Affordable Housing and City Welfare *

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Abstract

Housing affordability is the main policy challenge for most large cities in the world. Zoning changes, rent control, housing vouchers, and tax credits are the main levers employed by policy makers. How effective are they at combatting the affordability crisis? We build a dynamic stochastic spatial equilibrium model to evaluate the effect of these policies on the well-being of its citizens. The model endogenizes house prices, rents, construction, labor supply, output, income and wealth inequality, the location decisions of households within the city as well as inter-city migration. Its main novel features are risk, risk aversion, and incomplete risk-sharing. We calibrate the model to the New York MSA. Housing affordability policies carry substantial insurance value but affect aggregate housing and labor supply and cause misallocation in labor and housing markets. Housing affordability policies that enhance access to this insurance especially for the neediest households create substantial net welfare gains.

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1 Introduction

The increasing appeal of major urban centers has brought on an unprecedented housing affordability crisis. Ever more urban households are burdened by rents or mortgage payments that take up a large fraction of their paycheck and/or by long commutes. The share of cost-burdened renters in the United States has doubled from 24% in the 1960s to 48% in 2016. Over this period, median home value rose 112%, far outpacing the 50% increase in the median owner income (Joint Center for Housing Studies of Harvard University, 2018). Hsieh and Moretti (2019) argue that our most productive cities are smaller than they should be because of lack of affordable housing options, underscoring the importance of the issue. The Covid-19 pandemic lent new urgency to the affordability crisis with 10 million American renters behind on $60 billion in rent as of February 2021, and near-20% house price appreciation in 2021.

Policy makers throughout the world are under increasing pressure to improve affordability. They employ policy tools ranging from rent regulation, upzoning, inclusionary zoning, housing vouchers, to developer tax credits. While there is much work, both empirical and theoretical, on housing affordability, what is missing is a general equilibrium model that quantifies the aggregate and distributional impact of such policies on individual and city-wide welfare. This paper provides such a model. It endogenizes prices and quantities of owned and rented housing, the spatial distribution of housing and households, commuting patterns, incentives to work, income and wealth inequality within and across neighborhoods, output, and in- and out-migration to other metropolitan areas. We calibrate the model and use it as a laboratory to conduct various housing policy experiments, allowing us to study the various policy instruments and compare their effectiveness. This new framework is well suited for studying the impact of place-based policies.

We find that the expansion of housing affordability policies improves welfare. In an incomplete markets model with risk and risk aversion, such policies play a quantitatively important role as an insurance device. The housing stability they provide disproportionately benefits low-income households. These insurance benefits trade off against the aggregate and spatial distortions in housing and labor markets that accompany such policies. Our results highlight the importance of general equilibrium effects and of how the affordability policies are financed.

Our model consists of two metropolitan areas. The first metro is the one we focus on and whose housing policies we study. We think of this metro as a "gateway" city with a housing affordability problem. This metro consists of two zones, the urban core (zone 1) and the suburbs (zone 2). Working-age households who live in zone 2 commute to zone

1 for work, incurring an opportunity cost of time and a financial cost. Zones have different sizes, limited by restrictions on the housing stock, provide different amenity benefits. Households who live in the urban core also enjoy higher productivity, capturing agglomeration effects. The second metro serves as an alternative, more affordable, location for residents of the first metro. We allow migration between the two metros, subject to moving costs. The spatial aspect of the model is important since affordable housing policies affect the desirability of housing in each location and incentives to work.

The economy is populated by overlapping generations of risk averse households who face idiosyncratic labor productivity and mortality risk. They make dynamic decisions on location, non-housing and housing consumption, labor supply, tenure status (own or rent), savings in bonds, primary housing, investment property, and mortgage debt. Since households cannot perfectly hedge labor income and longevity risk, markets are incomplete. Progressive tax-and-transfer and social security systems capture important insurance mechanisms beside affordable housing policies. The model generates a rich cross-sectional distribution over age, labor income, tenure status, housing wealth, and financial wealth. This richness is paramount to understanding not only the distributional but also the aggregate implications of housing affordability policies.

On the firm side, each metro produces tradable goods and residential housing, subject to decreasing returns to scale. As an area approaches its housing limit, construction becomes increasingly expensive, and the housing supply elasticity falls. Wages, house prices, and market rents in each metro are determined in equilibrium.

We calibrate the first metro to the New York metropolitan statistical area (NY MSA), designating Manhattan as zone 1 and the remaining 24 counties of the NY MSA as zone 2. Our calibration targets key features of the data, including the relative housing stock and population of zone 1 and zone 2, the income distribution in the New York MSA, observed commuting times and costs, the housing supply elasticity, current zoning laws, the current size and scope of the rent stabilization system, and the current federal, state, and local tax-and-transfer system.

The baseline model generates realistic income, wealth, and home ownership patterns over the life-cycle for various percentiles of the income distribution. It matches both income and wealth inequality. The model also matches house price and rent levels for the MSA. Finally, it generates a housing affordability problem, with high price-income and rent-income ratios, and over half of renters that are cost-burdened.

We think of the second metro as the rest of the U.S., it is an outside option for current New Yorkers, and a source for migration into New York. It is calibrated to the average of the next 74 largest MSAs in the U.S. It only has one zone, no rent stabilization, and a lower income level for top-productivity households, but is otherwise similar to the NY MSA. We calibrate moving costs to match in-migration rates and out-migration rates by age and income for the NY MSA.

We model rent regulation in NY as rent stabilization (RS). The government mandates a slower rate of growth for rents on RS housing units than for market rentals. In a stationary economy, this translates into a rent level discount relative to the market rent, which grows with the length of stay in the RS unit (tenure). Developers in the model must make a fixed share of the housing stock rent stabilized. RS units are allocated by lottery to capture the random nature of the allocation process in reality. RS is subject to a housing size constraint but has no tenant income qualification and suffers from low turnover. This results in substantial misallocation of RS housing in the model, mimicking that in the data.

We define *access to insurance* as the likelihood that a household in the bottom half of the income distribution that experiences a negative labor productivity shock gains access to a RS housing unit. We define the *stability of insurance* as the likelihood that a household in the bottom half of the income distribution that is already in a RS unit can remain there the next period. The *value of insurance* depends on the size of the RS unit, how deeply the rent is discounted, and on household risk aversion.

The RS system creates multiple inefficiencies which trade off with the insurance benefits. The first one is that the housing stock is misallocated. Because there is no income qualification, some RS units go to higher-income households by sheer luck, taking away affordable units from the needy. Given the maximum size constraint on RS units, these households often under-consume housing. This under-consumption may get worse as households age because of rising labor income profiles and growing discounts. Other, lower-income RS tenants over-consume housing because of the RS discount. Households choose to live in a zone where they otherwise would not because they won the RS lottery in that zone. A lower-productivity household, with a lower opportunity cost of commuting, may be taking the place of a higher-productivity household in the urban core. RS may therefore trigger spatial misallocation of labor as well as housing.

