

The Rise of Housing Supply Regulation in the U.S.: Local Causes and Aggregate Implications*

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Abstract

Regulatory restrictions on housing supply have been rising in recent decades in the U.S. and have become a major determinant of house prices. What are the implications of the rise in regulation for aggregate productivity, and for wage and house price dispersion across metropolitan areas? To answer this question, I build a general equilibrium model with multiple locations, heterogeneous workers and endogenous regulation. Regulation is decided by voting: renters want less regulation and owners want more. In locations with faster exogenous productivity growth, labor supply and house prices also grow more rapidly. Homeowners in these places vote for stricter regulation, which raises prices further and leads to greater price dispersion. High-skilled workers, being less sensitive to housing costs, sort into productive places, which leads to larger wage dispersion. That is, wage and house price differences are amplified by regulation choices. To quantify this amplification effect, I calibrate the model to the U.S. economy and find that the rise in regulation accounts for 23% of the increase in wage dispersion and 85% of the increase in house price dispersion across metro areas from 1980 to 2007. I find that if regulation had not increased, more workers would live in productive areas and output would be 2% higher. I also show that policy interventions that weaken incentives of local governments to restrict supply could reduce wage and house price dispersion, and boost productivity.

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

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

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1 Introduction

Regulation of housing supply in the U.S. has become much stricter since the 1970's. This is important because land, materials and labor are far from the only costs faced by builders: zoning laws, public opposition to new construction, and project approval delays all add significantly to the cost of providing housing. Locations also differ greatly in how strictly they regulate housing supply, and these differences have been increasing. Regulation has grown especially stringent in highly productive metropolitan areas, such as San Francisco, New York and Boston, meaning that workers often choose to live not where they are most productive but where housing is affordable.¹ The housing affordability crisis and the restrictions on housing supply in the most productive U.S. metro areas have attracted a lot of attention from the media, policymakers and academics in recent years.² Yet we know little about the mechanisms that make housing markets in productive places so regulated, and the magnitude of their effects on the economy as a whole.

The rise of regulation has been accompanied by a broad pattern of spatial divergence in the U.S. Since 1980, the variance of log mean hourly wages across metro areas almost doubled, while the variance of log quality-adjusted house prices more than tripled. During the same period, workers have become more sorted by skill: metro areas with a larger fraction of college-educated workers in the labor force in 1980 added more college workers over the next three decades than other metro areas.³ Some of the previous attempts to explain these facts emphasized the role of regulatory restrictions on the supply of housing. However, those studies did not take into account the endogeneity of regulation to local characteristics, such as population size, skill mix and real estate prices. Furthermore, the existing work typically focuses on the effects of the levels of regulation rather than the effects of the increase in regulation.

This paper makes three contributions. First, it proposes a general equilibrium model with multiple locations and heterogeneous workers, in which regulation in every location is determined endogenously in a political process. Second, it calculates the effects of the rise of housing supply regulation in the U.S. on aggregate productivity, on the increase in wage and house price dispersion across metropolitan areas, and on the skill sorting between 1980 and 2007. Third, it quantitatively evaluates federal policies that reduce incentives of local governments to regulate housing supply, and shows that these policies could lower wage and house price dispersion across metro areas, and raise aggregate productivity.

¹This paper focuses on metropolitan statistical areas (MSAs), but uses the notions “metro area”, “city” and “location” interchangeably.

²See, for example, The Economist (2016) and White House (2016).

³Moretti (2012) calls these and other related phenomena “The Great Divergence.”

The model has a life-cycle structure and is populated by workers with heterogeneous skills. In the first period they choose where to live, and their choice depends on wages, housing costs, and idiosyncratic location preferences. In each subsequent period they choose whether to own or rent a house. Individuals prefer to own, however purchasing a house requires a downpayment. Thus buying immediately may not be feasible and workers need to accumulate savings to afford a house. Housing is built by competitive developers. In equilibrium, house prices depend on population size and regulation. Regulation is assumed to affect the prices through the elasticity of supply. In highly regulated markets the supply of housing will be slow to react to new demand and, as a result, the prices will increase. In markets with low regulation the supply of housing will accommodate most of the rise in demand and the prices will not change much.

Regulation is determined in a political process, designed along the lines of a standard model of probabilistic voting with lobbying. Every period elections are held for local governments, and residents vote for candidates, each of which runs with a proposed level of regulation. The selected level of regulation is determined by two competing sets of interests: those of renters and those of owners. Renters prefer less regulation because this decreases rents and house prices, thereby lowering the downpayment they need to pay in case they decide to buy. Homeowners prefer more regulation as it increases the value of their houses.⁴ Owners finance the candidates' campaigns with monetary contributions, and the size of the required contribution is increasing in the proposed level of regulation. Given that regulation is costly, the incentive of owners to support stricter regulation depends on how important the value of the house is in their asset portfolios and on the sensitivity of prices to changes in regulation which is higher in cities with scarce land. The ability of owners to influence local governments depends on the fraction of high-skilled workers among the homeowners, i.e. how educated they are. Therefore, in equilibrium, denser and more productive locations are more regulated.

The exogenous forces that drive the skill sorting and the rise in wage and house price dispersion are (1) changes in city-specific productivities and skill-biased technical change, (2) population growth, and (3) the increase in the share of workers with college degree. Locations where productivity is growing rapidly attract workers and, due to an increase in population density, housing there becomes more expensive. A rise in housing costs moderates the inflow of workers, but the high-skilled are not affected as much as the low-skilled, since the former spend less of their income on housing. Thus skill sorting across locations intensifies, especially if the changes in local productivity are skill-biased. Larger differences in skill ratios lead to

⁴The idea that homeowners favor stricter regulation due to their concern for the value of their property was promoted by Fischel (2001) and called the "homevoter hypothesis."

larger differences in mean wages. What is the role of regulation? An increase in house prices after a productivity shock makes real estate a more important asset in owners' portfolios and they vote to raise regulation. Once they do so, prices rise even more and the relative inflow of high versus low skilled workers is more disproportionate. That is, endogenous regulation choices amplify the effects of changes in exogenous productivities and lead to even more skill sorting, and wage and house price dispersion. Population growth makes cities more congested on average and enhances the demand for regulation. The increase in the share of college graduates improves the ability of residents to affect the decisions of local governments.

The model parameters are disciplined by a set of moments that describe local labor and housing markets in the U.S. in 2007. The calibrated economy comprises 190 metropolitan areas. As a measure of regulation, I use the Wharton Residential Land Use Regulatory Index, constructed for the year 2007 by Gyourko, Saiz and Summers (2008). The calibration only targets three moments of the observed distribution of regulation, yet the model predicts a significant portion of the observed distribution.

In order to study the effects of the *rise* in regulation, we must have data on regulation for multiple years, and such data does not exist for a broad set of metropolitan areas. However, given that the model explains well the observed variation in regulation in 2007, it can be used to impute levels of regulation for other years. Thus I construct a 1980 economy in which total population, exogenous productivities and college attainment are at the 1980 level. In this economy regulation endogenously adjusts: it is lower than in 2007 on average and the differences across locations are smaller, which is consistent with the literature on the increase in regulation. I focus on stationary spatial equilibria.⁵ To evaluate the effect of the rise in regulation on the U.S. economy, I compare the benchmark economy calibrated to 2007 with the same economy in which regulation is fixed at the 1980 level predicted by the model.

I find that if regulation had not increased after 1980, the magnitude of the skill sorting would be smaller. As a result, wage inequality across cities would grow by 23% less from 1980 to 2007. The rise of regulation also led to aggregate productivity losses. Had regulation remained at the 1980 level, output would be more than 2% higher in 2007, since more workers would be able to live in highly productive but currently unaffordable cities. Absent the growth in regulation, houses would be 43% less expensive on average in 2007, while house price dispersion would increase by 85% less between 1980 and 2007. These effects are highly heterogeneous across space. If regulation had not changed since 1980, house prices in some expensive areas such as New York, San Francisco and Miami would be more than 60% lower,

⁵By focusing on stationary environment I restrict my attention to long-term effects of regulation. However, elasticity of housing supply also matters for the ability of a city to withstand short-term fluctuations: Arias, Gascon and Rapach (2016) find that areas with less elastic supply experience more severe recessions.

whereas in many inexpensive areas such as Dallas and Houston they would not change much.

The main reason why the rise of regulation since 1980 has had negative aggregate effects, according to this paper's model, is that local governments choose regulation independently and disregard the implications of their decisions on the rest of the economy. In other words, residents of every city impose an externality on the residents of other cities. The existence of externalities implies that national-level policies might improve aggregate outcomes. To evaluate the effectiveness of such policies, I study two alternative arrangements. In the first, the federal government sets an exogenous limit on regulation which no city can exceed. In the second, the government runs a redistributive scheme which taxes owners of expensive real estate, which typically concentrate in highly regulated cities, and provides transfers to the owners of cheap real estate. These policies raise output and wages by about 1.5%, reduce average house prices by 20-25%, and lead to a substantial fall in house price dispersion and a moderate reduction in wage inequality. The effects, again, are heterogeneous across cities, and the policies mostly affect large expensive metro areas.

This paper is organized as follows. The rest of this section places this work in the existing literature. Section 2 describes the data and provides empirical evidence about local labor and housing markets, and land use regulation. Section 3 describes the model. Section 4 discusses the values of model parameters. Section 5 describes the benchmark economy and presents comparative static effects of regulation. Section 6 evaluates the role of the rise of regulation for aggregate productivity, and the increase in wage and house price dispersion from 1980 to 2007. Section 7 investigates hypothetical interventions of a central government into regulatory decisions of local governments. Finally, Section 8 concludes.

1.1 Literature

This paper is connected to several strands of literature.⁶ First, it draws on the evidence on the effects of land use regulation on housing supply and prices at the local level. This literature, summarized in Quigley and Rosenthal (2005), typically finds that stricter regulation causes higher land and house prices and lower supply of new structures.⁷ Saiz (2010) concludes that both geographic and regulatory constraints are central in explaining price differences across metropolitan areas in the U.S. Both types of constraints are also crucial in the current paper.

This paper contributes to a more recent literature that looks at general equilibrium implications of regulation. The common theme of this work is that regulation leads to

⁶Gyourko and Molloy (2015) provide an excellent review of the literature on land use regulation and its effects on housing and labor markets.

⁷See also Mayer and Somerville (2000) and Ihlanfeldt (2007).

misallocation of labor by preventing workers from living in productive places, and may therefore have aggregate effects.⁸ Ganong and Shoag (2015) build a time-series index of regulation at the state level, and show that regulation has risen on average and has become more different across U.S. states. Their paper argues that the increase in regulation has halted cross-state income convergence and contributed to the rising wage inequality since the 1970’s. Hsieh and Moretti (2015), using a quantitative spatial equilibrium model, argue that reducing regulation in just three highly productive metro areas with sky-high house prices – New York, San Francisco and San Jose – to the median U.S. level would lead to a nearly 10% rise in aggregate output in 2009 due to a massive inflow of workers who previously found these places unaffordable.⁹ The key driving forces of the mechanisms in these papers are also present in the current paper, however the previous work treats regulation as exogenous and remains silent on why some cities are more regulated than others.¹⁰

At the same time, a few papers modeled endogenous emergence of regulation in a spatial equilibrium setting. However, unlike this paper, they typically propose a theoretical mechanism without quantitatively evaluating the effects of regulation. Hilber and Robert-Nicoud (2013) study a lobbying game in which landowners, who prefer more regulation, compete with developers, who prefer less.¹¹ In equilibrium locations with better amenities are both more developed and more regulated. Their model is consistent with the observed positive relationship between amenities and regulation. In a voting model of Ortalo-Magné and Prat (2014), which formalizes the “homevoter hypothesis” of Fischel (2001), undersupply of housing occurs when the median voter is heavily invested in real estate. In this case, new construction reduces house values and hurts the median voter.

This paper joins the literature on the causes of the rise in house price dispersion across metro areas since around 1980. Besides, it contributes to a large literature on the causes of the escalation in income inequality since late 1970’s. Glaeser, Gyourko and Saks (2005b)

⁸Even if residential land use regulation has negative aggregate effects, it need not lead to welfare losses, since the stated aim of most land use regulation is to protect residents from negative externalities that arise from congestion or adjacent non-residential land use. Yet Turner, Haughwout and van der Klaauw (2014) and Albouy and Ehrlich (2016) find negative welfare effects. A separate literature models emergence of land use regulation in response to negative local externalities – see Duranton and Puga (2015) for a review. Stringent land use regulation also drives urban segregation by income, according to the findings of Lens and Monkkonen (2016).

⁹The output effect in their paper is much larger than what this paper finds, mostly due to the assumption of free labor mobility. In their framework moderate changes in house prices may lead to a massive labor reallocation. In this paper individuals have strong idiosyncratic location preferences and even large changes in wages and prices only result in modest changes in the distribution of labor across space.

¹⁰A related body of research connects labor misallocation across space to differences in taxation (Albouy (2009), Eeckhout and Guner (2015) and Fajgelbaum, Morales, Suárez Serrato and Zidar (2016)) and constraints to workers’ mobility (Şahin, Song, Topa and Violante (2014) and Parkhomenko (2016)).

¹¹Earlier work includes Brueckner (1995), Helsley and Strange (1995), Calabrese, Epple and Romano (2007), and Solé-Ollé and Viladecans-Marsal (2012).

and Albouy and Ehrlich (2016) find that the costs incurred by developers due to regulation vary greatly across metro areas, hence a large part of the price dispersion must be due to differences in regulation. Indeed, Gyourko, Mayer and Sinai (2013) show that a model in which local differences in supply elasticities are combined with the increase in exogenous wage inequality can explain about 80% of the rise in the price dispersion from 1970 to 2000, which is very close to the number this paper finds. At the same time, Van Nieuwerburgh and Weill (2010) find that most of the rise in house price dispersion can be explained by growing productivity differences across locations, though their mechanism relies on inelastic housing supply which may arise due to regulation. Moretti (2013) was one of the first studies to recognize that the rising income differences partly stem from the growing differences in the cost of living across metro areas. His paper finds that the cost-of-living differences account for 25-30% of the increase in the college wage gap between 1980 and 2000. On a related note, Baum-Snow and Pavan (2013) argue that the increase in wage inequality is to some extent a big city phenomenon: they find that at least 23% of the growth in the variance of log wages is explained by the faster growth in wage inequality in larger cities than in smaller cities. The current paper, by proposing a mechanism that generates regulation, emphasizes the feedback effect between the growing concentration of skills, the rising dispersion of house prices and incomes, and the increasingly different regulation levels and costs of living across communities.

This work is also related to efforts to understand why regulation has become more stringent in recent decades. Glaeser, Gyourko and Saks (2005a) argue that the most likely reasons are that residents' groups have become more politically influential and that the ability of developers to affect decisions of local planning boards has diminished. Fischel (2015) also links the rise of regulation to suburbanization and the increase of house values in portfolios of homeowners in the 1970s, both of which increased owners' incentives to undertake actions that preserve or raise the values of their houses. However, these mechanisms have not been quantitatively evaluated within an equilibrium framework in which regulation is chosen endogenously. The political economy model in this paper accommodates these mechanisms, and quantifies their general equilibrium effects.

Finally, this paper is connected to the literature in macroeconomics that investigates the effects of homeownership on labor markets. According to Head and Lloyd-Ellis (2012) and Karahan and Rhee (2014), ownership may contribute to aggregate unemployment, especially during recessions. Ferreira, Gyourko and Tracy (2010) and Schulhofer-Wohl (2011) study the role of ownership for geographic mobility and the ability of localities to respond to economic fluctuations. In the current paper, homeownership affects local house prices, and thus labor supply, via a political process that determines how regulated housing supply is.

2 Data and Empirical Evidence

In this section I describe the data used in this paper and present the empirical facts that motivate and discipline the model and the quantitative analysis.

