917	0.43856	0.33945	0.23755
x_{CA}	1.9496	2.1674	2.3801	2.5202	2.872	2.5524	2.0835
x_{CO}	0.12858	0.20061	0.25882	0.36037	0.45579	0.43109	0.33515
x_{CT}	0.26077	0.35498	0.37991	0.44442	0.43243	0.49102	0.46502
x_{DE}	0.02476	0.05425	0.0588	0.06677	0.07464	0.08402	0.08066
x_{FL}	0.70974	0.8814	1.1174	1.569	1.8354	1.8519	1.6342
x_{GA}	0.42954	0.66374	0.61509	0.86977	1.0098	1.0805	0.99416
x_{ID}	0.06838	0.08222	0.08243	0.0921	0.11027	0.11807	0.10849
x_{IL}	0.78593	0.9829	1.0271	1.0334	1.0442	1.0665	0.94415
x_{IN}	0.38249	0.50151	0.5932	0.6018	0.62581	0.65096	0.5848
x_{IA}	0.43221	0.45204	0.3357	0.39703	0.38358	0.29777	0.21013
x_{KS}	0.21906	0.25605	0.27939	0.30224	0.32924	0.28677	0.22666
x_{KY}	0.19182	0.26986	0.2931	0.3392	0.36952	0.37022	0.32225
x_{LA}	0.40878	0.46313	0.37772	0.47751	0.53847	0.54324	0.4388
x_{ME}	0.10077	0.14807	0.14852	0.34695	0.28039	0.17227	0.08994
x_{MD}	0.15791	0.28061	0.35686	0.50016	0.55275	0.55585	0.47954
x_{MA}	0.43564	0.64634	0.66819	0.76723	0.68893	0.7951	0.74088
x_{MI}	0.76784	0.97539	0.92599	0.90852	0.90334	0.96445	0.88285
x_{MN}	0.47411	0.668	0.50815	0.77468	0.68967	0.53966	0.3896
x_{MS}	0.20039	0.25929	0.27224	0.34695	0.39564	0.32939	0.24481
x_{MO}	0.39925	0.51209	0.56184	0.60836	0.67328	0.59179	0.47833
x_{MT}	0.056	0.06363	0.0569	0.07094	0.08427	0.0843	0.06897
x_{NE}	0.14191	0.13988	0.13028	0.1389	0.14062	0.13802	0.12019
x_{NV}	0.04362	0.04947	0.09979	0.14218	0.26358	0.24951	0.14358
x_{NH}	0.06305	0.07796	0.1119	0.21372	0.19147	0.17151	0.14479
x_{NJ}	0.75279	0.86776	0.8526	0.8027	0.81728	0.8285	0.73241
x_{NM}	0.17201	0.17127	0.17201	0.2155	0.27119	0.25628	0.19883
x_{NY}	1.0722	1.299	1.1569	1.2316	1.1977	1.1729	1.0369
x_{NC}	0.35239	0.51431	0.51997	0.6954	0.80776	0.97866	0.95061
x_{ND}	0.05238	0.05663	0.04756	0.05723	0.05889	0.05081	0.03831
x_{OH}	0.86746	1.2958	1.2278	1.2462	1.2494	1.2069	1.0498
x_{OK}	0.22039	0.43584	0.37334	0.68854	0.72117	0.48491	0.29684
x_{OR}	0.18515	0.23592	0.24423	0.26916	0.28896	0.30163	0.27224
x_{PA}	0.89127	1.1122	1.011	1.0567	1.0512	1.1786	1.1289
x_{RI}	0.08877	0.10815	0.11059	0.10224	0.10425	0.11083	0.10244
x_{SC}	0.22744	0.31183	0.31221	0.45366	0.52399	0.54634	0.49607
x_{SD}	0.07581	0.07454	0.06025	0.06319	0.07042	0.05871	0.04396
x_{TN}	0.27563	0.44863	0.53178	0.76008	0.84752	0.76095	0.64288
x_{TX}	1.0839	2.1725	1.8378	2.4331	2.7121	2.3661	1.8738
x_{UT}	0.22648	0.21084	0.16398	0.25127	0.26887	0.22862	0.18149
x_{VT}	0.04667	0.04452	0.03064	0.0462	0.05234	0.04939	0.03872
x_{VA}	0.33239	0.48036	0.55017	0.71	0.76346	0.74194	0.62715
x_{WA}	0.33639	0.42032	0.45242	0.49837	0.6073	0.64381	0.56343
x_{WV}	0.15143	0.16819	0.10855	0.11893	0.13047	0.15693	0.15003
x_{WI}	0.46707	0.63764	0.51238	0.53653	0.54186	0.50608	0.42872
x_{WY}	0.04172	0.04111	0.03779	0.05455	0.07612	0.06953	0.04436