The second distortion is on the supply of housing, which in the model encompasses the maintenance of the existing housing stock. The rent regulation mandate results in lower average prices for new housing development and a lower equilibrium housing supply. Reductions in housing supply result in higher equilibrium rents and prices, all else equal, worsening the affordability problem for market renters and potential home owners. Since the RS mandate varies across zones, so does the distortion.

We study housing policy reform in a sequence of experiments and ask whether they improve welfare. Most policies benefit some households while hurting others. Since the reforms in the NY MSA affect the attractiveness to live there, they change both out- and in-migration decisions. Generally, the mobility margin dampens the welfare effects since households have another margin of adjustment, namely to "vote with their feet." Migration complicates welfare analysis since the set of households that live in the NY MSA is different before and after the reform. As our main aggregate welfare criterion, we focus on a fixed set of households who live in NY in the period before the reform, and compute the change in their value function in the first period after the reform regardless of whether they still live in NY. We take cross-sectional averages of value functions before and after, implicitly giving more weight to the needy (high marginal-utility households).

A first policy experiment expands the scope of the affordable housing mandate. Surprisingly, a 50% increase in the share of square footage set aside for RS housing units increases welfare by a large 0.91%. With more RS housing units, access to insurance increases without hurting the stability of that insurance. The benefits this brings to lower-income households outweigh the costs that arise from weaker incentives to construct and maintain housing, higher rents in market units, and more spatial misallocation of labor and housing. We find that welfare increases monotonically with the scope of the affordable housing mandate until demand is saturated.

A second policy aims to reduce the misallocation caused by RS. A policy that income-tests every RS tenant every period, but provides housing stability for existing RS tenants, delivers substantial welfare gains (0.66%). RS housing becomes much better allocated, improving access to insurance without compromising stability of insurance. Four forces limit the welfare gains. First, income qualification reduces incentives to work. Second, by replacing long-term tenants by new tenants, the policy reduces the average subsidy since new RS tenants start with much smaller rent discounts. Third, the policy results in a larger NY population, increasing competition for affordable housing. Fourth, because of a constraint on the maximum size (quality) of RS units, the least-needy households do not choose RS even in the absence of an income qualification.

A third policy experiments with the spatial aspects of affordable housing. It relocates all RS housing from the urban core to the suburbs. This policy increases average welfare by 0.25%. Gentrification of the core ensues, with fewer but higher-income residents, larger apartments, and more home ownership. Increased socio-economic segregation, with low-income households missing out on the agglomeration benefits of living in the core, and a better spatial allocation of labor, with more high-productivity households in the core, are two sides of the same coin.

The fourth policy experiment increases the maximum amount of housing that can be built in the urban core, for example through a relaxation of land use or height restrictions.

This "upzoning" policy increases the equilibrium population share and the housing stock of zone 1. Rents fall, which benefits both market and RS renters. It generates a modest welfare gain of 0.11%. The policy involves less redistribution, creating benefits for all age, productivity, income, and wealth groups, at least in the long-run. But it generates only a modest improvement in the plight of low-income households.

Housing vouchers are transfers provided to low-income households for housing expenditures. A fifth reform expands the outlay on vouchers by $800 million. It produces no average welfare gain, despite benefits to low-income, high-marginal utility households. A powerful interaction between taxation and migration bedevils this program. We assume, consistent with reality, that a voucher expansion must be financed via distortionary income taxes. Since higher taxes prompt an outflow of high-productivity households, the tax rate must be even higher to finance the same dollar expansion in housing vouchers. This prompts further out-migration, etc. The labor supply distortions are much larger than in a model without migration. The same migration response triggers a drop in the housing stock and higher rents. The housing voucher program triggers an interesting spatial response. In equilibrium low-income households are not more likely to "move to opportunity," but end up living in the same areas they were before. In fact, the urban core gentrifies, housing a larger share of top-productivity and higher-income households, with fewer renters and higher rents. Vouchers "remove from opportunity" some medium-productivity households who end up farther from their jobs or migrating to a different MSA. This experiment underscores the importance of spatial equilibrium considerations and of how housing affordability policies are paid for in equilibrium.

Related Literature Our work is at the intersection of the macro-finance and urban economics literatures. A large literature in finance solves partial-equilibrium models of portfolio choice between housing (extensive and intensive margin), financial assets, and mortgages.[1] Recent work in macro-finance has solved such models in general equilibrium, adding aggregate risk, endogenizing house prices and sometimes also interest rates.[2] Like the former literature, our model features a life-cycle and a rich portfolio choice problem and captures key quantitative features of observed wealth accumulation and home ownership over the life-cycle. Like the latter literature, house prices, rents, and wages are determined in equilibrium. We abstract from aggregate risk which is not central to the

[1] Examples are Campbell and Cocco (2003), Cocco (2005), Yao and Zhang (2004), and Berger, Guerrieri, Lorenzoni, and Vavra (2017). Davis and Van Nieuwerburgh (2015) summarize this literature.

[2] E.g., Landvoigt, Piazzesi, and Schneider (2015), Favilukis, Ludvigson, and Van Nieuwerburgh (2017), Guren and McQuade (2019), and Kaplan, Mitman, and Violante (2019). Imrohoroglu, Matoba, and Tuzel (2016) study the effect of the 1978 passage of Proposition 13 which lowered property taxes in California.

question at hand. Our contribution to the macro-finance literature is to add a spatial dimension to the model and to evaluate a rich set of housing policies.

A voluminous literature in urban economics studies the location of households in spatial equilibrium models. Households trade off commuting costs and housing expenditures.[3] Guerrieri, Hartley, and Hurst (2013) study house price dynamics in a city and focus on neighborhood consumption externalities, in part based on empirical evidence in Rossi-Hansberg, Sarte, and Owens (2010). Couture, Gaubert, Handbury, and Hurst (2018) uses a similar device to explain the return of rich households to the urban core over the past decades, reversing an earlier wave of suburban flight. Our model also features such luxury amenities in the city center. Urban models tend to be static, households tend to be risk neutral or have quasi-linear preferences, and landlords are absentee (outside the model). The lack of risk, investment demand for housing by local residents, and wealth effects makes it hard to connect these spatial models to the macro-finance literature. When there is no risk, there is no insurance role for affordability policies.[4]

Because it is a heterogeneous-agent, incomplete-markets model, agents' choices and equilibrium prices depend on the entire wealth distribution. Because of the spatial dimension, households' location is an additional state variable that needs to be kept track of. We use state-of-the-art methods to solve the model. We extend the approach of Favilukis et al. (2017), which itself extends Gomes and Michaelides (2008) and Krusell and Smith (1998) before that. The solution approach accommodates aggregate risk, though we abstract from it in this model.