2.1 Data

The number of workers, wages and housing prices for each metropolitan area are calculated using individual level data from the 5% samples of the Census in 1980, 1990 and 2000, and the 3% sample of the American Community Survey in 2005-2007 from the IPUMS (Ruggles et al, 2015). The sample used in this paper is limited to heads of household and their spouses in prime working age (from 25 to 64 years old), who are employed and worked at least 35 hours a week for at least 27 weeks in the sample year. I exclude individuals who live in group quarters, work for the government or the military, and those who live in farm houses, mobile homes, trailers, boats, tents, etc. I also exclude observations with reported annual wage and salary income that is equivalent to less than half of the minimum federal hourly wage.

As the measure of regulation I use the Wharton Residential Land Use Regulatory Index (WRLURI) developed by Gyourko, Saiz and Summers (2008), based on a survey they conducted in 2007.¹² The survey questionnaire was sent to an official responsible for planning and zoning in every municipality in the U.S. and contained a broad set of questions about local rules of residential land use. The answers were then used to create eleven indices that measure different aspects of regulation, as well as a single index of regulation (the WRLURI) that summarizes the strictness of regulatory environment for each municipality.

The geographical unit of analysis is metropolitan statistical area (MSA). A metropolitan area consists of a county or several adjacent counties, and is defined by the Census Bureau such that the population of its urban core area is at least 50,000 and job commuting flows between the counties are sufficient for the area to be considered a single labor market. There are only 190 MSAs in the 48 contiguous U.S. states such that (1) they can be identified in the IPUMS Census/ACS samples in all years since 1980 and (2) the Wharton Index is available for municipalities in an MSA. Thus the sample used in this paper only includes individuals that reside in one of these 190 MSAs. The population of these 190 MSAs makes up 85% of the metro area population and 71% of total population of the contiguous U.S. in 2007.

An MSA is defined by the U.S. Census Bureau using job commuting patterns and thus constitutes a contiguous labor market. At the same time, land use regulation is determined by municipal governments, and large metro areas often consist of more than a hundred

¹²A few earlier surveys were conducted since the 1970's and are summarized in Saks (2008). Yet, compared to the WRLURI, they are more limited in the number of geographical units or the types of regulation.

municipalities. To focus on labor and housing markets and to abstract from the complexity associated with modeling a two-level geography, I assume that regulation is chosen at the MSA level and use the Wharton Index aggregated to the MSA level. Gyourko, Saiz and Summers (2008) find that differences in regulation within metro areas are smaller than the differences across metro areas.¹³

Observations with a college degree and above are defined as high-skilled. All others are defined as low-skilled. Hourly wage is calculated as the reported annual wage income divided by the number of weeks worked per year times the usual hours worked per week. Housing prices are calculated as follows. For each metro area I construct quality-adjusted owner-occupied and rental price indices using self-reported house values and rent payments.¹⁴ Each index is calculated using a hedonic regression that controls for housing unit characteristics, such as the number of rooms, the number of units in the building, and the construction year. I follow the approach used in Eeckhout, Pinheiro and Schmidheiny (2014).

2.2 Facts on Labor and Housing Markets

The following three facts characterize different aspects of regional divergence in the U.S. from 1980 to 2007.¹⁵

1. *The dispersion of house prices across metro areas surged.* From 1980 to 2007, the variance of log quality-adjusted house price index jumped by 258% (Figure 1). The increase in the mean and the variance of prices was faster than that of wages. As a result, real house prices increased by 44% on average, while their standard deviation jumped by 150%.¹⁶
2. *The dispersion of wages across metro areas increased.* The variance of log mean hourly wages across metro areas went up from 0.0085 in 1980 to 0.0167 in 2007 (Figure 2).

¹³The number of municipalities in a metro area and the distribution of population between them may matter. Fischel (2008) shows that MSAs with more fragmented governments, i.e. with many small suburbs, are more likely to have stringent development restrictions. The primary reason is that in larger jurisdictions developers are more influential and homeowners find it more difficult to organize around a common goal.

¹⁴Self-reported prices have been widely used in the literature in cases when other measures were not available. Kiel and Zabel (1999) show that, while self-reported prices are 3-8% higher than actual prices, the size of the bias does not depend on observable owners' characteristics and location. Thus, for the purposes of comparison across metro areas, self-reported prices are good proxies for market prices.

¹⁵These facts have been documented and studied before. The rise in wage and house price dispersion was analyzed in Van Nieuwerburgh and Weill (2010) and Hsieh and Moretti (2015). The increase in skill sorting across MSAs was first reported and studied by Moretti (2004) and Berry and Glaeser (2005). Shapiro (2006) finds that metro areas with higher shares of college graduates experience faster wage and house price growth. Diamond (2016) argues that the skill sorting that emerges from rising productivity differences across cities is amplified by endogenous skill-specific amenities.

¹⁶The change in real prices is measured as the growth rate of mean quality-adjusted house price in an MSA divided by the growth rate of mean hourly wage.

Most of the increase in the dispersion of both wages and house prices occurred at the right tail of the distribution, i.e. was driven by productive and expensive areas, such as New York, San Francisco and San Diego.

3. *Skill sorting across metro areas intensified.* Metro areas where high share of college graduates in 1980 saw a faster increase in the share of college graduates over 1980-2007 than other metro areas (Figure 3).

This paper focuses on the role of housing supply regulation in explaining these facts. First, I argue that these three facts help explain why housing supply regulation has increased and has become more different across cities. Second, I claim that the proposed political economy mechanism that determines regulation amplifies the effects of factors exogenous in the model, such as location-specific productivities, on these facts. Other empirical facts relevant for this paper are the increase in the share of college graduates from 0.255 to 0.398 between 1980 and 2007, and the increase of the log of the ratio of the mean wage of college graduates to the mean wage of the individuals without a college degree increased from 0.368 to 0.609 during the same period.¹⁷ Table 1 summarizes these and other empirical facts.

The next set of facts relates the stringency of land use regulation, as measured by the Wharton Index, to labor and housing market outcomes at the metropolitan area level. These observations inform the political economy model of regulation in this paper.

4. *Larger and denser metro areas are more regulated.* The correlation between the Wharton Index and the workforce size is 0.25, whereas the correlation between the Wharton Index and the population density is 0.34. (Figures 4 and 5).
5. *High-income expensive metro areas are more regulated.* Regulation is positively correlated with mean wages (0.41) and house prices (0.56), even controlling for city size (Figures 6 and 7). However, most of the correlation between wages and regulation is due to the fact that wage differences across metro areas partly reflect differences in housing prices. When real wages are used instead, the correlation drops to 0.27.
6. *Highly regulated metro areas have less homeowners.* Regulation is negatively correlated with homeownership (Figure 8). On the one hand, higher ownership rates should lead to more regulation as owners are likely to be interested in restricting new construction. On the other hand, high regulation leads to higher house prices and makes ownership unaffordable for a larger share of population. The negative correlation suggests that the second effect dominates in the data.

¹⁷These numbers are calculated for the sample of individuals I use in this paper. See Section 2.1.

7. *Regulation rose and became more different across locations.* While there is no comprehensive widely-accepted measure of land use regulation available across time and space, there is evidence that confirms that the regulatory barriers have tightened in the second half of the 20th century.¹⁸ Ganong and Shoag (2015) constructed a time series measure of regulation at the state level.¹⁹ Their paper finds that regulation has been increasing since at least 1940 and that most of the increase occurred between 1970 and 1990. In addition local differences in regulation have been widening, as in some states regulation grew faster than in others (Figure 9).²⁰ Morrow (2013) documents that the city of Los Angeles was zoned to accommodate about 10 mln inhabitants in 1960, at the time when its population was 2.5 mln.²¹ However, due to rising regulation in the following years, the city’s residential capacity shrank to just 3.9 mln in 1990, while its population grew to 3.5 mln. This implies that to expand population further the city must re-zone the land for denser use, an onerous task due to opposition by local homeowners. There is also indirect evidence on the rise of regulation. Gyourko and Molloy (2015) document a rising gap between real construction costs and real house prices since 1980. Noting that construction is a competitive industry with many small firms, they argue that the most likely reason for the widening gap is the rise of regulation.

3 Environment

3.1 Workers and Markets

The economy comprises M metropolitan areas, indexed by $m \in \{1, \dots, M\} \equiv \mathcal{M}$. A metro area is an “island” without any internal structure, as in Lucas and Prescott (1974). Every metro area is populated by a measure N_m of workers, and has its own labor and housing markets. Individuals live and work for T periods, and their age is indexed by a . They are endowed with a skill level, low or high, $s \in \{L, H\}$. Skill level is fixed for lifetime. Measures of each skill in the economy are given exogenously by λ_L and λ_H .

Consumption and savings. Workers consume a homogeneous consumption good and one unit of housing. Since housing consumption is fixed, the share of housing in expenditures

¹⁸McLaughlin (2012) reviews the existing evidence in the U.S. and other countries.

¹⁹They counted the number of cases in state appellate courts that contained the phrase “land use” and used their fraction among all cases as a measure of the level of stringency of land use regulation.

²⁰Unfortunately, a similar panel data does not exist for MSAs. Given significant variation in regulation within states, I cannot use the index of Ganong and Shoag (2015) to investigate dynamic relationships between regulation and labor and housing market outcomes at the MSA level.

²¹Every municipality in the U.S. is divided into zones. Each zone is characterized by requirements on minimum land area of a lot, maximum height, and often number of households that can occupy a lot. Thus it is possible to calculate the maximum population capacity of a municipality, given existing zoning.

falls with income.²² Housing can be rented or owned, but ownership provides additional utility γ . An individual must live in the same location where she works. The utility function is given by

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

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

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

$$Y_m = K_m^\alpha \left(\tilde{N}_{mL}^\eta + \tilde{N}_{mH}^\eta \right)^{\frac{1-\alpha}{\eta}},$$

where $\tilde{N}_{ms} \equiv \sum_{a=1}^T g_{msa} N_{msa}$ is local supply of s -skilled labor in efficiency units, and g_{msa} is the productivity of an individual of skill s and age a working in metro area m . The elasticity of substitution between the two types of labor is $\frac{1}{1-\eta}$.

Capital is supplied perfectly elastically at an exogenous interest rate i^k in all locations. The equilibrium wage is given by

$$w_{msa} = (1 - \alpha) \left(\frac{\alpha}{i^k} \right)^{\frac{\alpha}{1-\alpha}} g_{msa} \left(1 + \left(\frac{\tilde{N}_{ms'}}{\tilde{N}_{ms}} \right)^\eta \right)^{\frac{1-\eta}{\eta}}, \quad (3.1)$$

where $s' = H$ if $s = L$, and $s' = L$ otherwise.

The model of production does not feature agglomeration externalities, hence they implicitly show up as a part of city-specific productivity shifters, g_{msa} . In Section 6, I explain why including agglomeration would not change the quantitative results of this paper.

Construction. The model of the construction sector is based on the standard Rosen-Roback model in urban economics.²³ I extend their basic model by introducing dynamics and two types of housing.

Every individual must either rent or own exactly one unit of housing in the city where he works. In every city, there is a continuum of construction firms (*developers*). Each developer specializes either in owner-occupied (O) or rental (R) housing. Within these types housing

²²This feature is consistent with the empirical observation that the share of income spent on housing is decreasing with income. See Ganong and Shoag (2015).

²³See Rosen (1979), Roback (1982) and Glaeser (2008) for details.

is homogeneous in size and quality. The developers of both types sell the newly constructed housing units to *real estate managers* (described later in this section) who then sell or lease it to workers. The developers of owner-occupied housing sell the units at price p_{mt} in period t . The developers of rental housing sell the units at the price equal to discounted rents: $\sum_{v=t}^{\infty} \rho^{v-t} r_{mv}$. In a stationary environment this price is equal to $\frac{1}{1-\rho} r_{mt}$. Housing does not depreciate and can be destroyed at no cost. I assume that the cost of maintenance of vacant houses is high enough so that unoccupied housing is always destroyed. A city has time-invariant land endowment Λ_m . The land is owned by infinitely lived absentee landowners and leased to the developers at price r_{mt}^L . The landowners incur no costs when leasing land and discount future by factor ρ .

As in the Rosen-Roback model, I assume that housing development is continuous in horizontal and vertical dimensions. Let $J_{m,t-1}$ be the land area developed at the beginning of period t , and $Q_{m,t-1}^O$ and $Q_{m,t-1}^R$ be the quantity of owner-occupied and rental housing per unit of land at the beginning of the period. Then the total quantity of housing in city m at the beginning of period t is: $J_{m,t-1}(Q_{m,t-1}^O + Q_{m,t-1}^R)$. In each period developers may increase the quantity of existing housing based on changes in demand by building $q_{mt}^j J_{mt}$ units of type $j \in \{R, O\}$. The construction technology uses the consumption good and land. The cost of building q_{mt}^j units of housing on one unit of land is increasing and convex in the amount of existing housing of all types on the unit of land:

$$C_{mt}^j(q_{mt}^j) \equiv \chi_{mt}^j (Q_{m,t-1}^R + Q_{m,t-1}^O + q_{mt}^R + q_{mt}^O)^{\zeta_{mt}},$$

where χ_{mt}^j captures physical construction costs, while $\zeta_{mt} > 1$ determines how fast the cost increases with congestion. When a developer of one type of housing chooses to build more units, it raises the construction cost for the developers of the other type by increasing congestion in the city. Due to convex construction costs and given that landowners do not incur any costs, in equilibrium all land in the city will be developed, i.e. $J_{mt} = \Lambda_m$ for all t .²⁴ This means that the optimization problem of developers simplifies to the choice of quantity of construction per unit of land. This also implies that the model predicts sprawling urban growth: initially a city expands by using more land and then by building more densely.

Consider a stationary environment in which rents and costs are the same every period. Developers take housing price p_{mt} , rent r_{mt} and the cost of land r_{mt}^L as given, and choose construction q_{mt}^j per unit of land to maximize profits. The profit of the developer of owner-

²⁴Suppose that only a fraction of available land is developed. Then the owners of undeveloped land will offer their plots at a lower price and attract construction.

occupied housing is

$$\pi_{mt}^O = p_m q_{mt}^O \Lambda_m - C_{mt}^O (q_{mt}^O) \Lambda_m - \frac{r_{mt}^L}{1 - \rho} \Lambda_m.$$

The profit of the developer of rental housing is given by

$$\pi_{mt}^R = \frac{r_{mt}}{1 - \rho} q_{mt}^R \Lambda_m - C_{mt}^R (q_{mt}^R) \Lambda_m - \frac{r_{mt}^L}{1 - \rho} \Lambda_m.$$

In equilibrium both housing markets clear. The supply of owner-occupied housing is $Q_{m,t-1}^O + q_{mt}^O$ and, since everyone consumes one unit, the demand is equal to the number of owners in the city, N_{mt}^O . Hence $Q_{m,t-1}^O + q_{mt}^O = N_{mt}^O$. Similarly, for rental housing $Q_{m,t-1}^R + q_{mt}^R = N_{mt}^R$. However, since the cost function depends on the total quantity of housing, the prices of each type of housing depend on the total demand for both types of housing, $N_{mt} = N_{mt}^O + N_{mt}^R$. Local demand for each type of housing, N_{mt}^O and N_{mt}^R , is endogenous and arises from individual choices described in detail in Section 3.2. The equilibrium price of a house is

$$p_{mt} = \chi_{mt}^O \zeta_{mt} \left(\frac{N_{mt}}{\Lambda_m} \right)^{\zeta_{mt}-1}. \quad (3.2)$$

The equilibrium rent is given by

$$\frac{1}{1 - \rho} r_{mt} = \chi_{mt}^R \zeta_{mt} \left(\frac{N_{mt}}{\Lambda_m} \right)^{\zeta_{mt}-1}. \quad (3.3)$$

In this model, price-to-rent ratios are exogenous and given by $\frac{\chi_{mt}^O}{(1-\rho)\chi_{mt}^R}$. The differences in price-to-rent ratios across cities arise from the differences in physical construction costs χ_{mt}^j .²⁵ The price elasticity of housing supply in city m is given by $\frac{1}{\zeta_{mt}-1}$.

