Abstract

Regulatory restrictions on housing supply have been rising and have become a major determinant of house prices in the U.S. This paper asks two questions. First, what are the effects of regulation on aggregate productivity, and wage and house price dispersion across metropolitan areas? Second, can the federal government undo these effects by lowering local incentives to regulate housing supply? To answer these questions, I build an equilibrium model with multiple locations and heterogeneous workers. Regulation is endogenous and is decided locally, by voting. In locations with scarce land and high productivity, congestion is stronger and house prices are higher. These places vote for stricter regulation, which raises prices further and leads to greater house price dispersion. High-skilled workers, being less sensitive to housing costs, sort into productive areas, which leads to larger wage dispersion. Thus, the effects of land and productivity differences on wage and price dispersion are amplified by regulation choices. To quantify this amplification, I calibrate the model to the U.S. economy and find that regulation reduces aggregate productivity by about 3.5%, and contributes to the wage and house price dispersion across locations. I also show that a federal policy that weakens local incentives to restrict supply could boost productivity by about 2.5% and reduce house prices.

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

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

Regulation of housing supply in the U.S. has become much stricter since the 1970’s.¹ 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.² 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.³ However, we do not have a perfect understanding of 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. 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.⁴ 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.

This paper makes three contributions. First, it proposes an equilibrium model with multiple locations, in which regulation in every location is determined endogenously in a political process. Second, it calculates the effects of housing supply regulation in the U.S. on aggregate productivity, on wage and house price dispersion across metropolitan areas, and on the skill sorting.⁵ Third, it quantitatively evaluates a federal policy that reduces incentives of local governments to regulate housing supply, and shows that this policy could lower house prices and raise aggregate productivity.

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,

¹This paper uses the notions “housing supply regulation” and “land use regulation” interchangeably.
²This paper focuses on metropolitan statistical areas (MSAs), but uses the notions “metro area”, “city” and “location” interchangeably.
³See, for example, Yglesias (2012), The Economist (2016), and White House (2016).
⁴Moretti (2012) calls these and other related phenomena “The Great Divergence.”
⁵Several recent papers have also calculated the effects of regulation on productivity. See Section 1.1.
housing costs, local amenities, 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. House prices depend on local population size, exogenous land supply and endogenous housing supply regulation.

Regulation performs two functions. First, it reduces the elasticity of housing supply, making house prices and rents higher. Second, it lowers local congestion, increasing the amenity value of cities. Indirectly, by raising housing costs, regulation also reduces local population and wages, since the latter depend on agglomeration externalities. 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.

Individuals have three main considerations when choosing regulation: congestion, agglomeration and housing costs. First, both renters and owners want more regulation because it alleviates congestion. Second, both groups want less regulation because it lowers wages via the agglomeration externality. However, renters and owners have different views on housing costs. Renters prefer less regulation because this decreases rents, as well as 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. Therefore, all else equal, owners vote for higher regulation than renters. 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 the sensitivity of prices to changes in regulation which is higher in cities with scarce land. Costly regulation also means that the ability of owners to influence local governments depends on their incomes. Therefore, in equilibrium, denser and more productive locations are more regulated.

The main mechanism of the model works as follows. Highly productive cities attract workers and, due to an increase in population, housing there becomes more expensive. The need of residents to reduce congestion and the desire of owners to raise the value of their property makes regulation in such locations higher, which increases housing costs further. This effect is stronger in cities with scarce land. That is, endogenous regulation choices amplify the effects of exogenous differences in land and productivity on housing prices. Higher housing costs in productive places also restrict worker inflows, leading to spatial misallocation of labor which makes the entire economy less productive. However, high-skilled

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6The 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.”
workers spend a smaller share of their income on housing and therefore are less sensitive to house price increases. This results in the sorting of high-skilled individuals into productive and expensive cities and exacerbates locational wage differences.

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 202 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.

First, using the quantitative model I show that exogenous differences in land and productivity indeed produce higher overall regulation and lead to larger skill sorting, as well as house price and wage dispersion across cities.

In order to study the effects of regulation, I perform three experiments which compare the benchmark economy with counterfactual economies. First, I introduce a one-size-fits-all policy by setting regulation to the average level in all cities. Second, I halve regulation relative to the benchmark level in all cities. These two experiments yield similar results. Lowering regulation in highly productive places reduces spatial misallocation of labor and raises aggregate productivity by about 3.5-3.8%, reduces wage dispersion by 4-10% and diminishes skill sorting. It also lowers average house prices by 20-30%, as well as reduces dispersion of house prices across cities by 14-24%. Third, I completely eliminate regulation everywhere. In this experiment, aggregate productivity only increases by 1.2%. This is because, in the absence of regulation, congestion effects in large productive cities become very strong and these cities become unattractive to potential residents.

The main reason why regulation has a negative effect on aggregate productivity 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. This implies that a national-level policy that internalizes these externalities might improve aggregate outcomes. I design a Pigouvian tax policy and quantitatively evaluate it using the model. According to this policy, the federal government taxes highly regulated cities and provides transfers to cities with low regulation, thereby discouraging regulation in all cities. This policy raises output by about 2.5%. It also reduces average house prices by 36% and house price dispersion by 16%. However, it reduces skill sorting only marginally and therefore does not diminish wage inequality across cities.

This paper is organized as follows. The rest of this section places this work in the existing literature. Section 2 provides some 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 and describes the benchmark calibrated economy. Section 5 studies the importance of differences in land and productivity, and evaluates the effects of regulation on aggregate productivity, wage inequality and house prices. Section 6 describes a policy experiment that discourages local regulation and studies its effect on the economy. Finally, Section 7 concludes.

1.1 Literature

This paper is connected to several strands of literature. 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. 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 housing supply regulation. The common theme of this work is that regulation leads to misallocation of labor by preventing workers from living in productive places, and may therefore have aggregate effects. Ganong and Shoag (2017) 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 (2018), using a quantitative spatial equilibrium model, find that regulation led to misallocation of labor across U.S. cities and lowered economic growth rate by 36% in 1964-2009. Herkenhoff, Ohanian and Prescott (2017) identify land-use restrictions at the state level from 1950 to 2014 using a quantitative spatial equilibrium model with housing and labor markets, and argue that the increase in the restrictions slowed down economic growth in the U.S. Truffa (2017) uses a spatial equilibrium model to study the effects of regulation on wage inequality and housing prices, and finds

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

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

9 Even 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).
that increasing housing supply has a limited effect on productivity because of skill sorting.

Many of the key driving forces of the mechanisms in these papers are also present in the current paper, however most of the previous work treats regulation as exogenous and remains silent on why some cities are more regulated than others.\textsuperscript{10} One exception is \cite{Bunten2017} which proposes a model with endogenously determined regulation as a response to congestion, and finds that regulation reduces output and welfare by 1-2\%. However, it does not study the effects of regulation on skill sorting and house price and wage dispersion. It also does not discuss how a welfare-maximizing policy could be implemented.

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. \cite{HilberRobert-Nicoud2013} study a lobbying game in which landowners, who prefer more regulation, compete with developers, who prefer less.\textsuperscript{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 \cite{Ortalo-MagnePrat2014}, which formalizes the “homevoter hypothesis” of \cite{Fischel2001} 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. In \cite{Albouyetal2017}, the optimal city size chosen by local authorities may differ from the city size dictated by the central planner, which may be interpreted as the ability of local governments to exclude newcomers by using land-use regulations.

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. \cite{GlaeserGyourkoSaks2005b} and \cite{AlbouyEhrlich2016} 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, \cite{GyourkoMayerSinai2013} 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. At the same time, \cite{VanNieuwerburghWeill2010} 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. \cite{Moretti2007} explains that 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.\cite{Moretti2007}

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\textsuperscript{10}A related body of research connects labor misallocation across space to differences in taxation \cite{Albouy2009,EckhoutGuner2015} and Fajgelbaum, Morales, Suárez Serrato and Zidar \cite{Fajgelbaumetal2016} and constraints to workers’ mobility \cite{SahinSongTopaViolante2014} and \cite{Parkhomenko2016}.