The resulting model is a new laboratory that can be used to study how place-based policies affect the spatial distribution of people, housing, labor supply, house prices, output, and inequality. Favilukis and Van Nieuwerburgh (2021) use a related framework to study the effect of out-of-town investors on residential property prices. They do not study housing affordability policies and do not consider the inter-city migration decision, which adds both substantial complexity to the model solution and richness to the analysis. The idea that the migration margin provides insurance against adverse income shocks appears prominently in recent work by Bilal and Rossi-Hansberg (2021).

[3] Brueckner (1987) summarizes the Muth-Mills monocentric city model. Rappaport (2014) introduces leisure as a source of utility and argues that the monocentric model remains empirically relevant. Rosen (1979) and Roback (1982) introduce spatial equilibrium. Recent work on spatial sorting includes Van Nieuwerburgh and Weill (2010), Behrens, Duranton, and Robert-Nicoud (2014) and Eeckhout, Pinheiro, and Schmidheiny (2014).

[4] Hizmo (2015) and Ortalo-Magné and Prat (2016) bridge some of the gap between these two literatures by studying a problem where households are exposed to local labor income risk, make a once-and-for-all location choice, and then make an optimal financial portfolio choice. Their models are complementary to ours in that they solve a richer portfolio choice problem in closed-form, but don't have preferences that admit wealth effects nor allow for consumption and location choice each period.

Our model connects to an empirical literature that studies the effect of rent regulation and zoning policies on rents, house prices, and housing supply. Autor, Palmer, and Pathak (2014, 2017) find that the elimination of the rent control mandate on prices in Cambridge increased the value of decontrolled units and neighboring properties in the following decade, by allowing constrained owners to raise rents and increasing the amenity value of those neighborhoods through housing market externalities. The price increase spurred new construction, increasing the rental stock. Diamond, McQuade, and Qian (2019) show that the expansion of rent control in San Francisco led to a reduction in the supply of available housing, paradoxically contributing to rising rents and the gentrification of the area. While beneficial to tenants, it resulted in an aggregate welfare loss. We also find a lower housing stock and higher rents from an expansion of rent stabilization, but an aggregate welfare gain for the entire MSA in spatial equilibrium. Davis, Gregory, Hartley, and Tan (2017) study the effect of housing vouchers on location choice and children's schooling outcomes in a rich model of the Los Angeles housing market, while Davis, Gregory, and Hartley (2018) study Low Income Housing Tax Credits (LIHTC) and their effect on demographic composition, rent, and children's adult earnings. Diamond and McQuade (2019) find that LIHTC buildings in high- (low-)income neighborhoods have negative (positive) effects on neighboring property prices. Earlier work by Baum-Snow and Marion (2009) focuses on the effects of LIHTCs on low income neighborhoods and Freedman and Owens (2011) focuses on crime. Luque, Ikromov, and Noseworthy (2019) summarize financing methods for low-income housing development. We discuss a developer tax credit policy in the appendix.

We sidestep the question whether housing policy is the optimal policy to redistribute and provide insurance. In the spirit of Diamond and Saez (2011), we evaluate policy reforms that are extensions of existing policies, limited in complexity and potentially politically feasible. Housing policies are omnipresent, making it paramount to understand their macro-economic and distributional effects. One reason for their prevalence may simply be that housing policies are the most accessible levers for local policy makers to influence their citizen's welfare; they may have limited control over tax-and-transfer policies. While the public finance literature has generally argued for the superiority of cash transfers (following Atkinson and Stiglitz, 1976), it has also identified several rationales for in-kind transfers. Currie and Gahvari (2008) discuss paternalism, interdependent preferences, imperfect information on the part of the government, self-targeting, and mitigating income tax distortions.[5] We contrast housing policies to cash transfer programs, similarly

[5] In-kind transfers are very important in developed and developing countries alike. Health/food, education, and housing are the main ones. Currie and Gahvari (2008) conclude it is "more the norm than the

financed with distortionary taxation. A highly progressive cash transfer scheme generates the largest net benefit in our model, while a cash transfer system that follows the housing voucher design in all but its in-kind nature does not result in a welfare gain and is dominated by other housing policies.

The rest of the paper is organized as follows. Section 2 provides the institutional context. Section 3 sets up the model. Section 4 describes the calibration to the New York metropolitan area. Section 5 discusses the benchmark model's implications for quantities and prices, the distribution of households, and housing affordability. Section 6 studies the main counter-factual policy experiments. Section 7 concludes. Appendix A lists equilibrium conditions, Appendix B provides detail on the data, and Appendix C on the calibration. Appendix D studies several additional affordability policies, including a transit subsidy and developer tax credits. Appendix E revisits all policies in a model without inter-city migration, helping to isolate the role of migration. Appendix F contains sensitivity analysis.

2 Institutional Context

The model below features rent stabilization (RS). In a RS system, a governmental entity determines the growth rate of rents that applies to the RS units. It typically chooses a growth rate below that in the unregulated rental market. While the rent discount may be small upon first entry, the rent discount grows with the length of tenure.

Rent stabilization is prevalent. In New York City, RS units make up 30.3% of all housing units in 2017, more than the 29.4% of units that are market rentals. RS generally applies to apartments in buildings with six or more units constructed before 1974. The vast majority of units built after 1974 that are stabilized are so voluntarily. They receive tax abatement in return for subjecting their property to RS for a period of time, a program formerly known as 421-a. The rent on RS units does not depend on tenant income level, apartment size, how many people live there, or any other needs-based factors. In the past, New York landlords could increase rents after a tenant left based on individual apartment improvements made to the unit or major capital improvements made to the building. That ability became severely curtailed with the passage of new affordable housing legislation in the state of New York in 2019. Rent control (RC) refers to a much smaller program, only 0.7% of housing units in New York City in 2017. RC applies to buildings built before 1947 and has much larger average discounts that do not vary with

exception for governments to conduct redistribution in-kind."

tenure. Given the small size of the RC program, we will ignore it in this study. Appendix B.4 provides more detail.

Rent regulation is making a comeback. Fifteen cities in California have rent stabilization, including San Francisco and Los Angeles. De Blasio, the mayor of New York City, was re-elected on a platform to preserve or add 200,000 affordable housing units in 2018. Oregon, California, New Jersey, Maryland, and the District of Columbia imposed statewide RS policies in 2019 or 2020. New York State passed the most sweeping expansion of rent regulation laws in a generation in 2019. Local policymakers are trying to overturn preemption laws, on the books in 36 U.S. States, that prevent local governments from adopting rent regulation laws. Rent regulation has always been stronger and broader in Europe than in the U.S. (OECD, 2021).[6] Paris reintroduced rent control in 2019. Berlin passed a sweeping rent control program that went into effect in 2020. This international context provides external validity to our exercise.

Separately, many local governments are changing zoning laws. For example, in 2018, Minneapolis became the first major American city to eliminate single-family zoning. Other cities, such as New York and Seattle, have turned to upzoning policies that increase density in the urban core.