Homeownership and real estate managers. All individuals have access to a mortgage facility which allows to extend payments for the house over κ periods. If a renter decides to buy a house in period t , he must pay δp_{mt} where $\delta \in (0, 1)$ is the downpayment rate. In each period $t + 1, \dots, t + \kappa$ the worker pays $(1 + i^h)\mu p_{mt}$, where i^h is the mortgage interest rate and μ is the fraction of the house value to be paid off each period. Parameters μ and κ must satisfy $\delta + \mu\kappa = 1$. The equilibrium house price may change, but the worker always repays mortgage based on the purchase price. Starting from period $t + \kappa + 1$ the worker fully owns the house. An individual who has owned a house for h periods can sell it any time at

²⁵I do not model endogenous determination of price-to-rent ratios. One way to obtain differences in price-to-rent ratios is to have different expected growth rates of rents across cities, as in Campbell, Davis, Gallin and Martin (2009). However, this would rule out stationary equilibria.

current equilibrium price $p_{m,t+h}$. If the mortgage was not fully paid, the proceeds from the sale are equal to the fraction of the value of the house which has been repaid, $(\delta + \mu h)p_{m,t+h}$.

Developers sell the newly constructed units to the infinitely-lived competitive real estate managers (REMs). Then the REMs issue mortgages and hand over owner-occupied houses to owners, and lease rental houses to renters. When a house is sold on the secondary market, the REM pays $p_{m,t+h} \min\{\delta + \mu h, 1\}$ to the seller. The buyer pays the downpayment to the REM immediately and mortgage payments over the next κ periods.

I assume that the cost of default is large enough that buyers always fulfil their debt obligations to REMs. REMs bear all the risks associated with price changes: upside risks if the equilibrium price falls and incoming mortgage payments exceed loans to new homeowners, and downside risks in the opposite case. These risks are uninsurable, however in a stationary environment there is no price risk, and hence the REMs do not charge any risk premium.

3.2 Workers' Decisions

Choice of location. The measure of workers born in each location is exogenous and is described by the distribution $\{\psi_m\}_{m \in \mathcal{M}}$. At the very beginning of the first period, an individual is born in city m^* and must choose the location of residence m . This decision is irreversible – it is not possible to move later in life. The location choice is affected by three factors. First, at the moment of birth an individual receives a vector of *i.i.d.* utility shocks ε which is associated with living in each of the cities in the economy. This shock should be interpreted as the idiosyncratic utility cost or benefit of living in a given city. Second, individuals are attached to their birthplaces: choosing to live in a location other than the birthplace implies a disutility ξ , which is subtracted from utility.²⁶ Finally, workers compare the attractiveness of labor and housing markets in different cities. They take into account the lifetime wage profile $\{w_{msa}\}_{a=1}^T$ each city m offers to workers of their skill group s , and the costs of renting and buying a house: r_m and p_m . When choosing a city, workers not only consider the level of housing costs but also whether they will be able to afford the downpayment and purchase a house soon enough in the life cycle. This is because, all else equal, owning is preferred to renting. First, it brings additional utility γ . Second, a house is an asset that can be sold, and the proceeds from the sale can be consumed. Taking all these considerations into account, an individual moves out of city of birth if either he likes another location m for idiosyncratic reasons (high ε_m relative to ε_{m^*}) or labor and housing market conditions in m are much better than in m^* . Individuals are born with no real estate property and thus must rent during the first period of their lives.

²⁶For convenience, I assume that the disutility is only experienced in the first period. However, since migration in later periods is not allowed and since ξ is additive, this is equivalent to a disutility every period.

Timing and value functions. Every period an individual works and receives salary w_{msa} . Then he decides (1) how much to consume, (2) how much to save, and (3) whether to rent or own housing, in order to maximize the expected discounted lifetime utility. Renters pay rent r_m . Owners pay mortgage with interest $(1 + i^h)\mu p_{m,t-h}$ on the house bought h periods ago. A renter may decide to buy a house at any age, just as an owner may decide to sell the house and become a renter. The transactions that involve changes in homeownership status occur in the current period, but the actual changes in the status are effective next period. In the last period T , an owner pays the mortgage (if it has not been paid off), sells the house and consumes the proceeds. At the end of each period, developers adjust supply of housing of each type to satisfy the demand from new and existing residents.

There is no aggregate uncertainty, and the only source of individual uncertainty are the location-specific utility shocks.²⁷ The individual state is $x = (m^*, s; m, a, k, h)$. Birth location m^* and skill level s are fixed for life. Residence m is chosen in the first period and remains fixed, while age a , savings k , and the length of ownership h change every period. The aggregate state is described by the distribution of labor across individual states $\Phi : \mathcal{X} \rightarrow \mathbb{R}_+$, where $\mathcal{X} \equiv \mathcal{M} \times \{L, H\} \times \mathcal{M} \times \{1, \dots, T\} \times [0, \infty) \times \{0, \dots, T - 1\}$ is the space of individual states. Since the environment is stationary, a indexes both age and time.

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

$$\begin{aligned}
 V^R(m^*, s; m, a, k, h = 0; \Phi) = & \tag{3.4} \\
 & \max_{\{\text{own,rent}\}} \left\{ \max_{k' \geq 0} \left\{ \ln [w_{msa}(\Phi) - r_{ma}(\Phi) - \delta p_{ma}(\Phi) - k' + (1 + i^k)k] \right. \right. \\
 & \quad \left. \left. + \beta E [V^O(m^*, s; m, a + 1, k', 1; \Phi')] \right\} \right\}, \\
 & \max_{k' \geq 0} \left\{ \ln [w_{msa}(\Phi) - r_{ma}(\Phi) - k' + (1 + i^k)k] \right. \\
 & \quad \left. + \beta E [V^R(m^*, s; m, a + 1, k', 0; \Phi')] \right\} \left. \right\},
 \end{aligned}$$

²⁷The model, however, can accommodate cross-city differences in age-income profiles. Using Spanish administrative data, De la Roca and Puga (2016) document that larger cities have steeper income profiles.

where the expectation is over the distribution of population next period, Φ' . However, in a stationary economy the distribution is time-invariant, and a rational agent is aware of this.

An owner in period $2 \leq a < T$ decides on savings, and whether to keep the house or sell it and become a renter, taking wages and housing prices as given. Here the tradeoff is between a higher expected future utility $E[V^O]$ and a higher current consumption financed by revenues from selling the house. Note that, if the mortgage has not been repaid, then the owner who sells only receives the fraction of the value of the house that she has paid for: $p_{ma}(\Phi)(h\mu + \delta)$. The owner's value function is given by

$$\begin{aligned}
V^O(m^*, s; m, a, k, h; \Phi) = & \tag{3.5} \\
& \max_{\{\text{own, rent}\}} \left\{ \max_{k' \geq 0} \left\{ \ln [w_{msa}(\Phi) - \mathbb{I}_{h \leq \kappa}(1 + i^h)\mu p_{m, a-h} - k' + (1 + i^k)k] \right. \right. \\
& \quad \left. \left. + \gamma + \beta E[V^O(m^*, s; m, a + 1, k', h + 1; \Phi')] \right\}, \right. \\
& \left. \max_{k' \geq 0} \left\{ \ln [w_{msa}(\Phi) - \mathbb{I}_{h \leq \kappa}(1 + i^h)\mu p_{m, a-h} + p_{ma}(\Phi) \min\{h\mu + \delta, 1\} - k' + (1 + i^k)k] \right. \right. \\
& \quad \left. \left. + \gamma + \beta E[V^R(m^*, s; m, a + 1, k', 0; \Phi')] \right\} \right\}.
\end{aligned}$$

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

$$V^R(m^*, s; m, T, k, 0; \Phi) = \ln [w_{msa}(\Phi) - r_{ma}(\Phi) + (1 + i^k)k],$$

and for an owner it is given by

$$\begin{aligned}
V^O(m^*, s; m, T, k, h; \Phi) = & \ln [w_{msa}(\Phi) - \mathbb{I}_{h \leq \kappa}(1 + i^h)\mu p_{m, a-h} \\
& + p_{ma}(\Phi) \min\{h\mu + \delta, 1\} + (1 + i^k)k] + \gamma.
\end{aligned}$$

The expected lifetime utility of an s -skilled worker born in location m^* who decides to spend life in location m is

$$V(m|m^*, s, \varepsilon) = V^R(m^*, s; m, a = 1, k = 0, h = 0; \Phi') + \varepsilon(m) - \mathbb{I}_{m \neq m^*} \xi,$$

and the optimal location choice of this worker satisfies

$$m = \operatorname{argmax}_{m' \in \mathcal{M}} \{V(m'|m^*, s, \varepsilon)\}.$$

3.3 Political Economy of Housing Supply Regulation

I assume that housing supply regulation determines the elasticity of house prices and rents with respect to demand. Recall from Section 3.1 that the elasticity is given by $\frac{1}{\zeta_m - 1}$. I assume that $\zeta_m \equiv \bar{\zeta} + \zeta_m^{\text{reg}} + 1$, where $\bar{\zeta}$ is a common elasticity parameter and ζ_m^{reg} is city-specific stringency of housing supply regulation in city m . More stringent regulation makes supply less elastic and leads to higher prices in city m , as illustrated by the equilibrium price and rent expressions (equations 3.2 and 3.3).²⁸

The level of regulation is determined via a model of probabilistic voting with lobbying (Lindbeck and Weibull (1987), Baron (1994)).²⁹ In every city there is a regulatory board, and every period there is an election of local government which appoints members of the board.³⁰ Two parties, A and B , run for the government and propose a single policy: level of residential land use regulation. The only objective of a party is to be elected and, if elected, they must commit to the proposed level. At the end of each period, all residents aged $a \in \{1, \dots, T - 1\}$ vote, and the level proposed by the winning party is effective next period.³¹ Residents have two considerations when deciding which party to vote for: the expected utility of the proposed regulation level and their idiosyncratic taste for each party.

1. *Expected utility of regulation.* If party $l \in \{A, B\}$ is elected, a worker in state $x = (m^*, s; m, a, k, h)$ will optimally choose to be in state $x'(\zeta_l^{\text{reg}}) = (m^*, s; m, a + 1, k'_l, h'_l)$ next period. In addition, the worker knows that if city m chooses a different level of regulation, the distribution of population in the economy will change to Φ'_l leading to adjustments in wages and housing prices.
2. *Ideology.* Worker i with ownership status $j \in \{R, O\}$ has an idiosyncratic taste for party A , which can be interpreted as ideological bias. This taste shock is denoted by σ_i^j and distributed uniformly across workers on $[-1/2\phi_m^j, 1/2\phi_m^j]$. Parameter ϕ_m^j essentially measures how consolidated opinions on regulation are among the members of group j . In the extreme case of $\phi_m^j \rightarrow \infty$, all individuals of group j in city m have the same preference for regulation. In the opposite case of $\phi_m^j = 0$, individuals within the group completely disagree.

²⁸In reality different types of regulation may affect supply and prices through different channels. Yet Mayer and Somerville (2000) find that uncertainty associated with obtaining zoning approvals and building permits constrains new development much more than other types of regulation, such as development and impact fees. Paciorek (2013) finds a strong effect of regulation on the supply elasticity.

²⁹The model of probabilistic voting with lobbying is described in Persson and Tabellini (2002).

³⁰In the U.S., municipalities have a Planning and Zoning Commission charged with city planning and recommending to the local government boundaries of zoning districts and regulations to be enforced therein.

³¹I prohibit voting by the oldest generation, since they will not be around next period to live with the results of the vote and hence will be indifferent between the two levels of regulation.

In this model, owners prefer a higher level of regulation, since it raises the values of their houses. Renters favor a lower level, since it reduces rents. It also decreases house prices and thus makes downpayment more affordable.

Local elections are financed via campaign contributions. Party $l \in \{A, B\}$ receives C_l from each homeowner who votes for it.³² The contributions are needed to enact the level of regulation proposed by the party, and their size depends on the proposed level:³³

$$C_l = \omega_0 (\zeta_l^{\text{reg}})^{\omega_1}.$$

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

$$V^j(x'(\zeta_A^{\text{reg}}); \Phi'(\zeta_A^{\text{reg}})) + \sigma_i^j - \mathbb{I}_{j=O} C(\zeta_A^{\text{reg}}) \geq V^j(x'(\zeta_B^{\text{reg}}); \Phi'(\zeta_B^{\text{reg}})) - \mathbb{I}_{j=O} C(\zeta_B^{\text{reg}}),$$

and for party B otherwise.³⁴

In the unique Nash equilibrium, electoral competition between the two parties makes them converge to announcing the same policy. The equilibrium level of regulation maximizes the weighted social welfare of local residents, where the weights depend on population shares and on how consolidated a group of voters is in its preferences for the policy. The weighted social welfare function is given by

$$W_m(\zeta^{\text{reg}}) = \phi_m^O \int \frac{N_m^O(x)}{N_m} (V^O(x'(\zeta^{\text{reg}}), \Phi'(\zeta^{\text{reg}}); x) - \mathbb{I}_{j=O} C(\zeta^{\text{reg}})) dx + \phi_m^R \int \frac{N_m^R(x)}{N_m} V^R(x'(\zeta^{\text{reg}}), \Phi'(\zeta^{\text{reg}}); x) dx, \quad (3.6)$$

where $V^j(x'(\zeta^{\text{reg}}), \Phi'(\zeta^{\text{reg}}); x)$ stands for the next-period value function of a worker currently in state x if the chosen level of regulation is ζ^{reg} . The integration is performed across all

³²Alternatively, renters could be allowed to contribute toward less regulation. However, this would incite owners to contribute even more and lead to a contributions "arms race". As a result, the equilibrium level of regulation would be the same, but aggregate spending on elections would be much larger.

³³This approach is close in spirit to Glaeser, Gyourko and Saks (2005a), where homeowners spend time out of work to affect the decisions of the zoning authority, and to Hilber and Robert-Nicoud (2013), where regulation is a function of monetary contributions from landowners and developers to the planning board.

³⁴The future distribution of votes in a city also influences the value of locating in the city. However it is completely described by the value functions and the future distribution of labor $\Phi'(\zeta_l^{\text{reg}})$, and thus does not have to enter the value functions separately.

residents of age $a \in \{1, \dots, T - 1\}$. The elected level of regulation is then

$$\zeta_m^{\text{reg}} = \underset{\zeta^{\text{reg}} \in \mathbb{R}_+}{\text{argmax}} \{W_m(\zeta^{\text{reg}})\}. \quad (3.7)$$

From equation (3.6) one can see that the less owners or renters differ in their idiosyncratic preference for regulation, the more weight they have in the social welfare function, and hence more influence on the regulatory board. On the other hand, when the idiosyncratic views of owners or renters on regulation vary a lot, they tend to vote more often in ways that are not determined by regulation. As a result, they have a smaller weight in the welfare function.

Homeowners benefit from a higher ζ_m^{reg} since it makes the value of their house higher.³⁵ Fischel (2001) describes reasons why homeowners might want stricter residential land use regulation, but argues that most of the restrictions capitalize into higher house values. In practice this makes it difficult to distinguish the actions of owners that are explicitly driven by their willingness to increase or maintain the house value from those that are aimed at improving local public services, controlling congestion, etc. At the same time, a model in which the main reason why owners prefer regulation is because it raises house values, such as the model in this paper, can be interpreted more generally, since this motivation contains many other reasons for preferring stringent regulation.³⁶ For instance, regulation discourages inflows of workers, who would start as renters and vote for less regulation thus harming owners. This can be interpreted as the dislike of congestion, even though congestion is not modeled explicitly.

3.4 Equilibrium

Distribution of labor across locations. The vector of utility shocks ε follows the extreme value type 1 distribution with parameters μ_ε and σ_ε and that the shocks have zero mean.³⁷ Consider a worker born in location m^* with skill s . Before the vector of utility shocks ε is known to the worker, her value of choosing to spend life in location m' is³⁸

$$\tilde{V}(m'|m^*, s) \equiv V^R(m^*, s; m', a = 1, k = 0, h = 0; \Phi').$$

³⁵An increase in regulation may actually reduce prices if the resulting outflow of labor to other locations is large, as in Chatterjee and Eyigungor (2015). In this paper, the outflows are small due to individual location preferences and the inability to move after the first period.