\textsuperscript{11} Earlier work includes Brueckner \cite{Brueckner1995} Helsley and Strange \cite{HelsleyStrange1995} Calabrese, Epple and Romano \cite{CalabreseEppleRomano2007} and Solé-Ollé and Viladecans-Marsal \cite{Sole-OlleViladecans-Marsal2012}.
\end{footnotesize}
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. Baum-Snow and Pavan (2013) argue that the increase in wage inequality is partly a big city phenomenon: they find that at least 23% of the growth in the variance of log wages between 1979 and 2007 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 plausible 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 the macroeconomy. 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 Empirical Evidence

The following three empirical observations characterize different aspects of regional divergence in the U.S. from 1980 to 2007.\footnote{These 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 (2018). 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.} See Appendix A.2 for more details on the data.
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 A.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%.

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 A.2). 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.

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 A.3).

This paper focuses on the role of housing supply regulation in explaining these observations. 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 in labor force from 25.5% to 36.5% 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.

The next set of facts relates the stringency of land use regulation to labor and housing market outcomes at the metropolitan area level. These observations inform the political economy model of regulation. The measure of regulation used in this paper is the Wharton Residential Land Use Regulatory Index (WRLURI) developed by Gyourko, Saiz and Summers (2008) based on a survey conducted in 2007.

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 A.4 and A.5).

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13The 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.

14These numbers are calculated for the sample of individuals I use in this paper. See Section A.2.

15A 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.
5. *Metro areas with high incomes and expensive housing are more regulated.* Regulation is positively correlated with mean wages (0.41) and house prices (0.56), even controlling for city size (Figures A.6 and A.7). However, a large part of the correlation between wages and regulation is due to the fact that locational wage differences partly reflect housing price differences. 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 A.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.

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.\(^\text{16}\) Ganong and Shoag (2017) constructed a time series measure of regulation at the state level.\(^\text{17}\) 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 A.9).\(^\text{18}\) Jackson (2016) combines several sources to build a panel measure of land-use regulation for California cities in 1970-1995, and shows that the number of regulations increased over this period.\(^\text{19}\) 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.\(^\text{19}\) However, due to rising regulation in the following years, the city’s residential capacity shrunk 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

\(^\text{16}\) McLaughlin (2012) reviews the existing evidence in the U.S. and other countries.

\(^\text{17}\) They 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.

\(^\text{18}\) Unfortunately, similar panel data does not exist for MSAs. Given significant variation in regulation within states, I cannot use the index of Ganong and Shoag (2017) to investigate dynamic relationships between regulation and labor and housing market outcomes at the MSA level.

\(^\text{19}\) Every 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.
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.\textsuperscript{20}

3 Environment

3.1 Cities, Workers and Markets

Cities. The economy comprises \( J \) locations (cities), indexed by \( j \in \{1, \ldots, J\} \equiv J \). A city is an “island” with no internal structure, as in \textsuperscript{Lucas and Prescott (1974)}. Exogenous features of a city include the amount of land available for residential purposes \( \Lambda_j \) and consumption amenities \( \alpha_j \). Land supply is normalized such that \( \Lambda_j \in (0, 1) \). Every city is populated by an endogenously determined measure \( N_j \) of workers. Population of a city affects how productive and how congested it is. Productivity increases with city size thanks to agglomeration externalities, however utility declines with population density due to congestion.

Workers. Individuals live and work for \( T \) periods, and their age is indexed by \( t \). 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 \( \lambda_L \) and \( \lambda_H \). An individual must live in the same location where she works.

Workers consume a homogeneous consumption good and one unit of housing. Since housing consumption is fixed, the share of housing in expenditures falls with income.\textsuperscript{21} Housing can be rented or owned. In the first period of the life cycle all workers are renters, however later in life they may buy a house. Ownership provides additional utility \( \gamma \).\textsuperscript{22} The utility of consumption is given by

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

where \( h \in \{0, \ldots, T-1\} \) indicates how long the worker has owned the house, \( h = 0 \) indicating that the worker rents. Future utility is discounted with factor \( \beta \). Individuals can save a part

\textsuperscript{20}More recent evidence, documented by \textsuperscript{Cosman and Quintero (2018)} suggests that market concentration in the homebuilding industry has increased since 2005.

\textsuperscript{21}This feature is consistent with the empirical observation that the share of income spent on housing is decreasing with income, as documented in \textsuperscript{Ganong and Shoag (2017)} \textsuperscript{Piazzesi, Schneider and Tuzel (2007)} on the other hand, find that the housing expenditure share varies very little with real income.

\textsuperscript{22}Besides the “warm glow” interpretation, this assumption may also capture the fact that owner-occupied houses are larger in size. See \textsuperscript{Garriga and Hedlund (2017)}.
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.

Besides deriving utility from consumption, workers obtain utility from local amenities and disamenities (i.e. congestion). Congestion disutility is modeled as $\frac{\phi}{1 + z_j} \left( \frac{N_j}{\Lambda_j} \right)^\delta$, where $\phi$ is a parameter that accounts for the strength of the congestion effect and $\delta$ represents the elasticity of congestion with respect to population density. Parameter $z_j$ is land use regulation. Stricter regulation will reduce the congestion externality for a given density level. The overall net amenity value of city $j$ is defined as

$$ a_j = \alpha_j - \frac{\phi}{1 + z_j} \left( \frac{N_j}{\Lambda_j} \right)^\delta $$

(3.1)

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

$$ Y_j = A_j \tilde{N}_j, $$

(3.2)

where $A_j$ is local total factor productivity (TFP), and $\tilde{N}_j \equiv \sum_{s \in \{L,H\}} \sum_{t=1}^T \eta_{jst} N_{jst}$ is labor supply in efficiency units. The parameter $\eta_{jst}$ denotes the productivity of an $s$-skill worker of age $t$ in city $j$, while $N_{jst}$ denotes the number of such workers. Local TFP is determined as

$$ A_j = \tilde{A}_j N_j^\rho, $$

(3.3)

where $\tilde{A}_j$ is the exogenous part of TFP, while $\rho > 0$ is the agglomeration externality which captures the idea that productivity increases with city size. The equilibrium wage of an $s$-skill worker of age $t$ in city $j$ is then

$$ w_{jst} = \eta_{jst} \tilde{A}_j N_j^\rho. $$

(3.4)

**Housing markets.** Every individual must either rent or own one unit of housing in the city where he works. Rent in city $j$ is given by

$$ r_j = \chi_j^{R} N_j^{C_R}, $$

(3.5)

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23The theory and empirical estimates of agglomeration externalities are discussed in Duranton and Puga (2004) and Combes and Gobillon (2015).
and the price of an owner-occupied house in city $j$ is

$$p_j = \chi^O_j N_j \zeta^O_j,$$

(3.6)

where $\chi^m_j$ is the city-specific term for housing of type $m \in \{R, O\}$ and $\zeta^m_j$ is the inverse elasticity of housing supply. These expressions for rents and prices can be microfounded using a standard Rosen-Roback model with a representative construction firm.\(^{24}\)

The inverse elasticity of housing supply is given by

$$\zeta^m_j \equiv \bar{\zeta}^m + \zeta^m_{\text{land}}(1 - \Lambda_j) + \zeta^m_{\text{reg}}z_j,$$

(3.7)

where $\bar{\zeta}^m$ is the baseline level of elasticity common for all cities, $\zeta^m_{\text{land}}$ represents the effect of land scarcity, $(1 - \Lambda_j)$, on the elasticity, while $\zeta^m_{\text{reg}}$ is the effect of and housing supply regulation, $z_j$, on the elasticity. That is, both land scarcity and housing supply regulation reduce the elasticity of housing supply.\(^{25}\)

The price-rent ratio is

$$\frac{p_j}{r_j} = \frac{\chi^O_j}{\chi^R_j} N_j \zeta^O_j - \zeta^R_j.$$

The ratio accounts for possible differences in city-specific terms $\chi$ which could, for instance, represent differences in construction costs for each type of housing. The ratio also accounts for potential differences in supply elasticities of each type of housing. If the supply of owner-occupied housing is less elastic – a pattern documented by the empirical analysis of this paper – then larger cities have a higher price-rent ratio.