3 Model

The model consists of two metropolitan areas (MSA), a "gateway" MSA, whose housing affordability problem we study, and an outside MSA. The gateway MSA has an urban core (zone 1) and a suburban area (zone 2). Zone 1 is the central business district where all employment takes place. Households living in zone 2 face a commuting cost. While clearly an abstraction of the more complex production and commuting patterns in large cities, the monocentric city assumption captures the essence of commuting patterns (Rappaport, 2014) and is the simplest way to introduce a spatial aspect in the model. Households face a moving cost to move into or out of the gateway MSA; the population of the gateway MSA is endogenous and will respond to housing policy changes.

3.1 Households

Preferences The economy consists of overlapping generations of risk averse households. There is a continuum of households of a given age a. The total population in the economy is fixed.

[6] See `https://www.oecd.org/els/family/PH6-1-Rental-regulation.pdf`.

Each household maximizes a utility function u over consumption goods c, housing h, and labor supply n. Utility depends on location ℓ and age a, allowing the model to capture commuting time and amenity differences across locations.

The period utility function is a CES aggregator of c and h and leisure l:

$$U(c_t, h_t, n_t, \ell_t, a) = \frac{\left[\chi_t^{\ell,a} \mathcal{C}(c_t, h_t, l_t)\right]^{1-\gamma}}{1-\gamma}, \tag{1}$$

$$\mathcal{C}(c_t, h_t, l_t) = \left[(1-\alpha_n)\left((1-\alpha_h)c_t^{\epsilon} + \alpha_h h_t^{\epsilon}\right)^{\frac{\eta}{\epsilon}} + \alpha_n l_t^{\eta}\right]^{\frac{1}{\eta}}$$

$$h_t \geq \underline{h} \tag{2}$$

$$n_t^a = \begin{cases} 1 - \phi_T^{\ell} - l_t \geq \underline{n} & \text{if } a < 65 \\ 0 & \text{if } a \geq 65 \end{cases} \tag{3}$$

$$\chi_t^{\ell,a} = \begin{cases} 1 & \text{if in Outside MSA} \\ \chi^{NY} & \text{if } \ell = 2 \\ \chi^{NY}\chi^{1} & \text{if } \ell = 1 \text{ and } a < 65 \\ \chi^{NY}\chi^{1}\chi^{R} & \text{if } \ell = 1 \text{ and } a \geq 65 \end{cases} \tag{4}$$

The coefficient of relative risk aversion is γ. The parameter ϵ controls the intra-temporal elasticity of substitution between housing and non-housing consumption.

Equation (2) imposes a minimum house size requirement ($\underline{h}$), capturing the notion that a minimum amount of shelter is necessary for a household. The city's building code often contains such minimum size restrictions.

Total non-sleeping time in equation (3) is normalized to 1 and allocated to work (n_t), leisure (l_t), and commuting time ϕ_T^{ℓ}. Since we will match income data that exclude the unemployed, we impose a minimum constraint on the number of hours worked ($\underline{n}$) for working-age households. This restriction will also help us match the correlation between income and wealth. There is an exogenous retirement age of 65. Retirees supply no labor.

The taste-shifter $\chi^{\ell,a}$ captures the relative amenity value of the various locations. They are allowed to depend on age as follows. The amenity value of the Outside MSA is normalized to 1. The value of living in the gateway MSA is governed by χ^{NY}. The additional amenity value of zone 1 relative to zone 2 is given by χ^{1}. For retirees living in zone 1, there is an amenity shifter χ^{R} which will help the model match the fraction of retirees living in zone 1.

There are two types of households in terms of the time discount factor. One group of households have a high degree of patience β^{H} while the rest have a low degree of patience β^{L}. This preference heterogeneity helps the model match observed patterns of wealth inequality and wealth accumulation over the life cycle.

Endowments A household's labor income y_t^{lab} depends on the number of hours worked n, the wage per hour worked W, a deterministic component G^a which captures the hump-shaped pattern in average labor income over the life-cycle, and an idiosyncratic labor productivity z, which is stochastic and persistent.

To capture the effect of living in the urban core on current and future income, we assume that households working in the city center experience higher productivity. This productivity shifter $\mathcal{A}^1 > \mathcal{A}^2 = 1$ will help the model match the income differential between zone 1 and zone 2.[7]

After retirement, households earn a retirement income which is the product of an aggregate component $\overline{\Psi}$ and an idiosyncratic component $\psi^{a,z}$. The idiosyncratic component has cross-sectional mean of one, and is determined by productivity during the last year of work. Labor income is taxed linearly at rate τ^{SS} to finance retirement income. Other taxes and transfers are captured by the function $T(\cdot)$ which maps total pre-tax income into a net tax (negative if transfer). Net tax revenue goes to finance a public good which does not enter in household utility.

Households face mortality risk which depends on age, p^a. Although there is no intentional bequest motive, households who die leave accidental bequests. We assume that the number of agents who die with positive wealth leave a bequest to the same number of agents alive of ages 21 to 65. These recipient agents are randomly chosen, with one restriction. Patient agents (β^H) only leave bequests to other patient agents and impatient agents (β^L) only leave bequests to other impatient agents. One interpretation is that attitudes towards saving are passed on from parents to children. Conditional on receiving a bequest, the size of the bequest $\widehat{b}_{t+1}$ is a draw from the relevant distribution, which differs for β^H and β^L types. Because housing wealth is part of the bequest, the size of the bequest is stochastic. Agents know the distribution of bequests, conditional on β type. This structure captures several features of real-world bequests: many households receive no bequest, bequests typically arrive later in life and at different points in time for different households, households anticipate bequest sizes to some degree, and there is substantial heterogeneity among bequest sizes for those who receive a bequest.

[7] This productivity shifter is a reduced-form way of capturing production agglomeration effects in the urban core. It includes network effects, better access to good schools, etc. Note that because all employment takes place in the urban core, traditional production agglomeration effects are already maximized.

Affordable Housing As discussed in Section 2, we model rent stabilization (RS) in the gateway MSA to capture key features in reality. A fraction η^{ℓ} of rental housing units in zone ℓ are rent stabilized. The rent per square foot is a fraction $\kappa_1(d) < 1$ of the free-market rent, with a discount is increasing in the length of tenure d.[8] The assignment of RS units to renters is by lottery. Every household in the model enters the affordable housing lottery every period. A household that wins the lottery in a zone can choose to turn down the affordable unit, and rent or own in the location of its choice on the free market.[9] There is a maximum RS housing size. The model allows for an income qualification requirement whereby the income of a RS tenant must be below a fraction κ_2 of area median income (AMI). In the baseline model, as well as in reality, there is no income qualification requirement for RS units, so that $\kappa_2 = \infty$. We explore policies below that lower κ_2.