³⁶Dubin, Kiewiet and Noussair (1992) show that in a 1988 election in San Diego, precincts with a larger fraction of owners had a larger proportion of votes cast in favor of growth control measures.

³⁷The extreme value type 1 distribution is commonly used in the discrete-choice literature. The density of the extreme value type 1 distribution with parameters μ_ε and σ_ε is $f(x) = \exp(-\exp(-(x - \mu_\varepsilon)/\sigma_\varepsilon))$. The mean is $\mu_\varepsilon + \sigma_\varepsilon \bar{\gamma}$, where $\bar{\gamma} \approx 0.5772$ is the Euler-Mascheroni constant, and the variance is $\sigma_\varepsilon^2 \pi^2/6$. Hence the utility shock has zero mean if $\mu_\varepsilon = -\sigma_\varepsilon \bar{\gamma}$.

³⁸In the discrete-choice literature these functions are called *conditional value functions*.

Let $\Pi(m|s, m^*)$ be a conditional choice probability (CCP), the probability that, after observing ε , an s -skilled worker born in location m^* will choose to live in m . The distributional assumption on ε allows to derive a closed-form expression for the CCP:³⁹

$$\Pi(m|m^*) = \frac{\exp\left(\tilde{V}(m|m^*, s)\right)^{\frac{1}{\sigma\varepsilon}}}{\sum_{m' \in \mathcal{M}} \exp\left(\tilde{V}(m'|m^*, s)\right)^{\frac{1}{\sigma\varepsilon}}} \quad (3.8)$$

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

$$N_{ms1} = \sum_{m^* \in \mathcal{M}} \Pi(m|m^*, s) \psi_{m^*} \lambda(s),$$

where ψ_{m^*} is the exogenous measure of individuals born in m^* and $\lambda(s)$ is the exogenous fraction of s -skilled workers. Then the total supply of s -skilled workers is $N_{ms} = TN_{ms1}$, and the total population in the location is $N_m = N_{mL} + N_{mH}$.

Definition 3.1. A *stationary spatial equilibrium* consists of value functions V^O and V^R , and the associated decision rules that determine optimal location, ownership status, and savings; prices $w_{msa}(\Phi)$, $p_m(\Phi)$ and $r_m(\Phi)$; new construction of each type in each city, q_m^j ; levels of regulation ζ_m^{reg} ; conditional choice probabilities Π ; distribution of labor Φ ; and a transition function $F : \mathcal{X} \rightarrow \mathcal{X}$, such that: (1) the value functions maximize expected utility and the decision rules attain the value functions; (2) wages, house prices and rents clear markets at the city level; (3) the resource constraint holds (aggregate output equals aggregate consumption plus construction costs); (4) the social welfare function (3.6) is maximized in every city via the probabilistic voting mechanism; (5) the distribution of labor is stationary: $F(\Phi) = \Phi$.

Computing an equilibrium. An advantage of focusing on stationary equilibria is that rational agents learn that they are in a stationary environment and know that next period the distribution of workers across individual states will be the same as in the current period. Moreover, in a stationary equilibrium political parties run with the same proposed level of regulation every period. They know that the composition of population in the city is exactly the same as in the previous period, and therefore the announced level of regulation that maximizes their probability of winning is the same as one period before. Workers, in turn, know that the parties will offer the same level of regulation next period and embed this

³⁹The possibility of obtaining closed-form solutions for conditional choice probabilities in models with extreme value type 1 shocks was first discovered by McFadden (1973).

knowledge in their value functions. These features greatly simplify the computation.

However, even in a stationary environment, the political economy part of the equilibrium poses a significant computational challenge for two reasons. First, maximization of the social welfare function (equation 3.6) requires evaluation of workers' value functions at different non-equilibrium regulation levels. To do that, I need to know an entire dynamic path of regulation in every city starting from any level of regulation. Second, when voting on regulation, individuals must know how every elected level of regulation would affect labor supply in a city. In other words, they must fully know the shape of the aggregate transition function F . Yet F is a high-dimensional object and its computation is difficult. In order to deal with these two issues during computation of an equilibrium, I make two simplifying assumptions. In Appendix A.1, I discuss these assumptions and other details of the computation of a stationary spatial equilibrium.

3.5 Rise in Regulation, Skill Sorting and Wage Inequality

Why has regulation increased since the 1970s? Glaeser, Gyourko and Saks (2005a) examine several possibilities and assert that the most likely reasons are that residents' groups have become more politically influential, either building upon the organizational successes of the civil-rights and the anti-war movements or because of better education of homeowners. Another possible reason is that the ability of developers to affect decisions of local planning boards using legal and illegal payments has diminished thanks to the overall reduction in corruption and improvements in the news media. Fischel (2001) claims that homeowners would support any measure that raises the value of their property, strict land use regulation being one of them, and since the 1970s they have been more able to incite local governments to adopt regulation that favors their interests. According to Fischel (2015), one reason why regulation has risen is suburbanization. First, suburban communities tend to be more demographically homogeneous than central cities, which makes it easier for residents to organize and push for their desired policies. Second, large employers, who might support new residential construction, typically have smaller presence, and therefore less influence, in predominantly residential suburban communities. Another reason is the growing importance of house values in the portfolios of homeowners, which made them more willing to undertake actions that preserve or increase the values of their houses.

The political economy model of regulation proposed in this paper can accommodate all these forces. The rise in homeowners' influence, either because of greater political power or suburbanization, can be modeled as an increase in the degree of consolidation of owners' opinions on regulation, ϕ_m^O . Even though in the model developers do not take part in local

politics, the decline in their influence can still be modeled as an increase in the size of ϕ_m^O relative to ϕ_m^R , since the interests of developers would be aligned with those of renters. Finally, if real prices increase, housing becomes a more important part of households' portfolios, and therefore value functions will be more sensitive to price changes. As a result, all else equal, the rate of change of V^O with respect to regulation will be higher for a given level of ζ^{reg} and raise the value of the argument that maximizes the social welfare function.⁴⁰

In the model, changes in regulation occur in response to changes in fundamentals, such as exogenous type-specific productivities. Suppose that city m experiences a proportionate growth of type-specific productivities g_{msa} . This attracts new labor to the city, and demand for housing goes up. As a consequence, prices increase and labor inflow slows down. However, the inflow of high-skilled workers is not affected as much as the inflow of the low-skilled, since the former earn higher wages and therefore spend a smaller share of income on housing. As a result, the share of high-skilled workers in the city grows. If, for any reason, cities with initially high fraction of skilled labor experience faster productivity growth, then skill sorting ensues, i.e. locations with initially high share of high-skilled workers attract a larger number of the high-skilled than other locations. As a result, the differences in mean wages go up.⁴¹

What role does regulation play? When, following an inflow of labor, house prices go up, real estate becomes more important in individual portfolios, and owners vote to increase the level of regulation. This raises prices even more, and makes the relative inflow of low-skilled workers even lower. Skill sorting is more intense and wage inequality grows by more. In other words, the endogenous regulation mechanism *amplifies* the effect of increasing differences in exogenous productivities on skill sorting, house price dispersion, and wage inequality across locations. If productivity growth is skill-biased, i.e. g_{mHa} grows faster than g_{mLa} , then the magnitude of these effects is even larger.

4 Parameter Values

The quantitative model has 190 locations, which correspond to the 190 metro areas in my sample (see Section 2.1). Parameters of the model are set to reproduce central facts about local labor and housing markets, migration, and residential land use regulation in the United States in the 2005-2007 period. I focus on these years, since the data on regulation is only available for the year 2007. I take several parameters from the literature or calibrate them

⁴⁰The rate of change of V^R for a given level of ζ^{reg} will be larger too. But in the data there are more owners than renters and calibrated ϕ_m^O is larger than ϕ_m^R , hence the increase in the sensitivity of V^O will be quantitatively more important than the increase in the sensitivity of V^R .

⁴¹That the increase in skill sorting leads to the increase in mean wage differences cannot be shown analytically. However, for the model parameters and the observed changes in skill shares, this is the case.

outside the model. Then I estimate the labor demand equation to obtain the exogenous type-specific productivities and the elasticity of substitution between skills. Next I estimate the housing supply equation to obtain the elasticities of housing prices with respect to population density and regulation. The remaining parameters are calibrated jointly within the model. The rest of the section describes the details. Parameter values are summarized in Table 3.

4.1 Labor Markets

In the model, wage differences across locations are largely determined by exogenous location-skill-age specific productivities. I estimate the productivities for every year t using the labor demand equation which, after taking log of equation (3.1), can be expressed as

$$\ln w_{msa,t} = \ln \left((1 - \alpha) \left(\frac{\alpha}{i^k} \right)^{\frac{\alpha}{1-\alpha}} \right) + \frac{1 - \eta}{\eta} \ln \left(1 + \left(\frac{\sum_{\tilde{a}=1}^T g_{ms'\tilde{a},t} N_{ms'\tilde{a},t}}{\sum_{\tilde{a}=1}^T g_{ms\tilde{a},t} N_{ms\tilde{a},t}} \right)^\eta \right) + \varphi_t + \ln g_{msa,t}, \quad (4.1)$$

where φ_t is the year fixed effect. The interest rate is set to $i^k = \frac{1}{\beta} - 1 = \frac{1}{0.96} - 1$. The share of capital α is 0.335, following Valentinyi and Herrendorf (2008).

The remaining labor market parameters are estimated from the labor supply equation. If we were to estimate the equation (4.1), the type-specific productivity parameters $\ln g_{msa,t}$ would be regression residuals. However, these residuals are correlated with the regressor. First, mechanically, by being a part of labor supply in efficiency units. Second, the type-specific productivities are likely to be correlated with raw labor supply through channels other than wages. One possibility is that the size and the skill mix of labor force affect the productivity shifters via agglomeration externalities.

The second endogeneity problem can be overcome by using the Bartik (1991) labor demand shocks as an instrument for labor supply N_{msa} . Bartik shocks have been extensively used for identification in labor and urban economics, and are obtained by interacting cross-MSA differences in industrial composition at time t with changes in industrial composition at the national level between $t - 1$ and t . The identifying assumption is that changes at the national level are uncorrelated with local labor supply shocks. The Bartik instrument is defined as the change in labor supply of type (s, a) in city m as predicted by changes in the supply of this type of labor in each of the industries $z \in \mathcal{Z}$ in the rest of the economy:

$$B_{msa,t} = \sum_{z \in \mathcal{Z}} \left(\ln \left(\sum_{m' \neq m} N_{zm'sa,t} \right) - \ln \left(\sum_{m' \neq m} N_{zm'sa,t-1} \right) \right) \frac{N_{zm'sa,t-1}}{N_{msa,t-1}}.$$

In order to construct the Bartik instruments, I use 13 industry groups in the Census

classification.⁴² Since the instrument depends on industrial composition of city m in $t - 1$ and the change in labor supply to each industry in all cities but m , it is exogenous to current productivity levels in city m . The predicted supply of labor of each type is $\ln \hat{N}_{msa,t} = \ln N_{msa,t-1} + B_{msa,t}$, and the instrumented labor demand is given by

$$\ln w_{msa,t} = \ln \text{const}(\alpha, i^k) + \frac{1 - \eta}{\eta} \ln \left(1 + \left(\frac{\sum_{\tilde{a}=1}^T g_{ms'\tilde{a},t} \hat{N}_{ms'\tilde{a},t}}{\sum_{\tilde{a}=1}^T g_{ms\tilde{a},t} \hat{N}_{ms\tilde{a},t}} \right)^\eta \right) + \varphi_t + \ln g_{msa,t}. \quad (4.2)$$

The Bartik approach cannot however solve the first endogeneity problem, i.e. that type-specific productivities enter one of the regressors. Moreover, the definition of the Bartik shock requires a previous period. This implies that I cannot use 1980 and must start my analysis from 1990, missing a decade in which important changes in regulation and distribution of economic activity across space happened.⁴³

Therefore I proceed with estimating the original labor demand equation (4.1). I argue that the consequences of the endogeneity are quantitatively small. First, using Bartik shocks for the period of 1990-2007 yields similar parameter estimates as the estimation that ignores endogeneity. The elasticity parameter is $\eta = 0.626$ when estimated from equation (4.2) and $\eta = 0.644$ when estimated from (4.1) using the 1990-2007 data. The mean and the standard deviation of the vector g are 16.84 and 6.70 when estimated from (4.2), and 17.34 and 6.92 when estimated from (4.1). The correlation between g produced by estimation with and without Bartik shocks is 0.99, which means that the estimates obtained from (4.1) are simply slightly shifted upwards, but the relative values of g are nearly identical. Second, even though the productivity parameters g are correlated with one of the regressors by construction, the correlation is only -0.05, thus the endogeneity bias is small.

The labor demand equation is estimated using data from 1980, 1990, 2000 Censuses and 2005-2007 three-year American Community Survey sample. The estimated η is equal to 0.6824 and is close to the range of values estimated in Card (2009).⁴⁴

⁴²The industry groups are: (1) agriculture, forestry, and fisheries; (2) mining; (3) construction; (4) manufacturing of nondurable goods; (5) manufacturing of durable goods; (6) transportation, communications, and other public utilities; (7) wholesale trade; (8) retail trade; (9) finance, insurance, and real estate; (10) business and repair services; (11) personal services; (12) entertainment and recreation activities; (13) professional and related services.

⁴³While I could use the data from 1970 to define a Bartik shock for 1980, the IPUMS version of the Census only identifies 119 metropolitan areas for 1970.

⁴⁴Using a similar CES production function, Card (2009) estimates that the elasticity of substitution between college-equivalent and high school-equivalent labor in the U.S. is between 1.5 and 2.5, which corresponds to η between 0.33 and 0.6.

4.2 Housing Markets

The parameters that characterize the mortgage facility are fixed using the existing data on mortgages. According to the American Housing Survey in 2013, the average downpayment rate was 16.1% (excluding homes bought outright) and 25.1% (including homes bought outright). In practice, a common downpayment in mortgage contracts is 20%. Hence I set $\delta = 0.2$. As much as 80% of outstanding mortgages had a 30-year period, thus the mortgage term in the model is set to $\kappa = 6$ periods, which corresponds to 30 years. As a result, the per-period mortgage payment is $\mu = (1 - 0.2)/6 = 0.1333$. Finally, the interest rate on the mortgage is $i^h = 0.0621$, the average rate in 2005-2007, as reported by Freddie Mac.⁴⁵

The remaining housing supply parameters are estimated using the equilibrium price and rent expressions. Taking logs of equations (3.2) and (3.3), and using $\zeta_m = \bar{\zeta} + \zeta_m^{\text{reg}} + 1$, we obtain the expression for the house price

$$\ln p_m = \ln \chi_m^O + \ln (\bar{\zeta} + \zeta_m^{\text{reg}} + 1) + (\bar{\zeta} + \zeta_m^{\text{reg}}) \ln \left(\frac{N_m}{\Lambda_m} \right), \quad (4.3)$$

and the rent

$$\ln r_m = \ln (1 - \rho) + \ln \chi_m^R + \ln (\bar{\zeta} + \zeta_m^{\text{reg}} + 1) + (\bar{\zeta} + \zeta_m^{\text{reg}}) \ln \left(\frac{N_m}{\Lambda_m} \right). \quad (4.4)$$

Since the land use regulation data is only available for 2007, housing supply is estimated using individual-level data from the 2005-2007 ACS three-year sample. Define $p_{mi}^j = p_{mi}$ if $j = O$, and $p_{mi}^j = r_{mi}$ if $j = R$. Rents p_{mi}^R , originally reported at monthly frequency, are converted to 5-year rates to be consistent with the quantitative model. Combining equations (4.3) and (4.4), we can express the price of unit i as

$$\ln p_{mi}^j = \mathbb{I}_{j=R} \ln (1 - \rho) + \ln \chi_m^j + \ln (\bar{\zeta} + \zeta_m^{\text{reg}} + 1) + (\bar{\zeta} + \zeta_m^{\text{reg}}) \ln \left(\frac{N_m}{\Lambda_m} \right) + S_i^j + \epsilon_{mi}^j, \quad (4.5)$$

Land endowment Λ_m is taken from Saiz (2010) and represents the fraction of territory within a 50km radius from the population centroid of a metropolitan area that is not occupied by water or slopes steeper than 15%.⁴⁶ The vector S_i^j controls for differences in quality of units and consists of dummy variables for the number of rooms, the year of construction, and the number of housing units in the structure where the unit is located. Each of the dummies is

⁴⁵<http://www.freddiemac.com/pmms/pmms30.htm>

⁴⁶This implies that potential land area of an MSA only depends on geographic characteristics and not on population size or regulation.

allowed to vary depending on whether the unit is rental or owner-occupied:

$$S_i^j \equiv S_i^{\text{rooms},j} + S_i^{\text{year},j} + S_i^{\text{units},j}.$$

Equation (4.5) cannot be estimated directly: since prices affect labor supply, there is reverse causality. This issue is overcome by instrumenting for labor supply using Bartik (1991) labor demand shocks, similar to those described in Section 4.1. The Bartik instrument is defined as the change in the supply of labor of type (s, a) with ownership status j in city m , as predicted by changes in the supply of this type of labor in each of the industries $z \in \mathcal{Z}$ in the rest of the economy between 2000 and 2007. The instrument is given by

$$B_{msa,2007}^j = \sum_{z \in \mathcal{Z}} \left(\ln \left(\sum_{m' \neq m} N_{zm'sa,2007}^j \right) - \ln \left(\sum_{m' \neq m} N_{zm'sa,2000}^j \right) \right) \frac{N_{zmsa,2000}^j}{N_{msa,2000}^j},$$

and the predicted supply of labor of each type is $\ln \hat{N}_{msa}^j = \ln N_{msa,2000}^j + B_{msa,2007}^j$.