Table 23: Deregulation Experiments: Full set of parameters for 48 states

	AL	AR	AZ	CA	CO	CT	DE	FL	GA	IA	ID	IL	IN
Baseline $\alpha_{j,2014}$	0.024592	0.015033	0.040913	0.005362	0.011411	0.00489	0.010533	0.015775	0.022018	0.021204	0.025454	0.041241	0.059451
Deregulate CA to 2000 $\alpha_{j,2014}$	0.024592	0.015033	0.040913	0.007215	0.011411	0.00489	0.010533	0.015775	0.022018	0.021204	0.025454	0.041241	0.059451
Deregulate CA to 1980 $\alpha_{j,2014}$	0.024592	0.015033	0.040913	0.009102	0.011411	0.00489	0.010533	0.015775	0.022018	0.021204	0.025454	0.041241	0.059451
Deregulate CA & NY to 2000 $\alpha_{j,2014}$	0.024592	0.015033	0.040913	0.007215	0.011411	0.00489	0.010533	0.015775	0.022018	0.021204	0.025454	0.041241	0.059451
Deregulate CA & NY to 1980 $\alpha_{j,2014}$	0.024592	0.015033	0.040913	0.009102	0.011411	0.00489	0.010533	0.015775	0.022018	0.021204	0.025454	0.041241	0.059451
Deregulate All to 2000 $\alpha_{j,2014}$	0.023629	0.014734	0.043292	0.007215	0.011312	0.007771	0.023173	0.020835	0.018812	0.023409	0.020445	0.031213	0.046575
Deregulate All to 1980 $\alpha_{j,2014}$	0.026379	0.011889	0.042337	0.009102	0.01552	0.011252	0.039444	0.020036	0.033171	0.032188	0.029634	0.044447	0.031192
Deregulate 25% to TX $\alpha_{j,2014}$	0.028889	0.021719	0.041129	0.014466	0.019003	0.014112	0.018344	0.022276	0.026958	0.026347	0.029535	0.041375	0.055033
Deregulate 50% to Texas $\alpha_{j,2014}$	0.033185	0.028406	0.041345	0.02357	0.026594	0.023334	0.026155	0.028777	0.031898	0.031491	0.033616	0.041509	0.050615

continued...

Table 24: Deregulation Experiments: Full set of parameters for 48 states, continued

	KS	KY	LA	MA	MD	ME	MI	MN	MO	MS	MT	NC	ND
Baseline $\alpha_{j,2014}$	0.044064	0.040094	0.025438	0.01772	0.006213	0.003696	0.037832	0.022344	0.036284	0.03387	0.015953	0.06177	0.022089
Deregulate CA to 2000 $\alpha_{j,2014}$	0.044064	0.040094	0.025438	0.01772	0.006213	0.003696	0.037832	0.022344	0.036284	0.03387	0.015953	0.06177	0.022089
Deregulate CA to 1980 $\alpha_{j,2014}$	0.044064	0.040094	0.025438	0.01772	0.006213	0.003696	0.037832	0.022344	0.036284	0.03387	0.015953	0.06177	0.022089
Deregulate CA & NY to 2000 $\alpha_{j,2014}$	0.044064	0.040094	0.025438	0.01772	0.006213	0.003696	0.037832	0.022344	0.036284	0.03387	0.015953	0.06177	0.022089
Deregulate CA & NY to 1980 $\alpha_{j,2014}$	0.044064	0.040094	0.025438	0.01772	0.006213	0.003696	0.037832	0.022344	0.036284	0.03387	0.015953	0.06177	0.022089
Deregulate All to 2000 $\alpha_{j,2014}$	0.043544	0.044007	0.03512	0.017946	0.012034	0.0073	0.021241	0.020419	0.043056	0.034713	0.02444	0.053959	0.0125
Deregulate All to 1980 $\alpha_{j,2014}$	0.04119	0.061022	0.047996	0.012391	0.01617	0.022836	0.044614	0.013854	0.047138	0.044731	0.035349	0.058693	0.011371
Deregulate 25% to TX $\alpha_{j,2014}$	0.043493	0.040515	0.029523	0.023735	0.015104	0.013216	0.038819	0.027203	0.037657	0.035847	0.022409	0.056772	0.027011
Deregulate 50% to Texas $\alpha_{j,2014}$	0.042921	0.040936	0.033608	0.029749	0.023996	0.022737	0.039805	0.032061	0.039031	0.037824	0.028865	0.051774	0.031933

continued...