**Homeownership and real estate managers.** All individuals have access to a mortgage facility which allows extending payments for the house over $\kappa$ periods. If a renter decides to buy a house in period $t$, he must pay $dp_{jt}$ where $d \in (0, 1)$ is the downpayment rate. In each period $t + 1, ..., t + \kappa$ the worker pays $q(i_h, \kappa)(1 - d)p_{jt}$, where $q(i_h, \kappa) \equiv i_h / (1 - (1 + i_h)^{-\kappa})$ and $i_h$ is the mortgage interest rate. The equilibrium house price may change, but the worker always repays mortgage based on the purchase price $p_{jt}$. 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 current equilibrium price $p_{j,t+h}$. If the mortgage was not fully paid, the proceeds from the sale are equal to the current market price of the house minus the amount owed to the lender: $p_{j,t+h} - (1 - f_h)p_{jt}$, where $f_h \in [0, 1]$ is fraction of the loan which has already

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\(^{24}\)Glaeser (2008) describes such a model and arrives at a similar expression for rents. See Rosen (1979) and Roback (1982) for more details on the Rosen-Roback model.\(^{25}\) This specification is very similar to the one estimated in Saiz (2010).
been repaid after owning the house for $h$ periods.Absentee competitive real estate managers (REMs) own rental housing and issue mortgages. Buyers of owner-occupied houses pay the downpayment to the REM immediately and mortgage payments over the next $\kappa$ 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 would be no price risk, and hence the REMs would not charge any risk premium.

3.2 Workers’ Decisions

Choice of location. At the very beginning of the first period, an individual must choose the location of residence $j$. 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 $J \times 1$ vector of i.i.d. utility shocks $\varepsilon$ which are 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 take into account the amenity value of each location, $a_j$. Finally, workers compare the attractiveness of labor and housing markets in different cities: they take into account the lifetime wage profile $\{w_{jst}\}_{t=1}^T$ each city $j$ offers to workers of their skill group $s$, and the costs of renting and buying a house: $r_j$ and $p_j$. When choosing a city, workers not only consider the level of housing costs but also the price-rent ratio, since it determines whether they can 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 $\gamma$. Second, a house is an asset that can be sold, and the proceeds from the sale can be consumed. Individuals are born with no real estate property and thus must rent during the first period of their lives.

Timing and value functions. Every period an individual works and receives wage $w_{jst}$. Then he decides (1) how much to consume, (2) how much to save, and (3) whether to rent or own a house, in order to maximize the expected discounted lifetime utility. Renters pay rent $r_j$. Owners pay mortgage with interest $q(i_h, \kappa)(1 - d)p_{j,t-h}$ 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

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26The fraction $f_h$ is determined recursively. Right after the downpayment was paid in the period when the homebuyer still rents, $f_0 = dp_{j,t}$. Next period, $f_1 = f_0 + (q(i_h, \kappa) - i_h(1 - f_0))p_{j,t-1}$. In the following period, $f_2 = f_1 + (q(i_h, \kappa) - i_h(1 - f_1))p_{j,t-2}$, and so on.
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.

There is no aggregate uncertainty, and the only source of individual uncertainty are the location-specific utility shocks in the first period. The individual state is $x = (j, s, t, k, h)$. Skill level $s$ is fixed for life. Residence $j$ is chosen in the first period and remains fixed thereafter, while age $t$, savings $k$, and the length of ownership $h$ change every period. The aggregate state is described by the distribution of labor across individual states $\Phi : \mathcal{X} \to \mathbb{R}_+$, where $\mathcal{X} \equiv J \times \{L, H\} \times \{1, \ldots, T\} \times [0, \infty) \times \{0, \ldots, T - 1\}$ is the space of individual states. This paper focuses on a stationary environment, hence $t$ indexes both age and time.

The value function of a renter in period $1 \leq t < T$ describes the decision between becoming a homeowner and remaining a renter, and the decision on the next period’s savings. Wages $w_{jst}(\Phi)$, rents $r_{jt}(\Phi)$, house prices $p_{jt}(\Phi)$, and amenities $a_{jt}(\Phi)$ depend on the distribution of population across individual states $\Phi$. When making decisions, individuals take wages, rents, prices and amenities 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, renter must pay downpayment $dp_{jt}(\Phi)$ in the current period. The value function of a renter is given by

$$V^R(j, s, t, k, h = 0; \Phi) = \max_{\{\text{own, rent}\}} \left\{ \max_{k' \geq 0} \left\{ \ln[w_{jst}(\Phi) - r_{jt}(\Phi) - dp_{jt}(\Phi) - k' + (1 + i_k)k] ight. \\
+ a_{jt}(\Phi) + \beta E[V^O(j, s, t + 1, k', 1; \Phi')] \right\}, \\
+ \ln[w_{jst}(\Phi) - r_{jt}(\Phi) - k' + (1 + i_k)k] \\
+ a_{jt}(\Phi) + \beta E[V^R(j, s, t + 1, k', 0; \Phi')] \right\},$$

where the expectation is defined over the distribution of population next period, $\Phi'$. However, in a stationary economy the distribution would be time-invariant, and a rational agent is aware of this.

An owner in period $2 \leq t < T$ 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 of ownership, $E[V^O]$, and a higher current consumption.

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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.
financed by revenues from selling the house. The owner’s value function is given by

\[
V^O (j, s, t, k, h; \Phi) = \max_{\{\text{own, rent}\}} \max_{k' \geq 0} \left\{ \max_{\{\text{own, rent}\}} \left\{ \ln [w_{jst}(\Phi) - \mathbb{I}_{h < \kappa} q(i_h, \kappa)(1 - d)p_{j,t-h} - k' + (1 + i_k)k] \right. \right.
\]
\[
+ a_{jt}(\Phi) + \gamma + \beta E \left[ V^O (j, s, t + 1, k', h + 1; \Phi') \right] \right\},
\]
\[
\left. \max_{k' \geq 0} \left\{ \ln [w_{jst}(\Phi) - \mathbb{I}_{h < \kappa} q(i_h, \kappa)(1 - d)p_{j,t-h} + p_{jt}(\Phi) - (1 - f_h)p_{j,t-h} - k' + (1 + i_k)k] \right. \right.
\]
\[
+ a_{jt}(\Phi) + \gamma + \beta E \left[ V^R (j, s, t + 1, k', 0; \Phi') \right] \right\} \right\}.
\]

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

\[
V^R (j, s, T, k, 0; \Phi) = \ln [w_{jst}(\Phi) - r_{jt}(\Phi) + (1 + i_k)k] + a_{jt}(\Phi),
\]

and for an owner it is given by

\[
V^O (j, s, T, k, h; \Phi) = \ln [w_{jst}(\Phi) - \mathbb{I}_{h < \kappa} q(i_h, \kappa)(1 - d)p_{j,t-h} + p_{jt}(\Phi) - (1 - f_h)p_{j,t-h} + (1 + i_k)k] + a_{jt}(\Phi) + \gamma.
\]

The expected lifetime utility of an s-skilled worker who chooses to spend life in location j is

\[
V(j|s, \varepsilon; \Phi) = V^R (j, s, t = 1, k = 0, h = 0; \Phi) + \varepsilon(j),
\]

and the optimal location choice of this worker satisfies

\[
j = \arg \max_{j' \in J} \{ V(j'|s, \varepsilon; \Phi) \}.
\]

### 3.3 Political Economy of Housing Supply Regulation

Housing supply regulation performs two functions. First, it reduces the elasticity of housing supply and consequently raises rents and prices, as illustrated by equations (3.5), (3.6) and (3.7). Second, regulation increases the amenity value of a city, as shown by equation (3.1).\(^{28}\)

\(^{28}\)In practice, different types of regulation may affect supply and prices through different channels. Yet Mayer and Somerville (2000)\(^{29}\) 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)\(^{30}\) finds a strong effect of regulation on the supply elasticity.
In this model, homeowners and renters have different preferences for regulation. On one hand, both owners and renters would like to have more regulation in order to enjoy better amenities, since regulation reduces congestion, and less regulation to be able to earn higher wages, since regulation weakens agglomeration effects by making cities smaller. On the other hand, while owners prefer a higher level of regulation, since it raises the values of their houses, renters favor a lower level, since it reduces rents and also makes buying a house more affordable.\footnote{Dubin, 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. Hankinson (2017) runs a nationwide survey and finds that, while homeowners exhibit an aversion toward new construction, renters on average express high support for new housing. However, the difference in attitude between renters and owners is smaller in expensive housing markets.}

The level of regulation is determined in a model of probabilistic voting with lobbying \cite{Lindbeck1987, Baron1994}.\footnote{The model of probabilistic voting with lobbying is described in Persson and Tabellini (2002).} In every city there is a regulatory board, and every period there is an election of local government which appoints members of the board.\footnote{In 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.} Two parties, $A$ and $B$, run for the government and each party proposes a level of residential land use regulation: $z_A$ and $z_B$. The only objective of a party is to be elected and, if elected, it must implement the proposed level. At the end of each period, all residents aged $t \in \{1, ..., T - 1\}$ vote, and the level proposed by the winning party is effective next period.\footnote{Members of the oldest generation do not vote, 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.} Residents have two considerations when deciding which party to vote for: the utility of the proposed regulation level and their idiosyncratic taste for each party.