To convert the Wharton index of regulation into units suitable for the housing supply specification in this paper, I decompose the regulation level as

$$\zeta_m^{\text{reg}} = \tilde{\zeta}^{\text{reg}} \tilde{W}_m, \quad (4.6)$$

and estimate $\tilde{\zeta}^{\text{reg}}$. \tilde{W}_m is the log of the Wharton index plus 3.⁴⁷ The equation (4.5) can be transformed into the following estimating equation

$$\ln p_{mi}^j = \text{const} + \bar{\zeta} \ln \left(\frac{\hat{N}_m}{\Lambda_m} \right) + \tilde{\zeta}^{\text{reg}} \tilde{W}_m \ln \left(\frac{\hat{N}_m}{\Lambda_m} \right) + S_{mi}^j + \varphi_m + \epsilon_{mi}^j, \quad (4.7)$$

where φ_m is the city fixed effect and $\hat{N}_m = \sum_{j \in \{O,R\}} \sum_{s \in \{H,L\}} \sum_{a=1}^T \hat{N}_{msa}^j$. I identify $\bar{\zeta}$ and $\tilde{\zeta}^{\text{reg}}$ from the housing supply equation. The estimated elasticities are: $\bar{\zeta} = 0.1093$ and $\tilde{\zeta}^{\text{reg}} = 0.0666$. Using the estimated $\tilde{\zeta}^{\text{reg}}$, I construct the measure of regulation based on equation (4.6) and use moments of the distribution of ζ^{reg} in the calibration of the model (see Section 4.4).

Finally, I calibrate χ_m^j . First, I assume that $\chi_m^O = \chi^O$ in all cities and fix χ^O so as to match the average expenditures on housing as a fraction of wage and salary income.⁴⁸

⁴⁷The original Wharton Index is built such that it has mean of zero and standard deviation of one. This transformation is used by Saiz (2010) in order to ensure positive levels of regulation in the estimation. He claims that adding other positive constants to the log of the original index does not change his results.

⁴⁸While physical construction costs do differ across cities, Gyourko and Saiz (2006) show that most of the differences come from factors that in my model are captured by the inverse supply elasticity, land availability and population density, and not by physical construction costs χ_m^j .

According to the Consumer Expenditure Survey, this fraction was 0.199 in 2007.⁴⁹ Then $(1 - \rho)\chi_m^R = \frac{p_m}{r_m}\chi_m^O$, i.e. $(1 - \rho)\chi_m^R$ is found from the observed price-to-rent ratio in every location in 2007 using the model of the construction sector. Note that I cannot separately identify ρ and χ_m^R , however this is not needed for the quantitative model.

4.3 Workers, Preferences and Location Choice

There are 8 model periods that correspond to ages 25-29, 30-34, ..., 60-64. The fraction of high-skilled workers in the economy is $\lambda_H = 0.3984$, which is the share of observations with a college degree in the sample. The time discount factor is $\beta = 0.96$.

The remaining parameters related to workers and their preferences are calibrated (all values and targets are summarized in Table 3). The utility of homeownership γ affects how often individuals choose to own rather than rent, and thus is calibrated to match the average homeownership rate in the U.S.

The disutility of living outside the home location, ξ , determines the relative importance of economic factors, such as housing prices and wages, in location choices. The value of ξ is important for quantitative exercises with counterfactual levels of regulation. If ξ is high enough, then changes in regulation will have no effect on the economy, since all individuals live in their birth locations no matter what. If $\xi = 0$, then the distribution of population and economic activity is extremely sensitive to changes in regulation. The value of ξ must reflect the propensity of the young to migrate, and therefore is calibrated to replicate the five-year inter-MSA migration of the 20-29 year olds. Unfortunately, five-year migration is not observed directly. Hence I construct the five-year rates using the metro area of residence one year ago reported by individuals in the ACS. If an individual of age 20-29 reports an MSA different from the MSA of current residence, he or she is a migrant. I calculate the five-year rate directly from the one-year rate as $mig_5 = 1 - (1 - mig_1)^5$, and obtain 0.361, i.e. more than one-third of individuals aged 20-29 move across metropolitan areas in a five-year period.

Since migration is impeded by home attachment, the distribution of the newborn population ψ_m determines the city size distribution in the model. I calibrate ψ_m by targeting the observed distribution of labor force across metro areas in 2005-2007.⁵⁰ Finally, the variance of the location preference shocks ε cannot be identified within the model, and I assume that

⁴⁹It is lower than the 0.24 share computed by Davis and Ortalo-Magné (2011). The difference arises because they use rent including utilities. I instead use both rent and mortgage payments, but exclude utilities, since they are unlikely to vary across locations for the same reasons prices vary in my model.

⁵⁰Many spatial models use unobserved amenities to reproduce the observed distribution of population, Hsieh and Moretti (2015) being one example. Hence, even though there are no amenities in this model, they could be introduced to play the same role as ψ_m .

the parameter that governs the variance, σ_ε , is equal to 1.⁵¹

4.4 Regulation

The influence of renters on the local government, ϕ_m^R , is assumed to be the same in all locations and is normalized to 1. The influence of owners is parameterized as a function of the fraction of college-educated individuals among homeowners in city m :

$$\phi_m^O = \bar{\phi}^O \frac{N_{mH}^O}{N_m^O}. \quad (4.8)$$

The assumption that ϕ_m^O depends on the fraction of college graduates relies on the assertion by Glaeser, Gyourko and Saks (2005a) that owners might have become more politically organized as education levels have increased. For instance, highly educated workers may have a better ability to unite for a common goal or have a better understanding that, by organizing their efforts, they have higher chances to persuade local government to serve to their needs.⁵² Alternatively, college educated residents may have stronger preferences for regulation in order to avoid congestion or preserve current appearance of their city.

Indeed, I find that college share has a significant positive effect on a metro area's Local Political Pressure Index even after controlling for wages, house prices, land availability and the share of voters who supported a democratic candidate in 2008 presidential elections (Table 2).⁵³ In a similar regression where the WRLURI is the dependent variable, the effect of college is small and insignificant, which suggests that in MSAs with more college graduates homeowners have more influence on local governments even if it does not necessarily result in more stringent regulation. The predictions of the model are identical – higher ϕ_m^O due to larger proportion of college graduates increases the influence of owners but does not guarantee higher regulation, since other factors also play a role.

The parameter $\bar{\phi}^O$ is calibrated to match the standard deviation of the estimated regulation ζ_m^{reg} . The parameters of the campaign contribution function, ω_0 and ω_1 are set as follows. Since ω_0 determines the magnitude of the contributions, its target is the average regulation. At the same time, ω_1 affects how compressed the distribution of regulation is, hence the target for this parameter is the p75-p50 ratio of the distribution of regulation.

⁵¹Most papers in the migration literature that use extreme value type 1 shocks cannot identify the variance parameter and normalize it to unity. The reason is that, since CCPs are defined relative to each other, σ_ε simply rescales all other parameters. See Arcidiacono and Ellickson (2011) for discussion.

⁵²Baldassare and Protash (1982) estimate that the best predictor of anti-growth policies among North California city planning agencies is the share of population employed in white-collar jobs. DiPasquale and Glaeser (1999) find that homeowners are more likely to vote in local elections.

⁵³The Local Political Pressure Index is one of the subindices of the Wharton Index. It measures the degree of involvement by various local actors, such as community pressure groups, in the development process.

Since the observed distribution of regulation is asymmetric, the p75-p50 ratio can be used on top of the standard deviation to identify an additional parameter. In the quantitative model, campaign contributions are equal to 1.7% of labor income, hence the fact that they are not used anywhere else in the economy should not have tangible general equilibrium consequences. All parameter values and targets are summarized in Table 3.

5 Benchmark Economy

This section discusses the benchmark economy calibrated to the U.S. economy in 2005-2007 (see Section 4). Table 4 compares the empirical targets for the calibrated parameters and the corresponding moments produced by the model. The calibrated model reproduces very well the six targeted moments, and the distribution of population is nearly perfectly correlated with the one observed in the data. The model also comes fairly close to reproducing a set of non-targeted moments (Table 5). Importantly, even though I assume that individuals of all types consume the same amount of housing, the model reproduces almost exactly the skill differences in expenses on housing and homeownership rates, even though these moments are not targeted. At the same time, the model underpredicts the magnitude of the dispersion of house prices across MSAs. One important reason for this is that in the model only contemporary factors determine the prices. In reality the expectations of future price growth are likely to be an important factor behind high prices in cities like New York and San Francisco.

Most importantly, the model produces a fairly accurate prediction of the level of regulation in each location, even though I only target three moments of the distribution of ζ_m^{reg} . The correlation between the WRLURI and the regulation predicted by the model is 0.48 (Figure 10). However, regulation affects land use and prices through many channels, while the channel emphasized in the model is the elasticity of supply. The correlation between the regulation predicted by the model and the Approval Delay Index (ADI), a part of the Wharton Index most related to the supply elasticity, is 0.68 (Figure 11).⁵⁴ Given that many reasons for why regulation differs across locations are outside the scope of the model, these correlations are fairly high.⁵⁵ If we interpret these correlations as the R^2 in the regressions of the model-predicted regulation on the WRLURI and the ADI, we can say that the model

⁵⁴The Approval Delay Index takes into account the average duration of the review of a building permit, the typical amount of time between application for rezoning and issuance of a building permit for hypothetical projects, and the typical amount of time between application for sub-division approval and the issuance of a building permit conditional on proper zoning being in place.

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

explains 23% of the variation in the WRLURI and 46% of the variation in the ADI.⁵⁶

In addition to being able to replicate aggregate moments and the distribution of regulation, the model is also capable of reproducing other cross-city distributions. Table 6 shows that city-specific homeownership rates, house prices, and fractions of labor force with college degree are all highly correlated with their counterparts in the data. The relationship between the observed and predicted house prices and shares of high-skilled workers are also depicted in Figures 12 and 13, respectively.

Table 7 lists the top 10 regulated metro areas in the model and their ranks in the data. It is remarkable, though not surprising, that four out of ten most regulated places in the model are located in California. The state has been known for its strict land use regulation which is often blamed for high housing prices there (Quigley and Raphael, 2005). One notable outlier in the top 10 list is Chicago. In the data, regulation there is fairly low, however the model predicts high regulation since this is an MSA with large population and a sizable proportion of its territory in the 50km radius is occupied by the lake.

5.1 Static Effects of Regulation

How do levels and cross-city differences in regulation matter for aggregate outcomes, such as output, and distributional outcomes, such as differences in wages and housing prices across locations? In this section, I study responses of the economy to exogenous changes in the distribution of regulation levels. The results are summarized in Table 8.

First, I equalize regulation levels in all locations to the population-weighted mean from the benchmark economy (0.0821). Regardless of the average level of regulation, differences across cities may act as distortions and lead to misallocation of labor across space, as in Hsieh and Moretti (2015). I find that setting regulation in all cities to the weighted mean level would result in an 11% decline in average house prices. The reason for this is that in the model prices are a convex function of the level of regulation.⁵⁷ Furthermore, equalizing regulation leads to a 68% fall in the variance of log prices. The result is not surprising, since regulation is a key component of construction costs in the model, and is consistent with Glaeser, Gyourko and Saks (2005b) and Saiz (2010), who found that a major part of the variation in housing prices across metro areas in the U.S. can be attributed to differences in residential land use regulation. In addition, equalizing regulation would lead to an approximately 2% increase in output and wages, as well as an 8% drop in the variance of log mean wages.

Second, I set regulation in every city to 1/2 of the calibrated level. In this case, the

⁵⁶In a univariate linear regression, R^2 is equal to the square of the correlation between the regressor and the dependent variable.

⁵⁷It is straightforward to check from equation (3.2) that $\partial^2 p_m / \partial (\zeta_m^{\text{reg}})^2 > 0$

distortions that arise from differences in regulation are still present, but are half as important everywhere. As a result of this experiment, the variance of log prices falls by half due to the fact that now construction costs are less dependent on regulation. Output grows by 1.9%. Wages also grow by 1.9% and the variance of log wages across MSAs falls by nearly 10%.

Finally, I set regulation to zero in all cities. Now regulation has no effect on housing prices, and they are determined solely by population density and physical construction costs. As a consequence, the variance of log house prices shrinks to just 15% of the benchmark variance. House prices are low and very similar in all locations, and therefore are relatively unimportant in the location choices of individuals. In this experiment, output and wages grow by 2.4%. Variance of log wages falls to a mere 15% of the benchmark level.

6 Endogenous Rise of Regulation from 1980 to 2007

What are the implications of the rise in regulation for aggregate productivity, and for wage and house price dispersion across metro areas? A natural way to answer this question would be to construct a counterfactual 2007 economy in which regulation is at the level of 1980. However, regulation is not observed in 1980. Hence I first construct a 1980 economy in which regulation is imputed from the model. To this end, I change the city-, skill-, and age-specific productivities, college attainment, national workforce size and the average mortgage rate to the 1980 level.⁵⁸ I also change the physical construction cost of owner-occupied housing χ^O to 8,935 and the utility of homeownership γ to 0.431 in order to match the expenditures on housing and the homeownership rate in 1980.⁵⁹ Finally, I recalibrate the distribution of ψ_m in order to reproduce the city size distribution in 1980. The rest of the parameters are left as in the benchmark calibration. In this 1980 economy regulation adjusts endogenously: it becomes smaller on average and less variable across metro areas. Figure 14 depicts the distributions of regulation levels in the benchmark and the 1980 calibrations. Table 9 displays the fit of a set of moments in the 1980 calibrated model relative to the data.

Then I construct a counterfactual economy in which all technological parameters and skill supply are as in 2007 but regulation is fixed at the 1980 level. The effect of the rise in regulation can be evaluated by comparing the benchmark economy with the same economy in which regulation remains fixed at the 1980 level. The results of this counterfactual

⁵⁸The estimated equation (4.1) provides productivities for 1980. College attainment is changed from 0.398 in 2007 to 0.255 in 1980. The average mortgage rate was 13.74% in 1980, according to the Freddie Mac data.

⁵⁹Homeownership rate and expenses on housing barely changed between 1980 and 2007. Homeownership rate increased from 0.709 to 0.725. Housing expenses, as a fraction of wage and salary income, grew from 0.192 in 1984 to 0.199 in 2007. The earliest available aggregated data from the Consumer and Expenditure Survey is for 1984, hence I use it as a proxy for 1980.

experiment are summarized in Table 10.