Table 25: Deregulation Experiments: Full set of parameters for 48 states, continued

	NE	NH	NJ	NM	NV	NY	OH	OK	OR	PA	RI	SC	SD
Baseline $\alpha_{j,2014}$	0.006321	0.005127	0.0151	0.014937	0.018411	0.05668	0.037927	0.046927	0.011113	0.016806	0.007331	0.018611	0.054079
Deregulate CA to 2000 $\alpha_{j,2014}$	0.006321	0.005127	0.0151	0.014937	0.018411	0.05668	0.037927	0.046927	0.011113	0.016806	0.007331	0.018611	0.054079
Deregulate CA to 1980 $\alpha_{j,2014}$	0.006321	0.005127	0.0151	0.014937	0.018411	0.05668	0.037927	0.046927	0.011113	0.016806	0.007331	0.018611	0.054079
Deregulate CA & NY to 2000 $\alpha_{j,2014}$	0.006321	0.005127	0.0151	0.02275	0.018411	0.05668	0.037927	0.046927	0.011113	0.016806	0.007331	0.018611	0.054079
Deregulate CA & NY to 1980 $\alpha_{j,2014}$	0.006321	0.005127	0.0151	0.052873	0.018411	0.05668	0.037927	0.046927	0.011113	0.016806	0.007331	0.018611	0.054079
Deregulate All to 2000 $\alpha_{j,2014}$	0.010799	0.010389	0.014151	0.02275	0.02182	0.07307	0.02587	0.041377	0.012401	0.031235	0.012756	0.021986	0.064264
Deregulate All to 1980 $\alpha_{j,2014}$	0.010994	0.016691	0.022741	0.052873	0.046373	0.041765	0.030146	0.031003	0.019439	0.050308	0.025564	0.036914	0.048318
Deregulate 25% to TX $\alpha_{j,2014}$	0.015185	0.01429	0.021769	0.021647	0.024253	0.052954	0.03889	0.04564	0.018779	0.023049	0.015943	0.024403	0.051004
Deregulate 50% to Texas $\alpha_{j,2014}$	0.024049	0.023452	0.028439	0.028357	0.030094	0.049229	0.039852	0.044353	0.026445	0.029292	0.024554	0.030194	0.047928

continued...

Table 26: Deregulation Experiments: Full set of parameters for 48 states, continued

	TN	TX	UT	VA	VT	WA	WI	WV	WY
Baseline $\alpha_{j,2014}$	0.0227	0.041778	0.013716	0.01699	0.010732	0.008866	0.044628	0.028848	0.020584
Deregulate CA to 2000 $\alpha_{j,2014}$	0.0227	0.041778	0.013716	0.01699	0.010732	0.008866	0.044628	0.028848	0.020584
Deregulate CA to 1980 $\alpha_{j,2014}$	0.0227	0.041778	0.013716	0.01699	0.010732	0.008866	0.044628	0.028848	0.020584
Deregulate CA & NY to 2000 $\alpha_{j,2014}$	0.0227	0.041778	0.013716	0.01699	0.010732	0.008866	0.044628	0.028848	0.020584
Deregulate CA & NY to 1980 $\alpha_{j,2014}$	0.0227	0.041778	0.013716	0.01699	0.010732	0.008866	0.044628	0.028848	0.020584
Deregulate All to 2000 $\alpha_{j,2014}$	0.027724	0.045522	0.012106	0.02455	0.019434	0.008722	0.052553	0.025305	0.025626
Deregulate All to 1980 $\alpha_{j,2014}$	0.03559	0.038712	0.012247	0.034752	0.0231	0.015375	0.069771	0.02515	0.029469
Deregulate 25% to TX $\alpha_{j,2014}$	0.027469	0.041778	0.020731	0.023187	0.018494	0.017094	0.043915	0.03208	0.025883
Deregulate 50% to Texas $\alpha_{j,2014}$	0.032239	0.041778	0.027747	0.029384	0.026255	0.025322	0.043203	0.035313	0.031181

C Identification of Model Parameters

This section shows how the parameters for land-use regulations, amenities, and state TFP are identified. We assume the econometrician has data on the share parameters, r, n_j, y_j/n_j, p_j, and x_j. This proof relies on specific functional forms for production in order to obtain closed form solutions. However, we obtain the same results in computer simulations with more general production functions. We assume $\alpha_j = \alpha_{hj} = \alpha_{yj}$.