Households that lived in a RS housing unit in a given zone in the previous period have an exogenously set, high probability of winning the RS lottery in the current period, $p^{RS,exog}$.[10] This parameter determines the average length of tenancy in the RS system. For households that were not previously in RS, the probability of winning the lottery for each zone is endogenously determined to equate the residual demand (once accounting for RS stayers) and the supply of RS units in each zone. Households form beliefs about this probability. This belief must be consistent with rational expectations, and is updated as part of the equilibrium determination. The presence of the RS housing program distorts labor supply, location choice, housing demand, and housing supply, as discussed further below.

Migration Households who lived in the gateway MSA in the previous period optimally decide to either remain or to migrate out to the outside MSA by comparing the value functions associated with each choice:

$$V = \max\left\{V^{NY}, m(a,z)V^{*}\right\}$$

where $m(\cdot)$ is a moving cost that depends on age a and on productivity z. Since the value function is negative $m(a,z) > 1$ denotes a moving cost and $m(a,z) < 1$ a moving benefit.

[8] A slower growth rate of RS rents than market rents in a growing economy translates into a growing rent discount with tenure in our stationary model. Appendix B.4 shows the discount in the data as a function of tenure for the New York MSA, which our calibration below targets.

[9] There is a single lottery for all affordable housing units. A certain lottery number range gives access to affordable housing in zone 1, while a second range gives access to housing in zone 2. Households with lottery numbers outside these ranges lose the housing lottery.

[10] For these households, the probability of winning the RS lottery in the other zone is set to zero.

Migration into the gateway MSA depends on the value in remaining in the outside MSA relative to the value of being in the gateway MSA and paying a moving cost:

$$\max \left\{ m^*(a,z)V^{NY}, V^* \right\}$$

The moving-in cost function is allowed to differ from the moving-out cost, as explained in the calibration section below.

Location and Tenure Choice within Gateway MSA Denote by $p^{RS,\ell}$ the probability of winning the RS lottery and being offered a RS unit in zone ℓ. The household chooses whether to accept the RS option with value $V_{RS,\ell}$, or to turn it down and go to the private housing market with value V_{free}. The value function, conditional on being in the gateway MSA, V^{NY} is:

$$V^{NY} = p^{RS,1} \max \left\{ V_{RS,1}, V_{free} \right\} + p^{RS,2} \max \left\{ V_{RS,2}, V_{free} \right\} + \left(1 - p^{RS,1} - p^{RS,2}\right) V_{free}.$$

A household that loses the lottery or wins it but turns it down, freely chooses in which location $\ell \in \{1,2\}$ to live and whether to be an owner (O) or a renter (R).

$$V_{free} = \max \left\{ V_{O,1}, V_{R,1}, V_{O,2}, V_{R,2} \right\}.$$

The Bellman equations for $V_{RC,\ell}$, $V_{R,\ell}$ and $V_{O,\ell}$ are defined below.

Tenure Choice in Outside MSA In the outside MSA, there is only one zone (zone 1) and no RS system. The value function, conditional on being in the outside MSA, is:

$$V^* = \max \left\{ V_O^*, V_R^* \right\}.$$

State Variables Let S_t be the vector which includes the wage W_t, the housing price P_t^ℓ, the market rent R_t^ℓ and previous housing stock H_{t-1}^ℓ for each zone ℓ. There is a similar state variable for the outside location S_t^* except that there is only one zone in the outside MSA. The household forms beliefs about (S_t, S_t^*). The household's individual state variables are: net worth at the start of the period x_t, idiosyncratic productivity level z_t, age a, and housing status in the previous period d_t. The housing status is equal to 0 if the household was a market renter or owner in the gateway MSA and takes non-zero values to record both where and how long the household has been in the RS system (since the discount depends on the length of tenancy). We suppress the dependence on β-type in the problem formulation below, but note here that there is one set of Bellman equations for each β-type.

Market Renter Problem In the gateway MSA, a renter household on the free rental market in location ℓ chooses non-durable consumption c_t, housing consumption h_t, and working hours n_t to solve:

$$
\begin{aligned}
&V_{R,\ell}(x_t, z_t, a, d_t) = \max_{c_t, h_t, n_t, b_{t+1}} U(c_t, h_t, n_t, \ell_t) + (1 - p^a)\beta \mathbb{E}_t[V(x_{t+1}, z_{t+1}, a+1, 0)] \\
&\text{s.t.} \\
&c_t + R_t^\ell h_t + Q b_{t+1} + \phi_F^\ell = \left(1 - \tau^{SS}\right) y_t^{lab} + \overline{\Psi}_t \psi^z + \pi_t + x_t - T\left(y_t^{tot}\right), \\
&y_t^{lab} = W_t n_t \mathcal{A}^\ell G^a z_t, \\
&y_t^{tot} = y_t^{lab} + \left(\frac{1}{Q} - 1\right) x_t + \pi_t, \\
&x_{t+1} = b_{t+1} + \widehat{b}_{t+1} \geq 0, \\
&\text{and equations (1), (2), (3), (4).}
\end{aligned}
$$

The renter's savings in the risk-free bond, Qb_{t+1}, are obtained from the budget constraint. Pre-tax labor income y_t^{lab} is the product of wages W per efficiency unit of labor, the number of hours n, and the productivity per hour $\mathcal{A}^\ell G^a z$. The latter has location-, age-, and individual-specific components. Total pre-tax income, y^{tot}, is comprised of labor income and financial income. Financial income is the sum of interest income on bonds and a share of firm profits π_t, defined below. Net tax (taxes owed minus government transfers received) as a function of total pre-tax income is given by the function $T(y_t^{tot})$. It captures all insurance provided through the tax code. Additionally, a Social Security tax τ^{SS} is applied to labor income. Next period's financial wealth x_{t+1} consists of savings b_{t+1} plus any accidental bequests $\widehat{b}_{t+1}$. Housing demand and labor supply choices are subject to minimum constraints discussed above. In addition to a time cost, residents of zone 2 face a financial cost of commuting ϕ_F^ℓ.

In the outside location, the problem of a market renter is the same, with value function V_R^* and last term $\mathbb{E}_t\left[V^*(x_{t+1}, z_{t+1}, a+1)\right]$.

RS Renter Problem In the gateway MSA, a renter household in the RS system in location ℓ chooses non-durable consumption c_t, housing consumption h_t, and working hours

n_t to solve:

$$
\begin{aligned}
&V_{RS,\ell}(x_t, z_t, a, d_t) = \max_{c_t, h_t, n_t, b_{t+1}} U(c_t, h_t, n_t, \ell_t) + (1-p^a)\beta \mathbb{E}_t[V(x_{t+1}, z_{t+1}, a+1, \ell)] \\
&\text{s.t.} \\
&c_t + \kappa_1(d_t) R_t^\ell h_t + Q b_{t+1} + \phi_{F,t}^\ell = \left(1-\tau^{SS}\right) y_t^{lab} + \overline{\Psi}_t \psi^z + \pi_t + x_t - T\left(y_t^{tot}\right), \\
&x_{t+1} = b_{t+1} + \widehat{b}_{t+1} \geq 0, \\
&y_t^{lab} \leq \kappa_2 \overline{Y}_t \text{ if } d_t = 0, \\
&h_t \leq \kappa_3^\ell, \\
&\text{and equations (1), (2), (3), (4).}
\end{aligned}
$$

The per square foot rent of a RS unit is a fraction $\kappa_1(d_t)$ of the market rent R_t^ℓ, which depends on length of tenancy. In versions of the model where RS has income qualification, labor income must not exceed a fraction κ_2 of area median income (AMI), $\overline{Y}_t = Median[y_t^{lab,i}]$, the median across all residents in the MSA. There is no income qualification requirement in the benchmark model ($\kappa_2 = \infty$). The last inequality imposes that the maximum size for a RS unit must not exceed a threshold κ_3^ℓ. Length of tenancy in the RS system is updated through the state variable d_{t+1}.