The primary effect of the increase in regulation is the misallocation of labor: as real estate in productive locations becomes prohibitively expensive some workers trade off wages for more affordable housing in less productive places. Figure 15 shows that, if regulation had not increased since 1980, large productive metro areas would be even larger. This misallocation reduced aggregate productivity growth. In the absence of changes in regulation, total output would be 2.1% and mean wages 2% higher in 2007 than they actually were. These effects arise because productive areas tend to be more regulated, and therefore have higher house prices. As a result, labor is misallocated, as workers often choose to reside not where they are most productive but where housing is affordable. If there were no changes in regulation since 1980, there would be many more workers in some highly productive areas, and output in cities such as New York and San Diego, would be more than 40% larger (Table 11).

The magnitude of skill sorting is measured by the regression coefficient of the change in the fraction of college graduates in a city's labor force between 1980 and 2007 on the fraction in 1980. In the benchmark economy this coefficient is 0.283. However, when regulation is kept at the 1980 level, the coefficient falls to 0.133, i.e. the endogenous regulation mechanism accounts for about 53% of the skill sorting between 1980 and 2007. This difference emerges because fewer low-skilled would have to leave the most productive areas because of being priced out of local real estate markets.

More intense skill sorting leads to higher wage inequality. Indeed I find that if regulation had remained at the 1980 level, the variance of log wages across metro areas would be 0.147, whereas in the benchmark economy it is 0.162. This difference makes up about 0.23 of the rise in the inequality between 1980 and 2007 benchmark economies, hence the increase in regulation accounts for 23% of the growth in wage inequality across MSAs during this period.

However the largest effects of regulation are observed in housing markets. If regulation had not changed since 1980, house prices would still grow due to rising construction costs and population density, but the average price in 2007 would be 43% smaller than in the benchmark economy. Moreover, absent the growth in regulation, the variance of log prices would be only grow from 0.049 to 0.062, compared to 0.141 in the benchmark 2007 economy, i.e. the growth of house price dispersion would be 85% smaller.⁶⁰

The effects of the rise in regulation are heterogeneous across metro areas. If regulation had not changed since 1980, large productive cities would be even larger than they currently are: the population of New York, Los Angeles and Chicago would be 61%, 43% and 73%

⁶⁰Gyourko, Mayer and Sinai (2013), using a different framework in which regulation is exogenous and fixed over time, find that the rise in college supply and the increase in wage inequality can explain more than 80% of growth in house price dispersion between 1970 and 2000.

larger, respectively (Table 11). At the same time, most small cities would shrink. Without changes in regulation house prices in New York, Los Angeles, San Francisco and Miami would be more than 60% lower than they are now. At the same time, in inexpensive and lightly regulated areas, such as Dallas and Houston, they would not be much different compared to the present levels.

In this counterfactual experiment the effect on aggregate productivity is modest, compared to the findings of Hsieh and Moretti (2015).⁶¹ This is because workers have strong non-economic preferences for locations: attachment to home and location-specific utility shock. Wages and house price differences are often not large enough to overcome the disutility of living outside the preferred location. Thus even dramatic changes in regulation would have a moderate effect on the distribution of labor across space. Moreover, the estimates of agglomeration effects in the literature are not large enough to make a sizable difference for this paper’s quantitative results: existing studies find that doubling the city size increases productivity by 4-5%.⁶² If anything, a model with agglomeration might produce stronger results than I currently find, since, due to reallocation of workers to already big cities, productivity there would become even higher.

7 Policy Interventions

In the U.S., the federal and state governments have virtually no authority to interfere with municipal decisions on land use.⁶³ Land use regulation in the U.S. has always been administered by municipal governments, and direct federal involvement in land use issues would be unconstitutional.⁶⁴ In the model in this paper likewise local governments choose regulation independently, only considering local welfare and disregarding possible nationwide effects of their decisions. However, as the exercise in Section 6 illustrates, the freedom of cities to set their preferred level of regulation results in lower aggregate productivity. This happens because residents of any given city, when choosing regulation independently, impose an externality on the rest of the economy.

In this section, I study two alternative arrangements that reduce the level of regulation

⁶¹Hsieh and Moretti (2015) find that reducing regulation in only three highly productive metro areas – New York, San Francisco and San Jose – to the median U.S. level would raise aggregate productivity by almost 10%. They find a much larger effect than the current paper due to the assumption of free mobility of workers. In their model changes in housing supply elasticities lead to a massive reallocation of labor and New York, San Francisco and San Jose become more than five times larger. When they restrict mobility, their results are much smaller.

⁶²See Ciccone and Hall (1996) and Rosenthal and Strange (2008). Combes and Gobillon (2015) offer a comprehensive up-to-date review of empirical estimates of agglomeration externalities.

⁶³Hirt (2014) discusses the history of land use regulation in the U.S. and compares it to other countries.

⁶⁴Gyourko and Molloy (2015).

in those locations where homeowners have incentives to impose strict regulation. In the first, cities may choose their level of regulation up to an exogenous upper limit instituted and enforced by a central government. While this policy is not possible to implement due to legal constraints to federal involvement in local land use, it provides a ballpark estimate of what the central government could achieve with such a policy. In the second, the federal government introduces a tax that discourages regulation.

7.1 Cap on Regulation

Suppose that the federal government sets an upper limit on the level of regulation that no city can exceed. The election mechanism remains as described in Section 3.3 but, instead of equation (3.7), the chosen level of regulation has to satisfy

$$\zeta_m^{\text{reg}} = \operatorname{argmax}_{\zeta^{\text{reg}} \in [0, \bar{\zeta}^{\text{reg}}]} \{W_m(\zeta^{\text{reg}})\},$$

where $\bar{\zeta}^{\text{reg}}$ is the exogenously established upper limit.

In the following exercise regulation is capped at $\bar{\zeta}^{\text{reg}} = 0.0821$, the weighted average level of regulation observed in the data. All other parameters are taken from the benchmark economy. The results of the experiment are summarized in Table 12.

Introduction of a cap on regulation raises output and wages by 1.4%, as labor reallocates to more productive areas which are too expensive when regulation choices are unrestricted. Under the new regime, wage inequality across metro areas declines by more than 3%. However, the largest effect is on housing markets. On average, prices fall by 19%, and by much more in the most expensive areas: in New York prices drop by 54% and in San Francisco by 46%. The dispersion of house prices across MSAs shrinks to just two-thirds of the level under decentralized regulation. The policy also makes homeownership more widespread: the average ownership rate goes up from 73.4% to 80.6% and the ratio of ownership rates of high to low skilled workers falls from 1.2 to 1.15. In this experiment, the differences in regulation across cities become much smaller. Most cities that were highly regulated in the benchmark economy simply choose $\bar{\zeta}^{\text{reg}}$, the highest possible level of regulation.

7.2 Taxing Highly Regulated Cities

While the previous policy intervention would be successful in reducing the negative aggregate and distributional effects of regulation, it is politically infeasible due to legal barriers to federal involvement in local land use.

A more realistic way to deal with excessive regulation is to introduce a Pigouvian tax

that reduces incentives of local governments to regulate housing supply. This tax can take numerous forms. One option is a national system of transfers between communities in which the size of the transfer depends on a measurable indicator of supply restrictions (e.g. number of constructed units per capita). Another option is to introduce amendments to the personal taxation system. For instance, the federal government could lower the limit for the mortgage interest deduction and use the tax revenues to stimulate construction in highly regulated areas.⁶⁵ Also, the federal government could reform taxation of real estate capital gains. Currently, households can deduct up to \$500,000 of the taxable profit from the sale of real estate, and the capital gains tax rate does not depend on the sale price.⁶⁶ Lowering the deduction limit or making the tax rate increasing in the sale price may reduce incentives of homeowners to introduce supply restrictions that result in higher prices.

All these proposals essentially tax owners of expensive real estate, and thus can be interpreted as a progressive property tax. To understand how successful these policies might be, I introduce a redistributive tax which encourages deregulation of housing supply. Under this tax scheme, homeowners in expensive cities pay higher taxes on the value of their property. The tax proceeds are then transferred to owners in inexpensive places. I assume that the tax rate depends on house prices as follows:

$$\tau_m = \tau_0 + \tau_1 p_m.$$

When $\tau_0 < 0$, then, depending on the level of regulation, the tax rate may be positive or negative. If $\tau_m > 0$, then homeowners are taxed for choosing strict regulation that lead to high real estate prices. If $\tau_m < 0$, then owners are rewarded for selecting lax regulation. The policy is purely redistributive, i.e. net transfers in the economy are equal to zero:

$$\sum_{m \in \mathcal{M}} \tau_m p_m N_m^O = 0. \tag{7.1}$$

The parameters of the tax function are fixed as follows. I set τ_1 so that the tax rate is not too sensitive to price levels. I choose $\tau_1 = 1.68 \times 10^{-7}$: at this level a move along the interquartile range of the distribution of house prices in the benchmark economy (from \$129,570 to \$189,120) yields a 1 percentage point change in the tax rate. At this level of τ_1 , the value of τ_0 that satisfies equation (7.1) is -0.0384 . Local tax rates in this experiment range from -2.4% to 1.9%. The remaining parameters are as in the benchmark economy. The results of the experiment are summarized in Table 12.

⁶⁵This solution was originally proposed by Glaeser and Gyourko (2008). They suggested a reduction from the current \$1,000,000 to \$300,000.

⁶⁶<https://www.irs.gov/pub/irs-pdf/p523.pdf>

The disincentives to regulate brought by the tax lead to a significant reduction in the level of regulation: the average ζ^{reg} falls from 0.07 to 0.062. As a result, more labor locates in productive and previously expensive areas and both output and wages grow by about 1.5%. Wage inequality across MSAs falls by almost 5%. House prices fall by 25% on average, and the price dispersion across locations dwindles to just 52% of the benchmark level. The average homeownership rate increases from 73.4% to 82%. The ratio of ownership rates of high to low skilled workers drops from 1.2 to 1.12. As in the previous policy experiment, most of the decline in prices occurs in cities that were highly regulated in the benchmark economy: in New York they drop by 59% and in San Francisco by 45%.

8 Conclusions

In this paper, I argue that housing supply regulation and the forces that drive it are crucial to understand the divergent dynamics of labor and housing markets in the U.S. Since the 1980s, there has been an increase in sorting of skilled workers to more productive and expensive metro areas. The impact of higher sorting on wage and housing price dispersion across MSAs was amplified by the endogenously growing regulatory constraints to housing supply. In order to study this channel quantitatively, I build a general equilibrium model in which the distributions of labor, wages and housing prices across metro areas are determined endogenously, and housing supply regulation is chosen by local residents in a political process. To assess the magnitude of the amplification effect of the endogenous regulation mechanism, I construct a counterfactual scenario in which regulation remains at the level of 1980, but exogenous productivities, skill supply and total population are at the level of 2007. The amplification effect is sizable: endogenous regulation choices account for 23% of the rise in wage inequality and 85% of the increase in house price dispersion between 1980 and 2007. Moreover, the rise of regulation reduces productivity due to misallocation of labor, and results in the output loss of 2.1%.

These negative effects arise because regulation is determined locally and residents in each community do not internalize the consequences of their choices for the rest of the economy. In a policy experiment where the federal government provides monetary incentives to reduce regulation, I find that output would be 1.5% higher, wage differences 5% smaller, and average house prices 25% lower.

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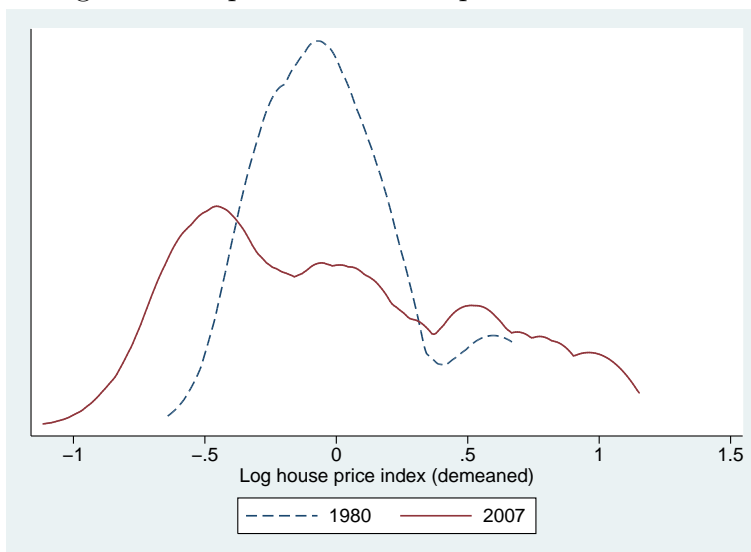
Figures and Tables

Table 1: Summary statistics

	1980	2007
<i>Labor markets:</i>		
Mean hourly wage, \$	8.48	26.18
Log college wage gap	0.368	0.609
Variance of log wages	0.0085	0.0167
Fraction of college graduates, %	25.5	39.8
<i>Housing markets:</i>		
Mean house price index, \$'000	51.7	244.1
Mean rent index	168	681
Variance of log prices	0.062	0.221
Variance of log rents	0.055	0.057
Fraction of homeowners, %	70.9	72.5
Expenses on housing, % income	0.192	0.199

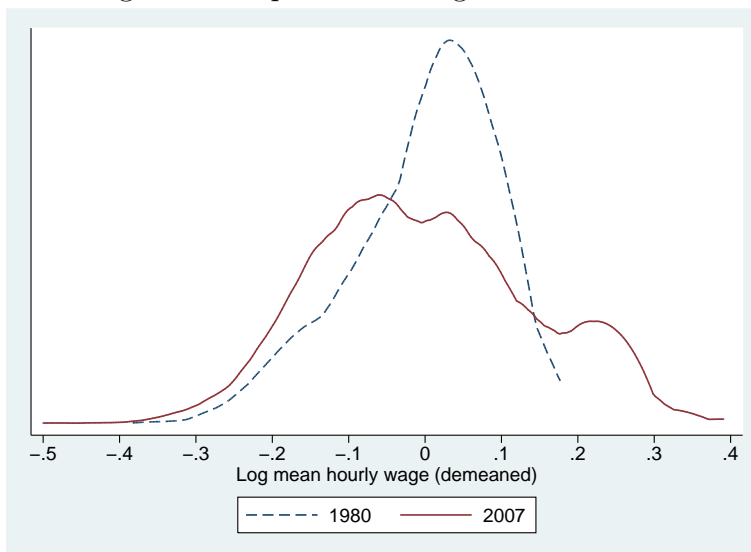
Note: The table compares summary statistics for labor and housing markets in 1980 and 2007 in the sample of 190 metropolitan areas used in this paper. See Section 2.2 for details.

Figure 1: Dispersion of house prices across MSAs



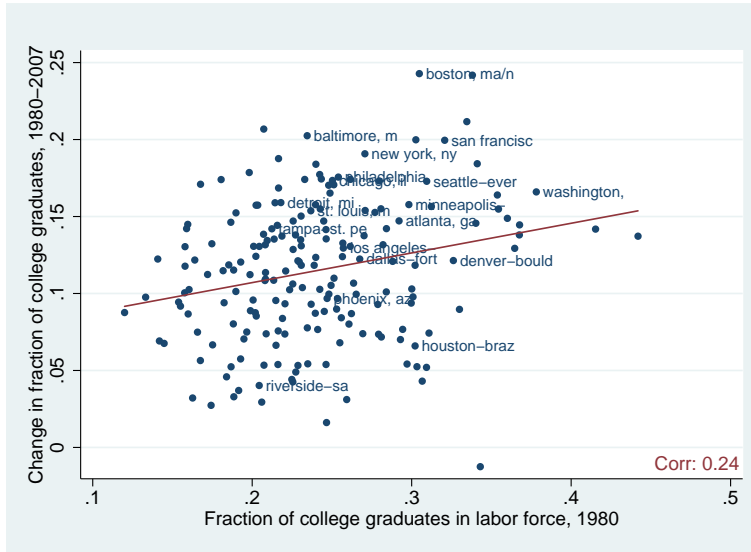
Note: The figure plots the population-weighted distribution of log quality-adjusted house prices across metropolitan areas in years 1980 and 2007. The adjustment for quality is conducted by means of a hedonic regression, as in Eeckhout, Pinheiro and Schmidheiny (2014). The distribution is smoothed using a Epanechnikov kernel. See Section 2.2 for details.