1. **Utility of regulation.** If party $l \in \{A, B\}$ is elected, then regulation level $z_l$ will be implemented, and a worker in state $x = (j, s, t, k, h)$ will optimally choose to be in state $x'(z_l) = (j, s, t + 1, k'_l, h'_l)$ next period. In addition, the worker knows that if city $j$ chooses a different level of regulation, the distribution of population in the economy will change to $\Phi'_l$ leading to adjustments in wages and housing prices. Thus, changes in individual and aggregate states will lead to changes in the utility of regulation.

2. **Ideology.** Worker $i$ has an idiosyncratic taste for party $A$, which can be interpreted as ideological bias. This taste shock is denoted by $\xi_i$ and distributed uniformly across workers on $[-\frac{1}{2\nu}, \frac{1}{2\nu}]$. Parameter $\nu$ measures how consolidated opinions on regulation are among the voters. If $\nu \to \infty$, all voters have the same preference for regulation. If $\nu = 0$, voters completely disagree.

Local elections are financed via campaign contributions. Party $l \in \{A, B\}$ receives $C_l$
from each homeowner who votes for it.\footnote{Alternatively, 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”, without changing the elected regulation.} The contributions are needed to enact the level of regulation proposed by the party, and their size depends on the proposed level:\footnote{This approach is close in spirit to \textcite{Glaeser2005} where homeowners spend time out of work to affect the decisions of the zoning authority, and to \textcite{Hilber2013} where regulation is a function of monetary contributions from landowners and developers to the planning board. While there is no data on how much money is spent on campaigning for or against residential development, anecdotal evidence suggests that such actions involve substantial resources. \textcite{LosAngelesTimes2017} estimates that more than $13 million were spent on campaigning before the 2017 vote on Measure S which would impose a two-year moratorium on all development in Los Angeles which requires a change in zoning.} 

\[ C_l = \omega_0 z_l^{\omega_1}. \]

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 \(m \in \{R, O\}\) votes for party \(A\) if

\[
V^m(x'(z_A); \Phi'(z_A)|x, \Phi) + \xi_i - \mathbb{I}_{m=O} C(z_A) \geq V^m(x'(z_B); \Phi'(z_B)|x, \Phi) - \mathbb{I}_{m=O} C(z_B),
\]

and for party \(B\) otherwise.\footnote{The 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 \(\Phi'(z_l)\), and thus does not have to enter the value functions separately.}

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:

\[
W_j(z) = \nu \int \left[ \frac{N^O_j(x)}{N_j} (V^O(x'(z); \Phi'(z)|x, \Phi) - C(z)) + \frac{N^R_j(x)}{N_j} V^R(x'(z); \Phi'(z)|x, \Phi) \right] dx,
\]

where \(V^m(x'(z), \Phi'(z)|x, \Phi)\) stands for the next-period value function of a worker currently in individual state \(x\) and aggregate state \(\Phi\), if the chosen regulation is \(z\). Integration is over all residents of age \(a \in \{1, \ldots, T-1\}\). Therefore the elected level of regulation in city \(j\) is

\[
z_j = \operatorname{argmax}_{z \in \mathbb{R}_+} \{W_j(z)\}. \tag{3.11}
\]

All else equal, homeowners benefit from a higher \(z_j\) since it makes the value of their houses higher.\footnote{An increase in regulation may actually reduce prices if the resulting outflow of labor to other locations is large, as in \textcite{Chatterjee2015}. In the current paper, the outflows are small due to individual} \textcite{Fischel2001} describes reasons why homeowners might want stricter res-
idential 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 house values from those that are aimed at improving local public goods and services. Nonetheless, a model in which the main reason why owners prefer strict regulation is because it raises house values, such as the model in this paper, can be interpreted more generally, since the house value motivation contains many other reasons for preferring stringent regulation.

3.4 Equilibrium

Distribution of labor across locations. The vector of utility shocks $\varepsilon$ follows the extreme value type 1 distribution with parameters $\mu_\varepsilon$ and $\sigma_\varepsilon$, and zero mean. Consider a worker with skill $s$. Before the vector of utility shocks $\varepsilon$ is known to the worker, her value of choosing to spend life in location $j$ is

$$\tilde{V}(j|s, \Phi) \equiv V^R(j, s; t = 1, k = 0, h = 0; \Phi).$$

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

$$\Pi(j|s, \Phi) = \frac{\exp(\tilde{V}(j|s, \Phi))^{1/\sigma_\varepsilon}}{\sum_{j' \in J} \exp(\tilde{V}(j'|s, \Phi))^{1/\sigma_\varepsilon}}$$

(3.12)

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 $j$ is given by

$$N_{js1} = \Pi(j|s, \Phi)\lambda_s,$$

where $\lambda_s$ is the exogenous fraction of $s$-skilled workers. Then the total supply of $s$-skilled workers is $N_{js} = TN_{js1}$, and the total population in the location is $N_j = N_{jL} + N_{jH}$.

---

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

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

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)].
I focus on stationary spatial equilibria. By doing this, I restrict attention to long-term effects of regulation.\footnote{Elasticity of housing supply also matters for the ability of a city to withstand short-term fluctuations: \cite{arias2016} find that areas with less elastic supply experience more severe recessions, while \cite{huang2012} and \cite{paciorek2013} find that in locations with restricted supply house prices are more volatile.}

**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 \(w_{jst}(\Phi)\), \(p_j(\Phi)\) and \(r_j(\Phi)\); levels of regulation \(z_j\); conditional choice probabilities \(\Pi\); distribution of labor \(\Phi\); 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 in every city; (3) the resource constraint holds (aggregate output equals aggregate consumption); (4) the social welfare function \(\text{(3.10)}\) 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 knowledge in their value functions. All 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 \(\text{(3.10)}\)) 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. Appendix\[A.3\] discusses these assumptions and other details of the computation of a stationary spatial equilibrium.
3.5 Rise in Regulation and Differences across Locations

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) argues 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 these forces. The rise in homeowners’ influence could be due to higher density in metro areas, which raise the demand for regulation, and higher incomes, which increase the lobbying power of owners. Finally, if real prices increase, housing becomes a more important part of households’ portfolios, and therefore value functions are 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 \( z \) and raise the value of the argument that maximizes the social welfare function.

Why is regulation higher in productive and land-scarce cities? Differentiating the equilibrium house price (equation 3.6) with respect to regulation and land scarcity, we obtain

\[
\frac{\partial^2 p_j}{\partial z_j \partial (1 - \Lambda_j)} = \chi_j \zeta_{\text{land}} \zeta_{\text{reg}} \left( \ln N_j \right)^2 \times N_j^{\zeta_{\text{land}} + \zeta_{\text{reg}} (1 - \Lambda_j) + \zeta_{\text{reg}} z_j}.
\]

The expression above is positive if \( \zeta_{\text{land}} > 0 \) and \( \zeta_{\text{reg}} > 0 \), which is indeed what the empirical analysis of this paper finds (see Section 4). Hence, in cities with less land, prices are more sensitive to changes in regulation.

In the model, changes in regulation would occur in response to changes in fundamen-
tals, such as exogenous type-specific productivities. Suppose that location $j$ experiences an increase in type-specific productivities $\eta_{jst}$. This attracts workers to the city, and the 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.\footnote{That 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.}

What role does regulation play? Following an inflow of labor, cities become more congested and house prices go up, making real estate a more important component of individual portfolios. Hence owners vote to increase the level of regulation. This raises prices even more, especially in land-scarce cities, and makes inflows of labor lower which reduces aggregate productivity. The effect on the inflow of low-skilled workers is stronger than on the high-skilled, and therefore skill sorting is more intense and wage inequality grows by more. Therefore, the endogenous regulation mechanism \textit{amplifies} the effect of exogenous differences in productivity and land supply on skill sorting, house price dispersion and wage inequality across locations. If productivity growth is skill-biased, i.e. $\eta_{jHt}$ grows faster than $\eta_{jLt}$, then the magnitude of these effects is even larger.