Owner's Problem In the gateway MSA, an owner in location ℓ chooses non-durable consumption c_t, housing consumption h_t, working hours n_t, and investment property $\widehat{h}_t$ to solve:

$$
\begin{aligned}
&V_{O,\ell}(x_t, z_t, a, d_t) = \max_{c_t, h_t, \widehat{h}_t, n_t, b_{t+1}} U(c_t, h_t, n_t, \ell_t, a) + (1-p^a)\beta E_t[V(x_{t+1}, z_{t+1}, a+1, 0)] \\
&\text{s.t.} \\
&c_t + P_t^\ell h_t + Q b_{t+1} + \kappa_4^\ell P_t^\ell \widehat{h}_t + \phi_{F,t}^\ell = \left(1-\tau^{SS}\right) y_t^{lab} + \overline{\Psi}_t \psi^z + \pi_t + x_t + \kappa_4^\ell R_t^\ell \widehat{h}_t - T\left(y_t^{tot}\right), \\
&x_{t+1} = b_{t+1} + \widehat{b}_{t+1} + P_{t+1}^\ell h_t (1 - \delta^\ell - \tau^{P,\ell}) + \kappa_4^\ell P_{t+1}^\ell \widehat{h}_t (1 - \delta^\ell - \tau^{P,\ell}), \\
&-Q_t b_{t+1} \leq P_t^\ell \theta \left(h_t + \kappa_4^\ell \widehat{h}_t\right) - \kappa_4^\ell R_t^\ell \widehat{h}_t - (y_t^{tot} - c_t), \\
&\widehat{h}_t \geq 0, \\
&\kappa_4^\ell = 1 - \eta^\ell + \eta^\ell \overline{\kappa_1}^\ell, \\
&\text{and equations (1), (2), (3), (4).}
\end{aligned}
$$

Local home owners are the landlords to the local renters. This is a departure from the typical assumption of absentee landlords in urban economics.[11] Our landlords are risk-

[11]The majority of rentals in the urban core are multi-family units owned by local owner-operators. For example, According to 2015 Real Capital Analytics data, 81% of the Manhattan multifamily housing stock is owned by owner-operator-developers which tend to be overwhelmingly local. Non-financial firms, some of which are also local, own 3%. The remaining 16% is owned by financial firms, private equity funds, or

averse households inside the model. For simplicity, we assume that renters cannot buy investment property and that owners can only buy investment property in the zone of their primary residence. Landlords earn rental income $\kappa_4^\ell R_t^\ell \widehat{h}_t$ on their investment units $\widehat{h}_t$. Per the affordable housing mandate, investment property is a bundle of η^ℓ square feet of RS units and $1-\eta^\ell$ square feet of free-market units. The effective rent earned per square foot of investment property is $\kappa_4^\ell R_t^\ell$. It depends on the RS discount $\overline{\kappa_1}^\ell$, which depends on both the discount by tenancy $\kappa_1(d)$ and the fraction of RS renters at each tenancy in zone ℓ. Since the average rent is a multiple $\kappa_4 \leq 1$ of the market rent, the average price of rental property must be the same multiple of the market price, $\kappa_4^\ell P_t^\ell$. Because prices and rents scale by the same constant, the return on investing in rental property is the same as that on owner-occupied housing. As a result, landlords are not directly affected by RS regulation. However, the lower average price for rental property ($\kappa_4 < 1$) has important effects on housing supply/development, as discussed below.

The physical rate of depreciation for housing units is δ^ℓ. The term $P^\ell h \delta^\ell$ is a financial costs, i.e., a maintenance cost. As shown in equation (A.3) below, the physical depreciation can be offset by residential investment undertaken by the construction sector.[12]

Property taxes on the housing owned in period t are paid in year $t+1$; the tax rate is $\tau^{P,\ell}$. Property tax revenue finances local government spending which does not confer utility to the households.[13]

Housing serves as a collateral asset for debt. For simplicity, mortgages are negative short-term safe assets. In practice, mortgage rates are higher than bond rates but mortgage interest is also tax deducible. We assume these two effects cancel out. Households can borrow a fraction θ of the market value of their housing.[14] We exclude current-period rental income and savings from the pledgable collateral. In light of the fact that one period is four years in the calibration, we do not want to include four years worth of (future) rental income and savings for fear of making the borrowing constraint too loose.[15]

publicly listed REITs, with at least some local investors. The majority of rentals outside the urban core are single-family rentals. About 99% of those are owned by small, local owners. A substantial minority are multi-family units, with again a non-trivial local ownership share.

[12]The model can accommodate a higher rate of depreciation for renter-occupied properties, possibly to reflect the higher rate of depreciation for RS housing units. We are not aware of empirical evidence that shows that RS housing results have higher depreciation rates than market rental units. In contrast, rent controlled and public housing units are often associated with severe under-maintenance. Nevertheless, as a robustness check, Appendix F considers an exercise where RS housing depreciates at a higher rate.

[13]This is equivalent to a model where public goods enter in the utility function, but in a separable way from private consumption. A model where the public good enters non-separably in the utility function would require taking a stance on the elasticity of substitution between private and public consumption.

[14]It is easy to introduce a different LTV ratio for primary residences and investment property. The empirically relevant case is $\theta_{res} \geq \theta_{inv}$. We abstract from this for simplicity.

[15]This assumptions helps the model match the home ownership rate. However, the affordable housing

For the outside location, the ownership problem is the same. We denote the value function V_O^*, and the last term on the right-hand side of the Bellman equation is
$E_t\left[V^*(x_{t+1}, z_{t+1}, a+1)\right]$.

3.2 Firms

Goods Producers There are a large number n_f of identical, competitive firms located in the urban core (zone 1), all of which produce the numéraire consumption good.[16] This good is traded nationally; its price is unaffected by events in the city and normalized to 1. The firms have decreasing returns to scale and choose efficiency units of labor to maximize profit each period:

$$\Pi_{c,t} = \max_{N_{c,t}} N_{c,t}^{\rho_c} - W_t N_{c,t} \tag{5}$$

Developers and Affordable Housing Mandate In each location ℓ there is a large number n_f of identical, competitive construction firms (developers) which produce new housing units and sell them locally. All developers are headquartered in the urban core, regardless of where their construction activity takes place.