Figure 2: Dispersion of wages across MSAs



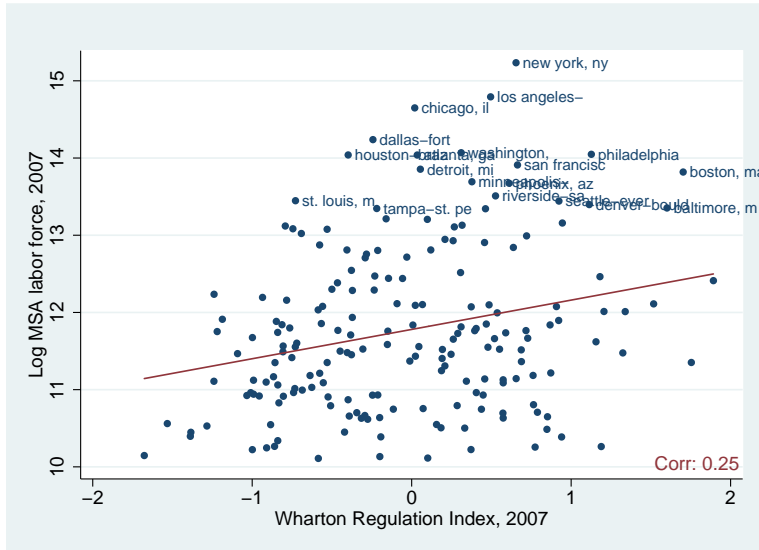
Note: The figure plots the population-weighted distribution of log average hourly wages across metropolitan areas. The distribution is smoothed using a Epanechnikov kernel. See Section 2.2 for details.

Figure 3: Skill sorting



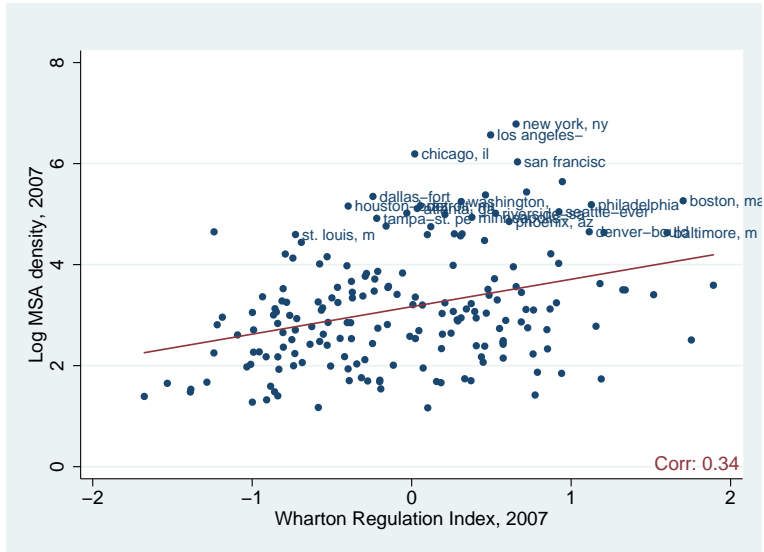
Note: The figure plots the relationship between the share of college graduates in a metro area's labor force in 1980 and the change in the share between 1980 and 2007. See Section 2.2 for details.

Figure 4: Regulation and city size



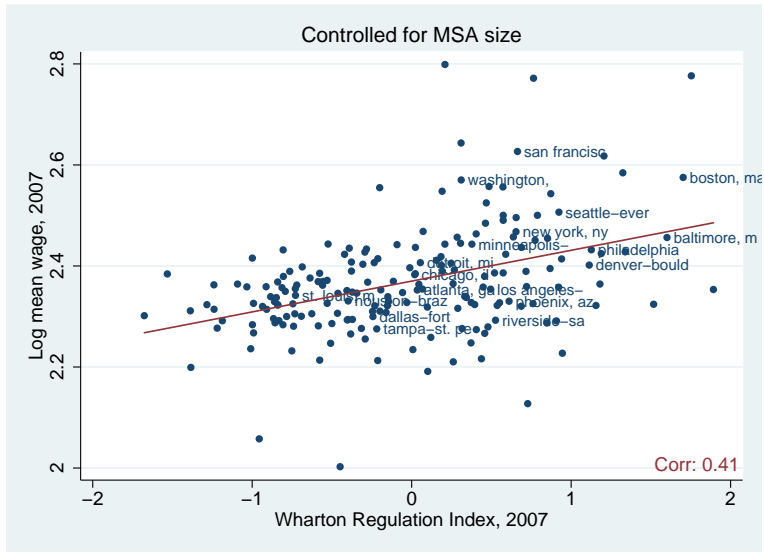
Note: The figure plots the relationship between a metro area's labor force and the Wharton Residential Land Use Regulatory Index. See Section 2.2 for details.

Figure 5: Regulation and population density



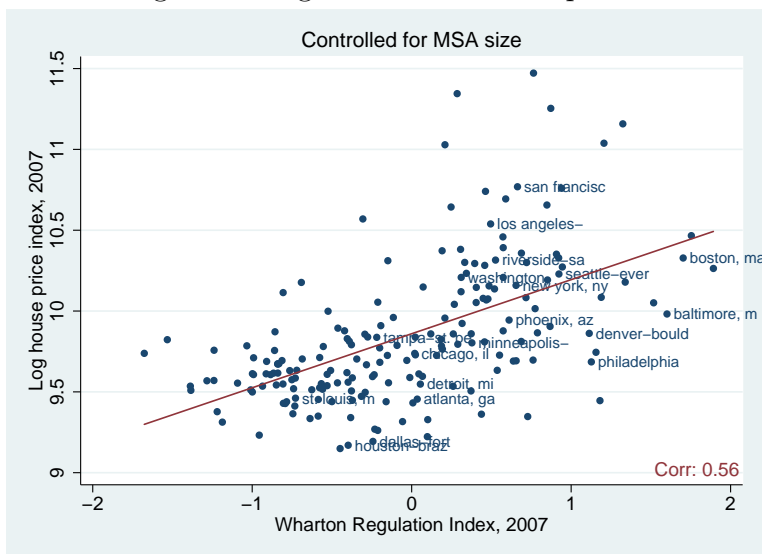
Note: The figure plots the relationship between city population density and the Wharton Residential Land Use Regulatory Index. Population density is measured as labor force per sq km of an MSA land area. The land area is the fraction of land within a 50km radius from the population centroid of a metropolitan area that is not occupied by water or slopes above 15%, taken from Saiz (2010). See Section 2.2 for details.

Figure 6: Regulation and wages



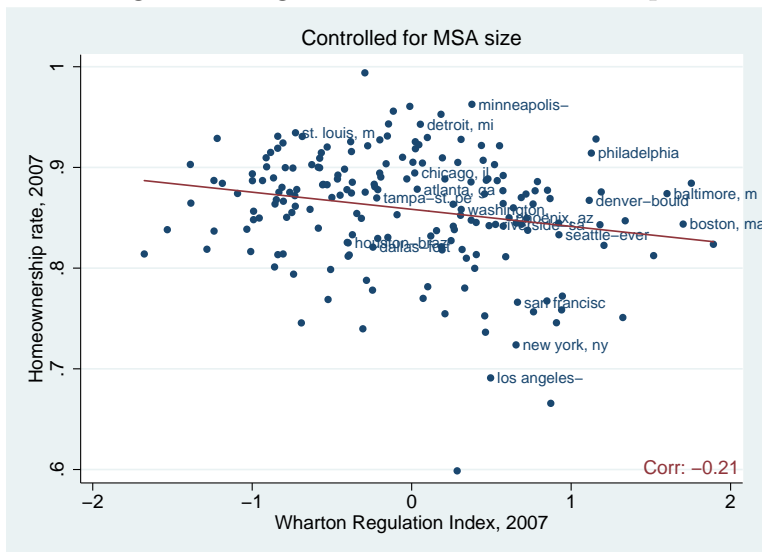
Note: The figure plots the relationship between mean hourly wage, controlled for workforce size, and the Wharton Index. See Section 2.2 for details.

Figure 7: Regulation and house prices



Note: The figure plots the relationship between the quality-adjusted house price index, controlled for workforce size, and the Wharton Index. See Section 2.2 for details.

Figure 8: Regulation and homeownership



Note: The figure plots the relationship between the mean homeownership rate, controlled for workforce size, and the Wharton Index. See Section 2.2 for details.

Figure 9: Rise in regulation and increasing differences across locations



Note: The figure plots the average and \pm one standard deviation across U.S. states of the regulation index constructed by Ganong and Shoag (2015). This figure is adapted from Table 1 of their paper.

Table 2: Predictors of Local Political Pressure Index

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

Note: The table lists coefficients of a regression of the metropolitan area's Local Political Pressure Index (part of the Wharton Index) on college share, wages, house prices, land availability (from Saiz (2010)), and share of votes for the Democratic candidate in 2008 presidential elections in the state where the metro area is located. Standard errors are in parentheses. See Section 4.4 for details.

Table 3: Model Parameters

Parameter			Source
<i>Production</i>			
Productivity shifters	g_{msa}	multiple	Estimate labor demand equation
Substitution between skills	η	0.682	Estimate labor demand equation
Capital share	α	0.335	Valentinyi and Herrendorf (2008)
<i>Housing</i>			
Construction cost	χ^O	15,040	Calibrate. Target: exp share on housing
Elasticity of price wrt density	$\bar{\zeta}$	0.1093	Estimate housing supply equation
Elasticity of price wrt regulation	$\tilde{\zeta}^{reg}$	0.0666	Estimate housing supply equation
Land	Λ_m	multiple	Data (Saiz, 2010)
Downpayment	δ	0.2	Data. 20% of house price
Per-period mortgage payment	μ	0.1333	80%/6
Mortgage term	π	6	Data. 30 years
Mortgage interest rate	i_h	0.0621	Data
<i>Workers and preferences</i>			
Distribution of skills	λ_H	0.3984	Data
Home attachment	ξ	6.52	Calibrate. Target: inter-MSA mig, 20-29
Distr. of preferences for cities	ψ_m	many	Calibrate. Target: distr. of labor force
Annual discount factor	β	0.96	
Utility of homeownership	γ	0.62	Calibrate. Target: homeownership rate
<i>Regulation</i>			
Campgn contribution function	ω_0	2.66E+07	Calibrate. Target: mean WRLURI
Campgn contribution function	ω_1	3.34	Calibrate. Target: p75/p50 WRLURI
Avg influence of homeowners	$\bar{\phi}^O$	15.71	Calibrate. Target: s.d. WRLURI
Avg influence of renters	$\bar{\phi}^R$	1.00	Normalization

Note: The table shows parameter values and whether they are estimated, calibrated, or taken from the literature. See Section 4 for details.

Table 4: Model Fit (targeted moments)

	Model	Data
Expenditures on housing (fraction of income)	0.21	0.20
Homeownership rate	0.73	0.73
Mean regulation	0.070	0.070
S.d. regulation	0.016	0.017
p75/p50 regulation	1.18	1.17
Inter-MSA mobility, ages 20-29	0.36	0.36
Population (corr: data vs model)	0.99	

Note: The table displays the targeted moments in the data and their counterparts in the model. See Section 4 for details.

Table 5: Model Fit (non-targeted moments)

	Model	Data
Dispersion of wages across MSAs (var of log)	0.016	0.017
Dispersion of house prices across MSAs (var of log)	0.141	0.221
Mean house price, \$000	277	244
Expenditures on housing, high/low skilled	0.70	0.72
Homeownership rate, high/low skilled	1.20	1.22

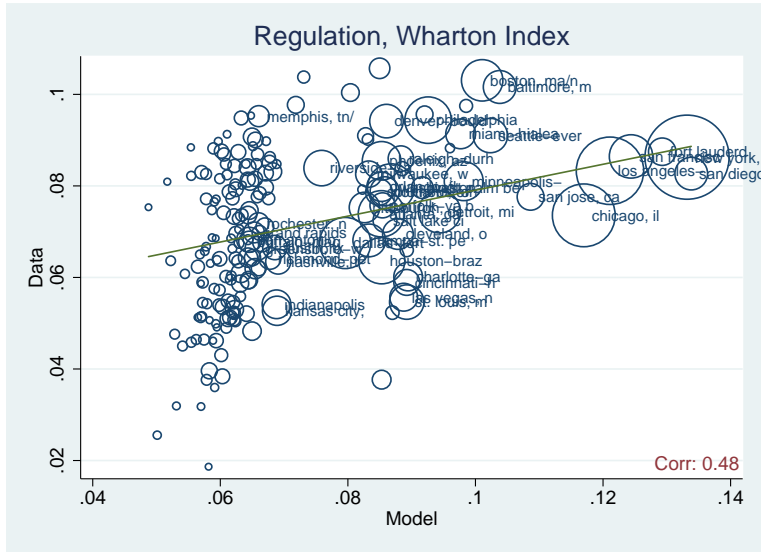
Note: The table displays some non-targeted moments in the data and their counterparts in the model. See Section 4 for details.

Table 6: Correlations: model vs data

	Correlation
Regulation (Wharton Index)	0.48
Regulation (Approval Delay Index, part of the Wharton Index)	0.68
Homeownership rate	0.76
College share	0.75
House prices	0.76

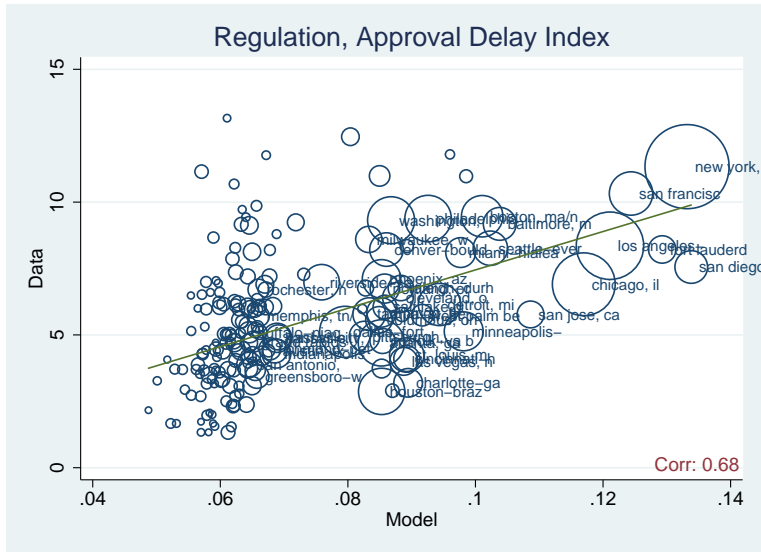
Note: The table displays correlations between MSA-level outcomes observed in the data and the outcomes produced by the model. The correlations are weighted by metro area's workforce size. See Section 4 for details.

Figure 10: Regulation: model vs data. Wharton Index



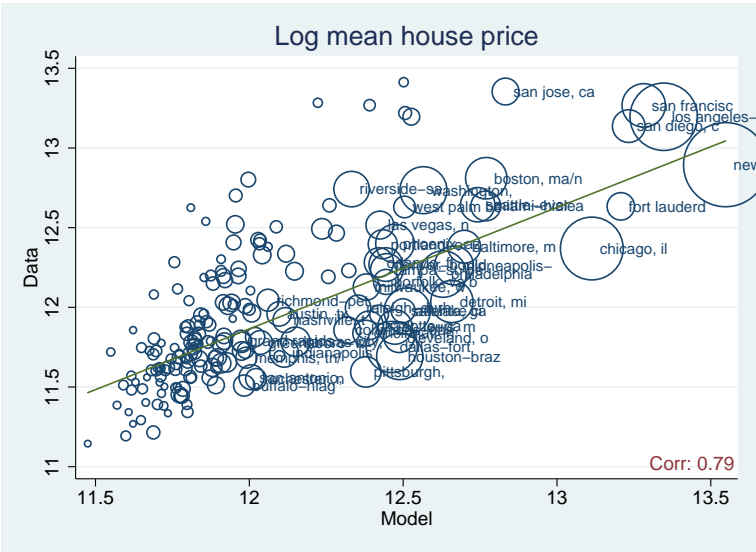
Note: The figure depicts the relationship between the observed level of regulation (Wharton Index) and the level predicted by the model. The fitted line is weighted by workforce size. See Section 5 for details.