\section{4 Parameter Values and Benchmark Economy}

The quantitative model has 202 locations, which correspond to the 202 metropolitan areas in the sample (see Appendix \ref{sec:appendix2} for more details on the sample).\footnote{Some metropolitan areas, mostly small ones, had to be dropped due to lack of data on land supply or land use regulation.} 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 outside the model. Then I estimate the labor demand and housing supply parameters. The remaining parameters are calibrated jointly within the model. Parameter values are summarized in Table \ref{tab:parameter_values}.
4.1 Parameter Values

4.1.1 Parameters Calibrated outside the Model

Land supply $\Lambda_j$ 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%.\textsuperscript{43} The degree of congestion $\delta$ is set to 0.25, following Albouy et al (2017).

A worker’s life cycle consists of $T = 8$ periods that correspond to ages 25-29, 30-34, ..., 60-64. The fraction of high-skilled workers in the economy is $\lambda_H = 0.365$, which is the share of observations with a college degree in the sample. The time discount factor is $\beta = 0.96$. The parameter that governs the variance of the location preference shocks, $\sigma_\varepsilon$, is set to 0.3, following Hsieh and Moretti (2018).\textsuperscript{44}

The parameter that determines the variance of the ideological taste shocks, $\nu$, is normalized to 1. The expression for local welfare (equation 3.10) illustrates that $\nu$ scales the total welfare but does not affect the welfare-maximizing choice of regulation, therefore the value of $\nu$ is irrelevant for the calibration. The savings interest rate is $i_k = 4.30\%$, which is the average rate on 5-year CDs in 2005-2007, according to the National Credit Union Administration.\textsuperscript{45}

The parameters that characterize mortgages are chosen from the data. 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 $d = 0.2$. 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. Finally, the interest rate on the mortgage is $i_h = 6.21\%$, the average rate in 2005-2007, as reported by Freddie Mac.\textsuperscript{46}

4.1.2 Labor Demand

Taking log of equation (3.4), we obtain the following labor demand specification:

$$\ln w_{jst} = \ln \bar{A}_j + \rho \ln N_j + \ln \eta_{jst}. \quad (4.1)$$

To estimate $\bar{A}_j$, $\rho$ and $\eta_{jst}$, I must first overcome the reverse causality between $w_{jst}$ and

\textsuperscript{43} This implies that potential land area of an MSA only depends on geographic characteristics and not on population size or regulation.

\textsuperscript{44} Hsieh and Moretti (2018) uses type 2 extreme value distribution, while I use the type 1 extreme value distribution. However the value of $\sigma_\varepsilon$ is the same across the two distribution types.

\textsuperscript{45} https://www.ncua.gov/DataApps/Documents/CUBNK200320042005.pdf

\textsuperscript{46} http://www.freddiemac.com/pmms/pmms30.htm
To this end, I use the Bartik (1991) labor demand shocks as an instrument for labor supply of each type $N_{jst}$. 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 year $y$ with changes in industrial composition at the national level between years $y - 1$ and $y$. The identifying assumption is that changes in industrial composition in all cities but $j$ are uncorrelated with labor supply shocks in $j$. The Bartik instrument is defined as the change in labor supply of type $(s, t)$ in city $j$ as predicted by changes in the supply of this type of labor in each of the industries $i \in I$ in the rest of the economy:

$$B_{jst,y} = \sum_{i \in I} \left( \ln \left( \sum_{j' \neq j} N_{ij'jt,y} \right) - \ln \left( \sum_{j' \neq j} N_{ij'jt,y-1} \right) \right) \frac{N_{ijjt,y-1}}{N_{ijjt,y-1}}.$$

In order to construct the Bartik instruments, I use 13 industry groups in the Census classification. Since the instrument depends on industrial composition of city $j$ in year $y - 1$ and the change in labor supply to each industry between years $y - 1$ and $y$ in all cities but $j$, it is exogenous to current productivity levels in city $j$. The predicted supply of labor of each type is $\ln \hat{N}_{jst,y} = \ln N_{jst,y-1} + B_{jst,y}$, and the estimating labor demand equation is given by

$$\ln w_{jst,y} = \ln \bar{A}_{jy} + \rho \ln \left( \sum_{s \in \{L, H\}} \sum_{t=1}^{T} \hat{N}_{jst,y} \right) + \ln \eta_{jst,y}. \tag{4.2}$$

I estimate the labor demand parameters using data from 1970, 1980, 1990 and 2000 Censuses and the 2005-2007 three-year American Community Survey sample. Parameters $\bar{A}_{jy}$ and $\eta_{jst,y}$ cannot be identified separately, however this is not needed, given that local wages depend on the product of the two parameters. The value of $\ln \bar{A}_{jy} + \ln \eta_{jst,y}$ is equal to the estimated residual plus the year fixed effect in the regression (4.2). The estimated agglomeration effect $\rho$ is equal to 0.0414 which is consistent with the estimates obtained in the literature.\footnote{The 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.}

\footnote{Combes and Gobillon (2015) summarize the empirical literature on agglomeration effects and find that estimates vary from 0.04 to 0.07.}
4.1.3 Housing Supply

Taking logs of equations (3.5) and (3.6), and plugging in equation (3.7), we obtain the following expressions for rents

\[ \ln r_j = \ln \chi^R_j + (\bar{\zeta}^R_j + \zeta^R_{\text{land}}(1 - \Lambda_j) + \zeta^R_{\text{reg}}z_j) \ln N_j, \]  

(4.3)

and house prices

\[ \ln p_j = \ln \chi^O_j + (\bar{\zeta}^O_j + \zeta^O_{\text{land}}(1 - \Lambda_j) + \zeta^O_{\text{reg}}z_j) \ln N_j. \]

(4.4)

Estimation of housing market parameter faces the same issue as the estimation of labor demand: there is reverse causality between labor supply \( N_j \) and prices or rents. This issue is solved by instrumenting for labor supply using Bartik (1991) labor demand shocks, similar to those described above. The Bartik instrument is defined as the change in the supply of labor of type \((s,t)\) with ownership status \(m \in \{R,O\}\) in city \(j\), as predicted by changes in the supply of this type of labor in each of the industries \(i \in I\) in the rest of the economy between years \(y - 1\) and \(y\). The instrument is given by

\[ B_{jst,y}^m = \sum_{i \in I} \left( \ln \left( \sum_{j' \neq j} N_{ij'st,y}^m \right) - \ln \left( \sum_{j' \neq j} N_{ij'st,y-1}^m \right) \right) \frac{N_{ij'st,y-1}^m}{N_{jst,y-1}^m}, \]

and the predicted supply of labor of each type is \( \ln \hat{N}_{jst}^m = \ln N_{jst,y-1}^m + B_{jst,y}^m \).

Rents, originally reported at monthly frequency, are converted to 5-year rates to be consistent with the model period. The values \( \ln r_j \) and \( \ln p_j \) are average rents and prices for a given metropolitan area, controlled for differences in the number of rooms, the year of construction, and the number of housing units in the structure where the unit is located.49

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. To convert the Wharton index of regulation into units suitable for the housing supply specification in this paper, I take the log of the Wharton index and add 3.50

---

49I follow the hedonic regression approach used in Eeckhout, Pinheiro and Schmidheiny (2014).

50This transformation is used by Saiz (2010) in order to ensure positive levels of regulation in the estimation, as the Wharton Index is built such that it has mean of zero and standard deviation of one. That paper claims that adding a positive constant to the log of the original index does not change the results.
The estimating equations are

\[
\ln r_j = \ln \chi_j^R + (\bar{\zeta}^R + \zeta_{\text{land}}(1 - \Lambda_j) + \zeta_{\text{reg}}^R z_j) \ln \hat{N}_j, \\
\ln p_j = \ln \chi_j^O + (\bar{\zeta}^O + \zeta_{\text{land}}(1 - \Lambda_j) + \zeta_{\text{reg}}^O z_j) \ln \hat{N}_j.
\] (4.5)

Parameters \( \ln \chi_j^R \) and \( \ln \chi_j^R \) correspond to residuals in the regressions above. The estimated sensitivity of prices of owner-occupied housing with respect to land scarcity and land use regulation is higher than that of rents: \( \zeta_{\text{land}}^O = 0.051 \) and \( \zeta_{\text{reg}}^O = 0.042 \) compared to \( \zeta_{\text{land}}^R = 0.024 \) and \( \zeta_{\text{reg}}^R = 0.031 \).