The cost of the affordable housing mandate is born by developers. Affordable housing regulation stipulates that for every $1-\eta^\ell$ square feet of market rental units built in zone ℓ, η^ℓ square feet of RS units must be built. Developers receive an average price per square foot for rental property of $\kappa_4^\ell P_t^\ell$, while they receive a price per square foot of P_t^ℓ for owner-occupied units.[17] Given a home ownership rate in zone ℓ of ho_t^ℓ, developers receive an average price per square foot $\overline{P}_t^\ell$:

$$\overline{P}_t^\ell = \left(ho_t^\ell + (1-ho_t^\ell)\kappa_4^\ell\right) P_t^\ell. \tag{6}$$

The cost of construction of owner-occupied and rental property in a given location is the same. After completion of construction but prior to sale, some of the newly constructed housing units are designated as rental units and the remainder as ownership units. The renter-occupancy designation triggers affordable housing regulation. It results in a lower

policies would have similar effects without it.

[16]We assume that the number of firms is proportional to the number of households in each MSA when solving the model. With this assumption, our numerical solution is invariant to the total number of households in the economy. Due to decreasing return to scale, the numerical solution would depend on the number of households otherwise.

[17]Recall that $\kappa_4^\ell = 1-\eta^\ell+\eta^\ell\overline{\kappa_1}^\ell$, where $\overline{\kappa_1}^\ell = \sum_d \omega^\ell(d)\kappa_1^\ell(d)$ and $\omega^\ell(d)$ is the share of RS square feet in a zone that goes to RS tenants in that zone with tenure d, such that $\sum_d \omega^\ell(d) = 1$.

rent and price than for owner-occupied units. Developers would like to sell ownership units rather than rental units, but the home ownership rate is determined in equilibrium. Developers are price takers in the market for space, and face an average sale price of $\overline{P}_t^\ell$. A special case of the model is the case without rent stabilization: $\kappa_4^\ell = 1$ either because $\eta^\ell = 0$ or $\kappa_1 = 1$. In that case, $\overline{P}_t^\ell = P_t^\ell$. Without RS, the higher sale price for housing increases incentives to develop more housing.

Zoning Given the existing housing stock in location ℓ, H_{t-1}^ℓ, and average sale price of $\overline{P}_t^\ell$, construction firms have decreasing returns to scale and choose labor to maximize profit each period:

$$\Pi_{h,t}^\ell = \max_{N_{\ell,t}} \overline{P}_t^\ell \left(1 - \frac{H_{t-1}^\ell}{\overline{H^\ell}}\right) N_{\ell,t}^{\rho_h} - W_t N_{\ell,t} \tag{7}$$

The production function of housing has two nonlinearities. First, as for consumption good firms, there are decreasing returns to scale because $\rho_h < 1$.

Second, construction is limited by zoning laws and space constraints. The maximal amount of square footage zoned for residential use in zone ℓ is given by $\overline{H^\ell}$. We interpret $\overline{H^\ell}$ as the total land area available for residential use multiplied by the maximum possible number of floors that could be built on this land. This term captures the idea that, the more housing is already built in a zone, the more expensive it is to build additional housing. For example, additional construction may have to take the form of taller structures, buildings on less suitable terrain, or irregular infill lots. Therefore, producing twice as much housing requires more than twice as much labor. Laxer zoning policy, modeled as a larger $\overline{H^\ell}$, makes development cheaper, and all else equal, will expand the supply of housing.

When $\overline{H^\ell}$ is sufficiently high, the model's solution becomes independent of $\overline{H^\ell}$, and the supply of housing is governed solely by ρ_h. When $\overline{H^\ell}$ is sufficiently low, the housing supply elasticity depends on both $\overline{H^\ell}$ and ρ_h.[18]

Profits Per capita profits from tradeable and construction sectors are:

$$\Pi_t = \Pi_{c,t} + \Pi_{h,t}^1 + \Pi_{h,t}^2.$$

These profits represent a competitive compensation to capital and pure profit. Equivalently, the production function in both sectors contains a term K^{ρ_k}, with K is normalized

[18] In this sense, the model captures that construction firms must pay more for land when land is scarce or difficult to build on due to regulatory constraints. This scarcity is reflected in equilibrium house prices.

to 1. Aggregate profit is $((1-\rho_c-\rho_k)/(1-\rho_c))\,\Pi_t$. We assume that these profits go to local residents; the π_t term in the household budget constraint. Profits received depend on household age and productivity.

3.3 Equilibrium

Given parameters, a competitive equilibrium is a price vector $(W_t, P_t^\ell, R_t^\ell)$ and an allocation, namely aggregate residential demand by market renters $H_t^{R,\ell}$, RS renters $H_t^{RS,\ell}$, and owners $H_t^{O,\ell}$, aggregate investment demand by owners $\widehat{H}_t^\ell$, aggregate housing supply, aggregate labor demand by goods and housing producing firms $(N_{c,t}, N_{\ell,t})$, and aggregate labor supply N_t in each MSA, as well as a population share in each MSA, such that households and firms optimize and markets clear in each MSA.[19] Appendix A details the equilibrium conditions.

3.4 Welfare Effects of Affordability Policies

We compute the welfare effect of an affordability policy using the following procedure. Denote agent i's value function under benchmark policy θ_b as $V_{i,t}(x(b), z, a, S(b); \theta_b)$. Consider an alternative policy θ_c, which goes into effect in the gateway MSA in period $t+1$, with value function $V_{i,t+1}(x(c), z, a, S(c); \theta_c)$. Prices and hence asset valuations and wealth may be different under this new policy, hence the dependence of x and S on the policy. Because of endogenous migration, the set of households that is present in the gateway MSA before (at t) and after the reform (at $t+1$) may be different. Our main welfare measure averages over a fixed group of households that were present in the gateway MSA prior to the reform, the set g_t with cardinality G, and tracks them at time $t+1$ regardless of their mobility decisions. Finally, we express the welfare change in consumption equivalent units rather than utils. To summarize, our main welfare measure is:

$$\mathcal{W}_g = \left(\frac{\frac{1}{G}\sum_{i\in g_t} V_{i,t+1}(x(c), z, a, S(c); \theta_c)}{\frac{1}{G}\sum_{i\in g_t} V_{i,t}(x(b), z, a, S(b); \theta_b)} \right)^{\frac{1}{(1-\gamma)(1-\alpha n)}} - 1. \tag{8}$$

This welfare criterion is utilitarian in that it weighs each household in the group equally. But because of the curvature of the value function, lower-income households implicitly receive a larger weight. We also use (8) to compute welfare for subgroups of g_t, for example by labor productivity type, by income quartile, or net worth quartile. This welfare

[19]There is one price and allocation vector for each MSA, e.g., W_t for the gateway MSA and W_t^* for the outside MSA, etc. To ease notational burden we did not separately list all the variables for the outside MSA.