- Solve for k_{hj}: Use first order condition for k_{hj} in housing, $\frac{rk_{hj}}{p_j h_j} = \xi$, and the fact that the stand-in household sets $h_j = n_j$.
- Solve for k_{yj}: Use first order condition for k_{yj} in final goods, $\frac{rk_{yj}}{y_j} = \theta$
- Solve for w_j: Use first order condition for n_j in final goods, $\frac{w_j n_j}{y_j} = \chi$
- Solve for c: Finals goods resource constraint yields c and y, $\sum_j (k_{yj} + k_{hj}) = k$, $y = \sum y_j$, and in steady state $i = \delta k$, $c = y - i$.
- Solve for amenities a_j using the labor leisure condition:

$$-\frac{u_{njt}}{u_{ct}} = w_{jt} - p_{jt} + \frac{a_{jt}}{u_{ct}}$$

- Solve for effective units of land $\alpha_{hj} x_{hj}$: Use definition of production function, $h_j = (k_{hj})^{\xi} (\alpha_{hj} x_{hj})^{1-\xi}$, and solve for $\alpha_{hj} x_{hj} = \big(\frac{n_j}{(k_{hj})^{\xi}}\big)^{(1/(1-\xi))}$
- Solve for land price q_j: Use land share in housing, $\frac{q_j x_{hj}}{p_j n_j} = 1 - \xi$, and land share in final goods, $\frac{q_j x_{yj}}{y_j} = 1 - \theta - \chi$. Rearrange and add these equations, and use $x_j = x_{hj} + x_{yj}$:

$$q_j x_{hj} + q_j x_{yj} = (1 - \xi) p_j n_j + (1 - \theta - \chi) y_j$$

  Thus

$$q_j = \frac{1}{x_j} [(1 - \xi) p_j n_j + (1 - \theta - \chi) y_j]$$

- Recover x_{hj} and x_{yj}: $x_{hj} = \frac{(1-\xi) p_j n_j}{q_j}$, and land share in final goods, $x_{yj} = \frac{(1-\theta-\chi) y_j}{q_j}$
- Solve for α_{hj} using x_{hj} and the expression for effective units of land, $\alpha_{hj} x_{hj} = \big(\frac{n_j}{(k_{hj})^{\xi}}\big)^{(1/(1-\xi))}$,

$$\alpha_{hj} = \Big(\frac{n_j}{(k_{hj})^{\xi}}\Big)^{(1/(1-\xi))} \frac{q_j}{(1 - \xi) p_j n_j}$$

$$\alpha_{hj} = (1-\xi)\frac{q_j}{p_j}\left(\frac{n_j}{k_{hj}}\right)^{\frac{\xi}{1-\xi}}$$

Substitute in the definition of q_j

$$\alpha_{hj} = \frac{(1-\xi)}{x_j}\left(\frac{n_j}{k_{hj}}\right)^{\frac{\xi}{1-\xi}}[(1-\xi)n_j + (1-\theta-\chi)\frac{y_j}{p_j}]$$

- Impose $\alpha_j = \alpha_{hj} = \alpha_{yj}$. This allows us to identify TFP.
- Now using $(x_{hj}, x_{yj}, \alpha_{yj})$ and n_j, k_{yj}, y_j, we can recover total factor productivity A_j:

$$y_j = A_j k_{yj}^{\theta} n_j^{\chi} (\alpha_{yj} x_{yj})^{1-\theta-\chi}$$

D Wage Predictions

Our model features wages that are proportional to labor productivity. This section compares the model wages (labor productivity) to wage data. We used the 1962 Annual Social and Economic Supplement (ASEC) of the Current Population Survey (CPS), which is the earliest available data, and computed the hourly wage using the midpoint of actual hours worked in the previous week h_d, actual weeks worked in the previous year w_d, and total annual income y_d, and compared this to the model wage rate $(\frac{y_d}{h_d w_d})$. We use consistent time series and weights for 2014. We deflated the data using the regional CPI as described in Section 5. To compare the model to the data, we calculate the rank correlation between the model wage (labor productivity) and the wages. This rank correlation is 0.59, which indicates that regions with strong wage growth (strong labor productivity growth) in the model are also regions with strong wage growth in the data.[19]