### 4.1.4 Parameters Calibrated within the Model

The utility of homeownership \( \gamma \) is calibrated to the observed homeownership rate in 2005-2007. The two parameters of the campaign contribution function, \( \omega_0 \) and \( \omega_1 \), and the strength of the congestion effect \( \phi \) are calibrated to match the following three moments of the distribution of the Wharton index: mean, standard deviation, and the ratio between average regulation in the 20% of cities with least land and the 20% of cities with most land. The rationale for using the latter moment is that the congestion effects, and therefore the incentives to regulate, are larger in cities with less land. Finally, the exogenous amenity parameters \( \alpha_j \) are calibrated so as to match exactly the distribution of population across cities as observed in the data.

### 4.2 Benchmark Economy

Table 1 compares the empirical targets for the calibrated parameters and the corresponding moments produced by the model. The calibrated model reproduces very well the five targeted moments, and the distribution of population is matched exactly to the one observed in the data.

Table A.3 shows the performance of the model relative to a set of non-targeted moments. The dispersion of wages and college shares across cities produced by the model is higher than that observed in the data. However, since both wages and house prices in the model depend on city-specific parameters estimated from the data, wages and prices are highly correlated with their counterparts in the data. At the same time, house price dispersion is very similar to the one observed in the data. In addition, the correlations between regulation and wages, house prices, homeownership and land scarcity have the same sign and similar magnitude in the model as in the data. Even though not targeted, aggregate expenditures on housing in the model are equal to 24% of wage income, the same number as found by Davis and...
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 the Wharton index. The correlation between the Wharton index and the regulation predicted by the model is 0.34 (Figure 1). However, in practice 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 subindex of the Wharton Index most related to the supply elasticity, is 0.77 (Figure 2).\footnote{The 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. Therefore, a higher value of the ADI should indicate a lower housing supply elasticity.} Taking into account that many reasons why regulation differs across locations are outside the scope of the model, these correlations are fairly high.\footnote{Some of the reasons include historical land use patterns \cite{GlaeserWard2009} and political ideology of local voters \cite{Kahn2011}.} If we interpret these correlations as the $R^2$ in the regressions of the model-predicted regulation on the Wharton index and the ADI, we can say that the model explains 12\% of the variation in the Wharton index and 59\% of the variation in the ADI.\footnote{In a univariate linear regression, $R^2$ is equal to the square of the correlation between the regressor and the dependent variable.}
5 Causes and Implications of Regulation

What is the effect of exogenous land and productivity differences on regulation and the economy? How do levels and cross-city differences in regulation matter for aggregate productivity, housing prices and other variables? In this section, I perform two sets of experiments to answer these questions.
5.1 Causes of Regulation

As Section 3.5 argues, regulation amplifies the effects of exogenous differences in productivity and land across metropolitan areas. In order to understand how large the amplification is, I conduct the following counterfactual experiments. First, I set land endowment to the mean level in every city which allows me to single out the effect of land differences. Second, I set skill-age specific productivities to the mean level in every city which allows studying the effect of exogenous productivity differences.\footnote{That is, in every city a skill-\(s\) age-\(t\) worker has access to productivity \(\bar{\eta}_{jst} = \frac{1}{J} \sum_{j \in J}\eta_{jst}.\)} Note that this equalizes exogenous productivity parameters \(\eta_{jst}\) across cities, however TFP may still differ across cities due to agglomeration effects. Finally, I equalize both land and productivity across cities.

Endowing all cities with the same amount of land leads to an overall reduction in regulation and an increase in productivity. However the effect on skill sorting is very small, and therefore there is no effect on wage inequality across locations. In addition, even though differences in prices across cities fall, the average prices are 5.5% higher. This is because many cities with low prices see their land endowment shrink and hence prices there increase.

Equalizing productivities across locations results in a dramatic fall in wage inequality and skill sorting, however the effect is largely mechanical since a substantial fraction of wage inequality in the benchmark arises from differences in exogenous productivities. In this experiment, house prices and their differences across locations become smaller.

Finally, elimination of land and productivity differences at the same time allows to evaluate their joint effect on the economy. In this experiment, wage differences and skill sorting across cities decline significantly. House prices and house price dispersion fall as well.

Table 2 summarizes the results of these experiments.

<table>
<thead>
<tr>
<th></th>
<th>Benchmark</th>
<th>Same land</th>
<th>Same productivity</th>
<th>Same land &amp; productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean regulation</td>
<td>1.056</td>
<td>1.009</td>
<td>1.024</td>
<td>0.981</td>
</tr>
<tr>
<td>S.d. regulation</td>
<td>0.244</td>
<td>0.254</td>
<td>0.281</td>
<td>0.279</td>
</tr>
<tr>
<td>Output</td>
<td>1.000</td>
<td>1.012</td>
<td>0.952</td>
<td>0.958</td>
</tr>
<tr>
<td>Variance of log wages</td>
<td>0.042</td>
<td>0.043</td>
<td>0.023</td>
<td>0.023</td>
</tr>
<tr>
<td>Skill sorting</td>
<td>0.206</td>
<td>0.195</td>
<td>0.180</td>
<td>0.163</td>
</tr>
<tr>
<td>Mean house prices</td>
<td>1.000</td>
<td>1.055</td>
<td>0.803</td>
<td>0.903</td>
</tr>
<tr>
<td>Variance of log house prices</td>
<td>0.233</td>
<td>0.203</td>
<td>0.175</td>
<td>0.149</td>
</tr>
</tbody>
</table>
5.2 Implications of Regulation

In order to study the effects of regulation on the economy, I conduct three quantitative experiments.

First, I introduce a one-size-fits-all policy by setting regulation at the average level in all cities. In this case, highly regulated cities are forced to reduce regulation, while cities with low regulation levels have to increase regulation. As a result of this experiment, aggregate productivity increases by 3.8%. Average house prices fall by 20% relative to the benchmark, while house price dispersion, measured as the variance of log prices, drops by 24%. The large effect on house prices is not surprising, since regulation is a key component of house prices in the model, and is consistent with Glaeser, Gyourko and Saks (2005b) and Saiz (2010), which 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. With house prices being more similar across locations, skill sorting, measured as the standard deviation of college shares across metro areas, falls by nearly 20%, and as a result, wage inequality across cities, measured as the variance of log wages, falls by about 10%.

Second, I set regulation in every city to 1/2 of the benchmark level. In this scenario, the relative differences in regulation across cities are preserved, however regulation becomes lower everywhere. Because large productive cities become cheaper to live in, they experience an inflow of workers. As a result, aggregate productivity goes up by 3.5% and average house prices drop by 30%. Since cities still differ in regulation in this experiment, house price dispersion only decreases by 14% relative to the benchmark. A smaller effect on house price differences, relative to the previous experiment, also implies a smaller effect on skill sorting and wage inequality. The standard deviation of college shares across cities falls by 13%, while the variance of log wages across cities declines by 4%.

The effects in these experiments arise because highly productive areas are 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. Figure 3 shows that the counterfactual city size distribution in the experiment with half regulation is less compressed than the benchmark distribution: cities large in the benchmark become even larger, while small cities become even smaller.

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55 Results of the experiments in this paper are comparable to the results of Hsieh and Moretti (2018), which finds 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 3.7% (with imperfect mobility of workers) to 8.9% (with perfect mobility of workers).
In the third experiment, I eliminate regulation everywhere, i.e. set \( z_j = 0 \) in all cities. In this experiment, aggregate productivity only increases by 1.2%. Why a complete elimination of regulation leads to a much smaller effect on productivity? On the one hand, housing supply becomes much more elastic making the most productive cities much more affordable. On average prices fall by 57%. On the other hand, congestion effects become much stronger making big cities unpleasant locations to live. As a result, the city size distribution becomes more compressed and the aggregate productivity does not increase much. Elimination of regulation also does not lead to a reduction in skill sorting and wage inequality.

The results of the three experiments are summarized in Table 3.