Figure 11: Regulation: model vs data. Approval Delay Index



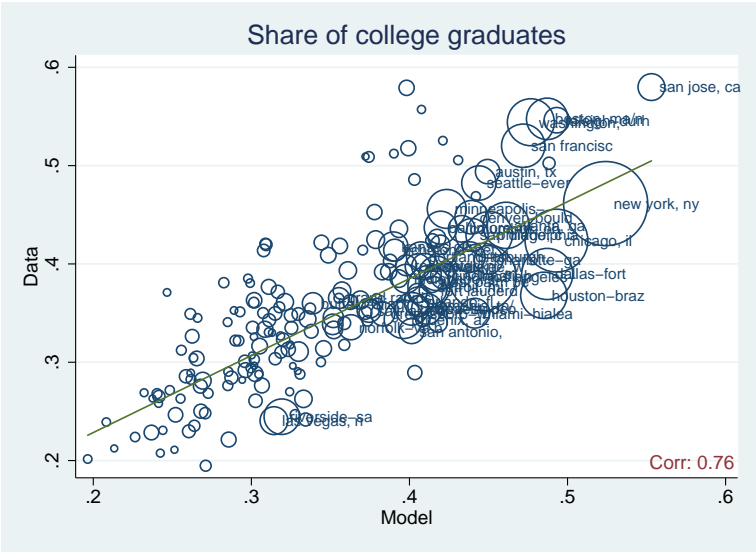
Note: The figure depicts the relationship between the observed level of regulation (Approval Delay Index, part of the Wharton Index) and the level predicted by the model. The fitted line is weighted by workforce size. See Section 5 for details.

Figure 12: House prices: model vs data



Note: The figure depicts the relationship between the observed level of the quality-adjusted house price index and the house prices predicted by the model. The fitted line is weighted by workforce size. See Section 5 for details.

Figure 13: Fraction of college graduates: model vs data



Note: The figure depicts the relationship between the observed share of high-skilled workers in the data (college graduates and above) and the share predicted by the model. The fitted line is weighted by workforce size. See Section 5 for details.

Table 7: Most regulated MSAs (top 10 out of 190)

	# model	# data
San Diego, CA	1	50
New York, NY-NJ-CT-PA	2	34
Fort Lauderdale, FL	3	28
San Francisco, CA	4	32
Los Angeles, CA	5	46
Chicago, IL	6	90
San Jose, CA	7	73
Baltimore, MD	8	4
Seattle, WA	9	16
Boston, MA-NH	10	3

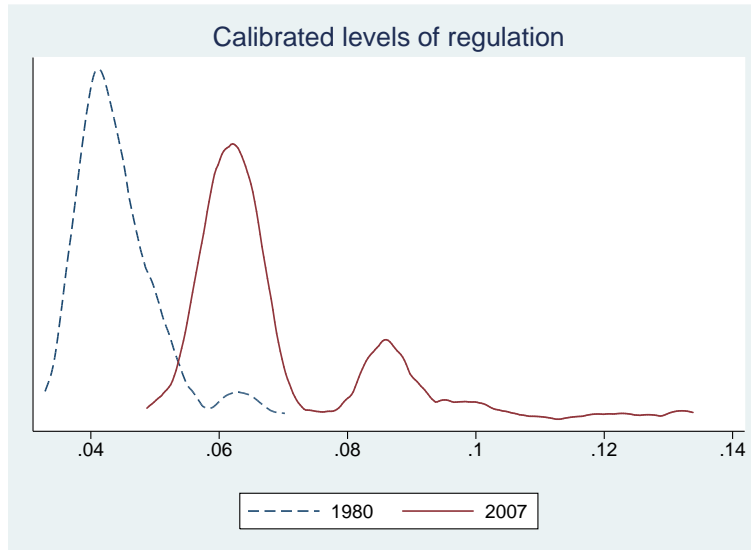
Note: The table shows the ten most regulated metropolitan areas in the model and their corresponding rank in the data, according to the Wharton Index. See Section 4 for details.

Table 8: Static effects of regulation

	Benchmark	Equal reg	Half reg	Zero reg
Mean regulation	0.070	0.082	0.034	0.000
S.d. regulation	0.016	0.000	0.007	0.000
Output	1.000	1.021	1.019	1.024
Mean wages	1.000	1.020	1.019	1.024
Variance of log wages	0.0162	0.0150	0.0147	0.0139
Mean house prices	1.000	0.891	0.533	0.273
Variance of log house prices	0.141	0.046	0.070	0.021

Note: This table shows the results of a quantitative experiment in which the distribution of regulation levels is changed exogenously. The column “Benchmark” shows moments from the benchmark 2007 calibration. The column “Equal reg” shows moments from the 2007 economy in which regulation in all MSAs is set to the weighted mean level, 0.082. The column “Half reg” displays moments from the 2007 economy in which in all cities regulation is half the benchmark level. The column “Zero reg” shows moments from the 2007 economy in which regulation is set to zero everywhere. See Section 5.1 for details.

Figure 14: Calibrated regulation



Note: The figure plots the Epanechnikov kernel-smoothed distribution of levels of regulation in the benchmark 2007 calibration and the 1980 levels imputed using the model. See Section 6 for details.

Table 9: Model fit, 1980 calibration

	Model	Data
<i>Targeted moments</i>		
Expenditures on housing (fraction of income)	0.19	0.20
Homeownership rate	0.73	0.71
<i>Non-targeted moments</i>		
Mean regulation	0.044	—
S.d. regulation	0.007	—
p75/p50 regulation	1.10	—
Inter-MSA mobility, ages 20-29	0.31	—
Dispersion of wages across MSAs (var of log)	0.010	0.011
Dispersion of house prices across MSAs (var of log)	0.049	0.062
Mean house price, \$000	83.3	51.7

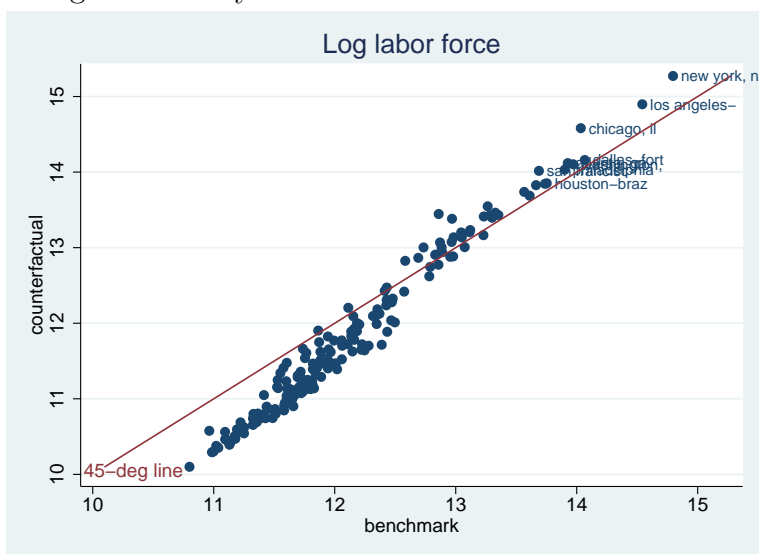
Note: The table displays targeted and some non-targeted moments in the data and their counterparts in the model for the 1980 calibration. See Section 4 for details.

Table 10: Effects of the rise in regulation from 1980 to 2007

	1980 benchmark	2007 benchmark	2007 counterfact	Contrib
Output	1.000	4.834	4.933	2.1%
Mean wages, \$'000	19.6	57.8	59.0	2.0%
Variance of log wages	0.0098	0.0162	0.0147	-23.5%
Mean house prices, \$'000	83.3	277.2	157.0	-43.4%
Variance of log house prices	0.049	0.141	0.062	-85.1%
Skill sorting	—	0.283	0.133	-53.1%

Note: This table summarizes the effects of the endogenous regulation mechanism on a set of variables of interest. The column “1980, benchmark” shows moments for the economy calibrated to 1980. The column “2007, benchmark” displays moments for the benchmark economy calibrated to 2007. The column “2007, counterfact” shows moments for the 2007 economy in which regulation is fixed at the 1980 level. The column “Contrib” calculates contribution of the rise of regulation to the value of a variable of interest. For output, mean wages, mean prices and skill sorting, the contribution is the comparison of the level in the benchmark 2007 economy with the level in the counterfactual 2007 economy. For variance of wages and house prices the contribution is the comparison of the rate of growth between the benchmark 2007 economy and the 1980 economy with the rate of growth between the counterfactual 2007 economy and the 1980 economy. See Section 6 for details.

Figure 15: City size: benchmark vs counterfactual



Note: The figure displays the relationship between the size of the labor force in the benchmark 2007 economy and the counterfactual 2007 economy in which regulation is at the level of 1980. The fitted line is weighted by workforce size. See Section 6 for details.

Table 11: Effects of the rise in regulation from 1980 to 2007, by city

	Regulation, ζ_m^{reg}		Change, %			
	benchmark	counterfact	Popul	Wage	Prices	Output
New York, NY-NJ-CT-PA	0.1332	0.0386	61	-5.4	-77	54
Los Angeles, CA	0.1211	0.0540	43	-0.6	-64	44
Chicago, IL	0.1170	0.0628	73	-2.7	-53	68
Dallas, TX	0.0796	0.0679	10	-1.1	-15	8
Washington, DC-MD-VA	0.0868	0.0472	14	-2.7	-44	11
Philadelphia, PA-NJ	0.0926	0.0623	14	-1.5	-35	12
Houston, TX	0.0853	0.0641	10	-1.6	-26	9
Atlanta, GA	0.0853	0.0456	21	-2.2	-43	19
San Francisco, CA	0.1244	0.0530	39	-2.0	-66	36
Detroit, MI	0.0944	0.0647	11	-0.7	-35	11
Boston, MA-NH	0.1011	0.0498	18	-2.8	-53	15
Minneapolis-St Paul, MN	0.0982	0.0481	19	-1.4	-51	18
Phoenix, AZ	0.0853	0.0490	8	-0.6	-41	7
Riverside-San Bernardino, CA	0.0759	0.0489	33	0.4	-30	32
St Louis, MO-IL	0.0892	0.0636	8	-0.7	-30	7
Seattle, WA	0.1023	0.0529	16	-1.5	-51	15
Denver, CO	0.0861	0.0509	14	-1.5	-39	13
Baltimore, MD	0.1038	0.0504	10	-1.1	-53	9
Tampa-St Petersburg, FL	0.0834	0.0465	20	-0.9	-40	19
San Diego, CA	0.1338	0.0469	51	-1.4	-71	48
Cleveland, OH	0.0878	0.0634	12	-0.7	-29	11
Pittsburgh, PA	0.0826	0.0597	9	-1.0	-27	8
Miami, FL	0.0977	0.0329	80	-1.9	-60	76
Orlando, FL	0.0853	0.0481	17	-0.9	-40	16
Kansas City, MO-KS	0.0689	0.0470	-6	-0.1	-28	-6

Note: The table displays the effect of the endogenous regulation mechanism for the 25 largest metropolitan areas in the U.S. The columns “Regulation, benchmark” and “Regulation, counterfact” show the levels of regulation in the benchmark calibration and the imputed 1980 levels, respectively. The next four columns show how much population, mean wages, house prices and output would change if in 2007 regulation remained at the 1980 level. See Section 6 for details.

Table 12: Federal policy interventions

	Benchmark	Cap on Reg	Tax on Reg
Mean regulation	0.070	0.065	0.062
S.d. regulation	0.016	0.009	0.008
Output	1.000	1.014	1.015
Mean wages	1.000	1.014	1.014
Dispersion of wages (var of log)	0.0162	0.0157	0.0154
Mean house prices	1.000	0.813	0.748
Dispersion of house prices (var of log)	0.141	0.089	0.073
Homeownership rate	0.734	0.806	0.820
Homeownership, high-skl/low-skl	1.203	1.150	1.117

Note: This table summarizes the results of government intervention in the way cities choose regulation. The column “Benchmark” shows moments from the benchmark 2007 calibration. The column “Cap on Reg” displays moments from the 2007 economy in which in maximum level of regulation that a city can choose is capped. See Section 7.1 for details. The column “Tax on Reg” shows moments from the 2007 economy in which the central government introduces a progressive property tax. See Section 7.2 for details.

A Appendix

A.1 Solving the Model

Solving the model involves finding equilibrium objects (defined in Section 3.4) such that the equilibrium conditions hold for given parameters of the model. The sufficient condition for stationarity is that over time the measure of low and high skilled workers remains constant in every location. If it is the case, then wages are stationary, since they are fully determined by labor supply and exogenous productivity. The demand for housing is stationary as well, since everyone consumes one unit of housing. Then, for a given level of regulation, house prices and rents are stationary. Finally, the stationarity of prices and population implies that the incentives to regulate are unchanged from period to period, and therefore regulation is stationary as well.

Solution algorithm. The solution algorithm is described below.

1. Take the supply of each skill and the levels of regulation in every location from the data, and use them as an initial guess. Compute wages, house prices and rents.
2. Solve Bellman equations (3.4) and (3.5), and obtain decision rules for assets and ownership status. The Bellman equations are solved by backward induction, starting from the last period in which value functions are equal to the utility of the last period's consumption.
3. Compute the distribution of workers of each skill across locations using the value functions and the conditional choice probabilities (equation 3.8).
4. Use the value functions and the distribution of workers to compute regulation by maximizing the weighted social welfare function (equation 3.6) in every location. The social welfare function is maximized using the Nelder-Mead search algorithm.
5. Update wages using the new distribution of labor. Update house prices and rents using the new distribution of labor and the updated regulation levels.
6. Go back to step 2 and repeat steps 2 to 5 until the supply of each skill in every city converges.

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

This feature makes computation of regulation very complex for two reasons. First, when solving their Bellman equations, workers would need to know the future path of regulation, given the level of regulation chosen today.⁶⁷ Second, they also need to know how labor

⁶⁷There are 972,800 types of workers: 190 cities, 2 skills, 8 ages, 40 asset grid points, 2 ownership statuses and, for an owner, 7 possible lengths of ownership. This is 5,120 types per city. Every type has a separate value function, and in every city the value functions have to be computed 20-40 times until the optimal regulation is found. The main complication emerges when for each of the 20-40 iterations I need to find the future path of regulation and labor supply that arise from optimal choices of agents.

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

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

Assumption A.1. Individuals believe that the regulation elected for the next period, $\zeta_{m,t+1}^{\text{reg}}$, will persist in all subsequent periods starting from $t + 1$.

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

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

$$\ln N_{ms,i} - \ln N_{ms,i-1} = \theta_0^s + \theta_1^s (\zeta_{mi}^{\text{reg}} - \zeta_{m,i-1}^{\text{reg}}),$$

where i indexes iterations in the solution algorithm.

One difference compared to the standard Krusell-Smith algorithm is that, due to computational cost, I do not run numerous simulations to find θ_0^s and θ_1^s . Instead I use the information generated when the model is solved. At every iteration toward the solution, a location experiences changes in labor supply and regulation, and I use these changes in order to estimate the relationship between labor supply and regulation. Using the estimated θ^s , agents predict that, if they vote to change regulation from ζ^{reg} to $\zeta^{\text{reg}'}$, then the supply of s -skilled workers will change to $\ln N_{ms,i} = \ln N_{ms,i-1} + \theta_0^s + \theta_1^s (\zeta^{\text{reg}'} - \zeta^{\text{reg}})$.

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