E Implied Housing Supply Elasticity

The elasticity of housing supply - the sensitivity of housing production to a change in price - is a common input in the empirical literature in this area. We therefore compute an implied housing supply elasticity from our model. Before doing this, it is important to note that this elasticity is not a primitive in our general equilibrium model. Therefore, we use the following approach. We follow the empirical literature and assume that there is a shock that raises the demand for housing. We therefore solve the model under the assumption that labor, $n_{j,2014}$, is exogenously set to its prior steady state level, and $w_{j,2014}$ is consistent with this value of $n_{j,2014}$. We then simulate a 'demand shock' which is modeled as a small exogenous increase in $n_{j,2014}$ that is equally distributed across islands. This mechanical increase in labor on each island requires a commensurate increase in housing on each island. The implied housing supply elasticity, which is the percent change in the housing stock relative to the percent change in the price of housing, is about 2.87. Even though there are important conceptual differences between the housing supply elasticity in our model and in the empirical literature, the value we obtain is within the range of 1 -3 reported by Saiz [2010]. While our housing

[19]We calculate the rank correlation given that it is well known that wage growth over the last 40 years has been less than productivity growth. This reflects the fact that labor share has changed, and that the composition of worker compensation has changed over time.

supply elasticity also falls within these bounds, this exercise brings up difficult conceptual issues faced by the applied literature. What is a demand shock, and how do equilibrium conditions factor into their analysis? In the event study that we conduct with our model, all equilibrium conditions except for the labor leisure condition and the first order condition for labor demand by firms, hold. Land adjusts, capital adjusts, and the housing constraint must be satisfied. There are an infinite number of other experiments to run; holding capital on some or all islands fixed; holding capital fixed within sectors; fixing land use, land prices, or other equilibrium objects that are inputs into the housing sector; fixing aggregate labor but simply shifting workers to one island; allowing the housing constraints to be slack in the short run, etc. etc. We have provided a simple estimate of 'a' housing supply elasticity, although it may or may not align with what empirical housing economists natural experiments are capturing.

F Impact of Deregulation on Other Aggregates: House Prices, Wages, and the Labor Wedge

Table 27 includes all aggregate variables in the model. The deregulation has an ambiguous impact on the aggregate house price (calculated as the employment weighted house price across regions). Aggregate house prices may increase after deregulation if the most heavily deregulated regions have large productivity levels in final goods production, thus inducing much more labor to enter the region and drive up house prices. Wages also increase under deregulation since labor becomes more productive. There are two reasons labor becomes more productive: (1) the direct effect of deregulation on productivity, and (2) capital and land are reallocated to the final goods sector. The implied aggregate labor wedge is also included in the table, where the implied labor wedge is calculated using a prototype, single-region, no-housing, neoclassical model with separable CRRA utility (i.e. Labor Wedge$=(1-\tau)=\frac{n^{\frac{1}{\psi}}c^{\sigma}}{w}$, $\psi=2$, $\sigma=2$). Larger values of the labor wedge indicate less implicit taxes on labor. This implicit tax is proportional to the regional house price, and thus the aggregate labor wedge is not necessarily increasing in the degree of deregulation. However, unambiguously, welfare and consumption improve under deregulation.

Table 27: Full List of Aggregates. Benchmark Calibration, $\lambda = 0$. Variables expressed relative to baseline values $\frac{x_{2014,counterfactual}}{x_{2014,baseline}}$. Welfare expressed as fraction of lifetime consumption.

	(1) Baseline	(2) Dereg. CA to 2000	(3) Dereg. CA to 1980	(4) Dereg. CA & NY to 2000	(5) Dereg. CA & NY to 1980	(6) Dereg. All to 2000	(7) Dereg. All to 1980	(8) Dereg. 25% to TX	(9) Dereg. 50% to Texas
Relative Consumption	1.000	1.007	1.013	1.014	1.045	1.033	1.090	1.071	1.119
Relative Output	1.000	1.007	1.015	1.013	1.037	1.029	1.072	1.062	1.101
Relative Measured Solow Residual	1.000	1.007	1.014	1.016	1.050	1.030	1.069	1.054	1.085
Relative Labor Productivity	1.000	1.011	1.021	1.023	1.073	1.044	1.100	1.079	1.124
Relative Investment	1.000	1.008	1.015	1.012	1.032	1.026	1.060	1.057	1.089
Relative Labor	1.000	0.997	0.994	0.990	0.967	0.986	0.974	0.984	0.979
Relative House Price	1.000	1.017	1.032	1.011	0.997	1.004	0.927	1.001	0.959
Relative Wage	1.000	1.010	1.020	1.024	1.078	1.047	1.112	1.084	1.135
Relative Final Goods Land Share	1.000	1.007	1.013	1.013	1.039	1.033	1.091	1.074	1.122
Relative Labor Wedge	1.000	1.002	1.004	0.999	0.996	1.013	1.055	1.049	1.091
Cons. Equiv. Welfare Gain (percentage points)	0	0.633	1.253	1.106	3.250	2.760	7.341	6.210	10.317