Table 3: Counterfactual experiments

<table>
<thead>
<tr>
<th></th>
<th>Benchmark</th>
<th>Mean reg</th>
<th>Half reg</th>
<th>Zero reg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean regulation</td>
<td>1.056</td>
<td>1.056</td>
<td>0.528</td>
<td>0</td>
</tr>
<tr>
<td>S.d. regulation</td>
<td>0.244</td>
<td>0</td>
<td>0.122</td>
<td>0</td>
</tr>
<tr>
<td>Output</td>
<td>1.000</td>
<td>1.038</td>
<td>1.035</td>
<td>1.012</td>
</tr>
<tr>
<td>Welfare (consumption equivalence)</td>
<td>1.000</td>
<td>1.193</td>
<td>1.189</td>
<td>1.027</td>
</tr>
<tr>
<td>Variance of log wages</td>
<td>0.042</td>
<td>0.038</td>
<td>0.040</td>
<td>0.041</td>
</tr>
<tr>
<td>Skill sorting</td>
<td>0.206</td>
<td>0.167</td>
<td>0.179</td>
<td>0.205</td>
</tr>
<tr>
<td>Mean house prices</td>
<td>1.000</td>
<td>0.794</td>
<td>0.700</td>
<td>0.429</td>
</tr>
<tr>
<td>Variance of log house prices</td>
<td>0.233</td>
<td>0.177</td>
<td>0.200</td>
<td>0.161</td>
</tr>
<tr>
<td>Homeownership rate</td>
<td>0.69</td>
<td>0.82</td>
<td>0.85</td>
<td>0.87</td>
</tr>
</tbody>
</table>
What are welfare gains under each of the experiments? In order to answer this question, I use a consumption-equivalent measure of a change in welfare. Under this measure, \( \Delta \), the parameter which measures the increase in consumption, must solve

\[ \int \left( \ln \left( c^1(x) \right) + I_{x:h \geq 1} \gamma + a^1(x) \right) d\Phi^1(x) = \int \left( \ln \left( c^0(x) + \Delta \right) + I_{x:h \geq 1} \gamma + a^0(x) \right) d\Phi^0(x), \]

where the 0-superscript indicates values and distributions in the benchmark economy, the 1-superscript indicates values and distributions in the counterfactual economy, and \( x = (j, s, t, k, h) \) is individual state. I find that the the consumption-equivalent measure of welfare would increase by 19.3% when regulation is set to the mean level, by 18.9% when regulation is halved, and by only 2.7% when regulation is set to zero. Welfare gains are much bigger than output gains in the first two experiments largely thanks to a much larger homeownership rate and lower housing costs. In the third experiment, the benefits of higher homeownership are trumped by a much lower amenity value of cities due to a larger congestion effect.

6 Federal Policy Interventions

In the U.S., the federal and state governments have virtually no authority to interfere with municipal decisions on land use.\(^56\) 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.\(^57\) 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 exercises in Section 5.2 illustrate, 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 an alternative political arrangement that reduces the level of regulation in those locations where homeowners have incentives to impose strict regulation. According to this policy, the federal government introduces a Pigouvian tax on cities with high regulation and uses the tax proceeds to provide transfers to cities with low regulation, therefore reducing the incentives to regulate in all cities. In practice such a tax would not be possible. However, the federal government provides sizable transfers to municipal governments.\(^58\) The policy proposed in this section could be viewed as a cut of federal transfers to

\(^{56}\) Hirt (2014) discusses the history of land use regulation in the U.S. and compares it to other countries.

\(^{57}\) See Gyourko and Molloy (2015).

\(^{58}\) National League of Cities estimates that about 5% of municipal revenues are transfers from the federal government and 20-25% are transfer from state governments. However, according to the Tax Policy
cities that restrict housing supply (i.e. cities with high housing supply regulation) and an increase in funding of cities that do not restrict supply. In practice such system of transfers between municipalities would not depend on the Wharton index but on a measurable indicator of supply restrictions (e.g. number of constructed units per capita during a period of time).

The tax is paid by all residents in a city and therefore reduces the disposable income. The tax rate depends on the current level of land use regulation in the city as follows:

$$\tau(z_j) = \tau_0 + \tau_1 z_j.$$  

If $\tau > 0$, then residents are taxed for choosing strict regulation that lead to high real estate prices. If $\tau < 0$, then residents receive a transfer as a reward for selecting lax regulation. The policy is purely redistributive, i.e. net transfers in the economy are zero:

$$\sum_{j \in J} \tau(z_j)N_j = 0. \quad (6.1)$$

The goal of the federal planner is to maximize aggregate productivity. The values of the parameters which maximize aggregate productivity while satisfying the condition 6.1 are $\tau_0 = -52,061$ and $\tau_1 = 79,850$. The highest regulation taxes are incurred by the New York and Los Angeles metropolitan areas: $\tau = 20,737$ and $\tau = 10,590$, respectively. Since the period is 5 years, this is equivalent to an annual federal tax of $4145$ (New York) or $2118$ (Los Angeles) per worker.

I find that the productivity-maximizing transfer scheme would increase output by about 2.5%. Output grows thanks to lower regulation and therefore higher population in highly productive cities. This policy also reduces average house prices by as much as 36% and the variance of log house prices by 16%. In addition, the federal intervention increases the national homeownership rate from 69% in the benchmark to 86%. However, this policy does not help reduce wage inequality across locations, largely because the effect of the policy on skill sorting is smaller. On the one hand, housing in large productive cities becomes cheaper. On the other hand, they face higher regulation taxes. Since the taxes are lump-sum, this discourages relative inflows of low-skilled workers, and therefore the effect on skill sorting is small. Table 4 summarizes results of the policy intervention.

---

Center, 30% of state revenues come from federal transfers, hence the transfers from the states to the municipalities also include federal funds. See https://www.nlc.org/revenue-from-intergovernmental-transfers and http://www.taxpolicycenter.org/briefing-book/what-are-sources-revenue-state-governments.
Using the consumption-equivalent measure of welfare introduced above, I find that the output-maximizing policy would increase welfare by 15.5%. Where are the sources of welfare gains? The largest gains come from lower house prices. First, thanks to lower prices homeownership increases and therefore more workers benefit from the utility of owning a house. Second, lower prices reduce housing expenditures and allow workers to consume more. Moderate gains also come from lower homeowners’ expenses on regulation and the consumption value of federal transfers. Welfare gains could be even larger if lower regulation did not increase congestion and thus reduce the amenity value of cities. Table 5 summarizes the channels of the welfare gains.

Table 5: Decomposition of welfare gains due to federal policy

<table>
<thead>
<tr>
<th>Contribution</th>
<th>% of Total Welfare Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total welfare gain</td>
<td>15.5%</td>
</tr>
<tr>
<td>Contribution of homeownership</td>
<td>8.1%</td>
</tr>
<tr>
<td>Contribution of expenses on regulation</td>
<td>3.2%</td>
</tr>
<tr>
<td>Contribution of federal transfers</td>
<td>1.3%</td>
</tr>
<tr>
<td>Contribution of amenities</td>
<td>-8.2%</td>
</tr>
<tr>
<td>Contribution of consumption</td>
<td>11.1%</td>
</tr>
</tbody>
</table>

A federal transfer scheme which punishes cities that restrict housing supply and rewards the others could also take other forms. One other option would be 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.59 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.60 Lowering the deduction limit or making the tax rate progressive in the sale price may reduce incentives of homeowners to introduce supply restrictions that result in higher prices.

7 Conclusions

In this paper, I argue that housing supply regulation lowers aggregate productivity and leads to higher house prices and house price dispersion in the U.S, as well as larger skill sorting and wage differences across locations. In order to study the impact of regulation quantitatively, I build a spatial equilibrium model in which the distributions of workers, 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 effect of the endogenous regulation mechanism, I construct counterfactual scenarios in which regulation is set at lower levels, and find that lower regulation could raise aggregate productivity by 3.5-3.8%, reduce wage inequality, and decrease house prices by 20-30%.

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 introduces a Pigouvian tax that discourages local regulation, I find that output would be 2.5% higher, average house prices 36% lower, and welfare more than 15% higher. The policy, however, does not reduce wage inequality.
References


A Appendix

A.1 Figures and Tables

Figure A.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 an Epanechnikov kernel. See Section 2 for details.

Figure A.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 an Epanechnikov kernel. See Section 2 for details.
Figure A.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 for details.
Figure A.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 for details.

Figure A.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 for details.
Figure A.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 for details.

Figure A.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 for details.
Figure A.8: Regulation and homeownership

Note: The figure plots the relationship between homeownership rate, controlled for workforce size, and the Wharton Index. See Section [2] for details.

Figure A.9: Rise in regulation and increasing differences across locations

Note: The figure plots the average and +/- one standard deviation across U.S. states of the regulation index constructed by Ganong and Shoag (2017). This figure is adapted from Table 1 of their paper.
Table A.1: Predictors of Local Political Pressure Index

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>College share, 2005-2007</td>
<td>2.321</td>
<td>(0.724)</td>
</tr>
<tr>
<td>Log mean wage, 2005-2007</td>
<td>-0.957</td>
<td>(0.520)</td>
</tr>
<tr>
<td>Log mean house prices, 2005-2007</td>
<td>0.338</td>
<td>(0.123)</td>
</tr>
<tr>
<td>Land availability (Saiz, 2010)</td>
<td>0.451</td>
<td>(0.204)</td>
</tr>
<tr>
<td>Votes for democratic candidate in state, 2008</td>
<td>-0.423</td>
<td>(0.386)</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.937</td>
<td>(1.237)</td>
</tr>
<tr>
<td>R2</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>187</td>
<td></td>
</tr>
</tbody>
</table>

*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 3.5 for details.*
Table A.2: Model Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production and Cities</strong></td>
<td></td>
</tr>
<tr>
<td>Productivity shifters</td>
<td>( \eta_{jst} ) multiple</td>
</tr>
<tr>
<td>Exogenous city-specific TFP</td>
<td>( A_j ) multiple</td>
</tr>
<tr>
<td>Agglomeration externality</td>
<td>( \alpha ) 0.0414</td>
</tr>
<tr>
<td>Congestion externality</td>
<td>( \delta ) 0.25</td>
</tr>
<tr>
<td><strong>Housing</strong></td>
<td></td>
</tr>
<tr>
<td>Baseline elasticity of prices</td>
<td>( \zeta^O ) 0.035</td>
</tr>
<tr>
<td>Elasticity of prices wrt land scarcity</td>
<td>( \zeta^\text{land} ) 0.051</td>
</tr>
<tr>
<td>Elasticity of prices wrt regulation</td>
<td>( \zeta^\text{reg} ) 0.042</td>
</tr>
<tr>
<td>Baseline elasticity of rents</td>
<td>( \zeta^R ) 0.048</td>
</tr>
<tr>
<td>Elasticity of rents wrt land scarcity</td>
<td>( \zeta^\text{land}^R ) 0.024</td>
</tr>
<tr>
<td>Elasticity of rents wrt regulation</td>
<td>( \zeta^\text{reg}^R ) 0.031</td>
</tr>
<tr>
<td>Downpayment</td>
<td>( d ) 0.2</td>
</tr>
<tr>
<td>Mortgage term</td>
<td>( \pi ) 6</td>
</tr>
<tr>
<td>Mortgage interest rate</td>
<td>( i_h ) 6.21%</td>
</tr>
<tr>
<td><strong>Workers and preferences</strong></td>
<td></td>
</tr>
<tr>
<td>Fraction of high-skilled workers</td>
<td>( \lambda_H ) 0.3652</td>
</tr>
<tr>
<td>Exogenous amenities</td>
<td>( \alpha_j ) many</td>
</tr>
<tr>
<td>Annual discount factor</td>
<td>( \beta ) 0.96</td>
</tr>
<tr>
<td>Utility of homeownership</td>
<td>( \gamma ) 0.5792</td>
</tr>
<tr>
<td>Savings interest rate</td>
<td>( i_k ) 4.30%</td>
</tr>
<tr>
<td>Variance of preference shock</td>
<td>( \sigma_\varepsilon ) 0.3</td>
</tr>
<tr>
<td><strong>Regulation</strong></td>
<td></td>
</tr>
<tr>
<td>Campgn contribution function</td>
<td>( \omega_0 ) 8300.02</td>
</tr>
<tr>
<td>Campgn contribution function</td>
<td>( \omega_1 ) 1.8349</td>
</tr>
<tr>
<td>Congestion effect</td>
<td>( \phi ) 0.01631</td>
</tr>
<tr>
<td>Ideological taste shocks</td>
<td>( \nu ) 1</td>
</tr>
</tbody>
</table>

Note: The table shows parameter values and whether they are estimated, calibrated, or taken from the literature. See Section 4 for details.
Table A.3: Model Fit (non-targeted moments)

<table>
<thead>
<tr>
<th>Model Data</th>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispersion of wages across MSAs (var of log)</td>
<td>0.042</td>
<td>0.017</td>
</tr>
<tr>
<td>Dispersion of house prices across MSAs (var of log)</td>
<td>0.233</td>
<td>0.224</td>
</tr>
<tr>
<td>Dispersion of college shares across MSAs (s.d.)</td>
<td>0.206</td>
<td>0.079</td>
</tr>
<tr>
<td>Correlation, mean wage vs regulation</td>
<td>0.84</td>
<td>0.44</td>
</tr>
<tr>
<td>Correlation, house price vs regulation</td>
<td>0.67</td>
<td>0.50</td>
</tr>
<tr>
<td>Correlation, homeownership vs regulation</td>
<td>-0.50</td>
<td>-0.23</td>
</tr>
<tr>
<td>Correlation, land scarcity vs regulation</td>
<td>0.27</td>
<td>0.30</td>
</tr>
<tr>
<td>Wages, correlation model vs data</td>
<td></td>
<td>0.75</td>
</tr>
<tr>
<td>House prices, correlation model vs data</td>
<td></td>
<td>0.94</td>
</tr>
</tbody>
</table>

*Note:* The table displays some non-targeted moments in the data and their counterparts in the model. See Section 4 for details.
A.2 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.

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 202 MSAs in the 48 contiguous U.S. states such that (1) they can be identified in the IPUMS ACS sample in 2005-2007, (2) the Wharton Index is available for municipalities in the MSA, (3) land availability measure is available for the MSA. Thus the sample used in this paper only includes individuals that reside in one of these 202 MSAs.

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. 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)].

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 conducted in 2007. The survey questionnaire was sent to an official responsible for planning and zoning in every municipality in the U.S. and contained a 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, and a single index of regulation (the WRLURI) that summarizes the strictness of regulatory environment for each municipality. The original WRLURI was constructed at the municipality level. Since my unit of analysis is an MSA, I use the WRLURI aggregated to the MSA level using population weights. While there may be variation in regulation across municipalities in an MSA, [Gyourko, Saiz and Summers (2008)] find that differences in regulation within metro areas are smaller than the differences across metro areas.62

61Self-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.

62The 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.
A.3 Solving the Model

Solving the model involves finding equilibrium objects such that the equilibrium conditions hold for given parameters of the model (equilibrium is defined in Section 3.4). A 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.

The solution algorithm is described below.

1. Take labor supply and 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 (3.8) and (3.9), 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 3.12).

4. Use the value functions and the distribution of workers to compute regulation by maximizing the weighted social welfare function (equation 3.10) 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 need to know the future path of regulation, given the level of regulation chosen today. Second, they need to know how labor supply, and

\[63\text{There are 1,034,240 types of workers: 202 cities, 2 skills, 8 ages, 40 asset grid points, 2 ownership statuses and, for an owner, 7 possible lengths of ownership. This is 5,120 types per city. Every type has a separate value function, and in every city the value functions have to be computed 20-40 times until the optimal regulation is found. The main complication emerges when for each of the 20-40 iterations I need to find the future path of regulation and labor supply that arise from optimal choices of agents.}\]
therefore prices, will respond to every chosen level of regulation. In other words, workers need to know the entire shape of the aggregate transition function $F$. However, 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, $z_{j,t+1}$, 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)](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:

$$\ln N_{js,i} - \ln N_{js,i-1} = \beta_{0} + \beta_{1} (z_{j,i} - z_{j,i-1})$$

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 $\beta_{0}$ and $\beta_{1}$. 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 estimated $\beta_{0}$ and $\beta_{1}$, agents predict that, if they vote to change regulation from $z$ to $z'$, then the supply of $s$-skilled workers will change to $\ln N_{js,i} = \ln N_{js,i-1} + \beta_{0} + \beta_{1} (z' - z)$.

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.