change is calculated in the first period after the reform, the first period of the transition towards a new steady state. Of course, the value function is forward-looking and incorporates the expected risk-adjusted present discounted values, but state variables have not settled down to their new steady state levels yet.[20]

4 Calibration

We calibrate the model to match important features of the New York MSA. The outside MSA is calibrated to the average of the 75 largest U.S. MSAs except for New York. Data sources are described in Appendix B. Appendix Table A.3 summarizes the chosen model parameters. The parameters are the same in the two MSAs unless explicitly mentioned. Some parameters are set exogenously, while others are chosen to match a moment in the data.[21]

Geography The New York MSA consists of 25 counties located in New York (12), New Jersey (12), and Pennsylvania (1). We assume that Manhattan (New York County) represents zone 1 and the other 24 counties make up zone 2. The zones differ in size, measured by the maximum buildable residential square footage permitted by existing zoning rules, $\overline{H^\ell}$. Appendix B describes detailed calculations on the relative size of Manhattan and the rest of the metro area, which imply that $\overline{H^1} = 0.0238 \times \overline{H^2}$. We then choose $\overline{H^2}$ such that the ratio of households living in zone 1 to households living in zone 2 is 12%, the fraction observed in the NY data. Since the model has no vacancy, we equate the number of NY households in the model with the number of occupied housing units in the NY data.

In the outside MSA, $\overline{H^*}$ is chosen to match the average population-weighted housing supply elasticity of 1.55 among the largest 75 U.S. MSAs outside the New York MSA using data from Saiz (2010).

Production and Construction We assume that the return to scale $\rho_c = 0.66$. This value implies a labor share of 66% of output, consistent with the data. For the housing sector, we also set $\rho_h = 0.66$ in order to match the housing supply elasticity, given the other parameters. The long-run housing supply elasticity in the model is derived in Appendix C.3. Saiz (2010) reports a housing supply elasticity for the New York metro area of 0.76.

[20] For the no-migration model in Appendix E, we also report a welfare measure that uses the steady-state value function under the alternative policy, $V_{i,\infty}(x(c), z, a, S(c); \theta_c)$.

[21] As in Andrews, Gentzkow, and Shapiro (2017), one parameter affects multiple moments but often has a disproportionate effect on one moment. With that caveat, we associate parameters with individual moments.

The model delivers 0.69. The housing supply elasticity is much lower in zone 1 (0.08) than in zone 2 (0.71), because in zone 1 the housing stock is much closer to $\overline{H}$ (12% from the constraint) than in zone 2 (70% from the constraint). Since the housing stock of the metro area is concentrated in zone 2, the city-wide elasticity is dominated by that in zone 2.

Demographics The model is calibrated so that one model period is equivalent to 4 years. Households enter the model at age 21, work until age 64, and retire with a pension at age 65. Survival probabilities p^a are calibrated to mortality data from the Census Bureau.

Labor Income Pre-tax labor income for household i of age a is $y_t^{lab} = W_t n_t^i G^a \mathcal{A}^\ell z_t^i$. The choice of hours n_t^i is subject to a minimum hours constraint, which is set to 0.5 times average hours worked.[22] Efficiency units of labor $\mathcal{A}^\ell G^a z_t^i$ consist of a deterministic component that depends on the location of the household ($\mathcal{A}^\ell$), a deterministic component that depends on age (G^a), and a stochastic component z^i that captures idiosyncratic income risk. The G^a function is chosen to match the mean of labor earnings by age. We use data from ten waves of the Survey of Consumer Finances (1983-2010) to estimate G^a.

The agglomeration parameter that governs the extra productivity a household derives from living in the urban core $\mathcal{A}^1 = 1.09757 > \mathcal{A}^2 = 1$ is chosen to match the 1.66 ratio of average income in zone 1 to zone 2 in NY.[23] Since the outside region has only one zone, it does not have this parameter.

The idiosyncratic productivity process z is chosen to match earnings inequality and persistence in household earnings. We discretize z as a 4-state Markov chain. Appendix C.1 explains how we choose the productivity grid points and the transition probabilities between states. In a nutshell, the model matches the pre-tax household income distribution for the NY metro and the outside metro. Income comes from the IPUMS Census data set. The model also matches the persistence of labor income of 0.9, how the variance of earnings rises with age in the SCF, and the observed correlation between income and wealth in the SCF. The first productivity bin contains the lowest 25%-productivity households. The second productivity level contains the middle 50% of households. Bin 3 is the next 12.5%, and bin 4 contains the 12.5% most productive households. The income calibration is an iterative process since both labor supply and MSA location are endogenous

[22] This constraint rules out a choice of a positive but very small number of hours, which we do not see in the data given the indivisibility of jobs. It also rules out unemployment since our earnings data are for the (part-time and full-time) employed. This constraint binds for only 11.15% of workers in equilibrium.

[23] While this is not a traditional agglomeration effect in the sense that a higher population in the urban core changes the productivity of all households living in the urban core, it nevertheless captures that population changes–caused by policy reform–affect the overall output of the city and the aggregate economy. Further enriching the agglomeration effects in the model is a fruitful direction for future research.

choices that depend on all other parameters and features of the model.

Taxation Since our model is an incomplete markets model, housing affordability policies can act as an insurance device and help to "complete the market." Therefore, a realistic calibration of the redistribution provided through the tax code is important. We follow Heathcote, Storesletten, and Violante (2017) and choose an income tax schedule that captures the observed progressivity of the U.S. tax code in a parsimonious way. Net taxes are given by the function $T(\cdot)$:

$$T(y^{tot}) = y^{tot} - \lambda(y^{tot})^{1-\tau}$$

The parameter τ governs the progressivity of the tax and transfer system. We set $\tau = 0.17$ to match the average income-weighted marginal tax rate of 34% for the U.S. It is close to the value of 0.18 estimated by Heathcote et al. (2017). We set λ to match federal, state, and local government spending to aggregate income, which ranges between 15-20%.[24] This delivers $\lambda = 0.75$. Appendix C.2 shows the resulting tax rate and after-tax income as a function of before-tax income. This tax-and-transfer system includes a baseline level of government transfer spending on housing vouchers.

Retirement Income Social Security taxes are proportional to labor earnings and set to $\tau^{SS} = 0.10$, a realistic value. Retirement income is increasing in the household's last productivity level prior to retirement, but is capped for higher income levels. We use actual Social Security rules to estimate each productivity group's pension relative to the average pension. The resulting pension income states are $\psi^z = [0.44, 1.25, 1.51, 1.51]$, where z reflects the last productivity level prior to retirement. They are multiplied by average retirement income $\overline{\Psi}$, which is endogenously determined in equation (A.5) to balance the social security budget. Average retirement income $\overline{\Psi}$ is \$33,189, which corresponds to 27% of average earnings.

Commuting Cost We choose the time cost to match the time spent commuting for the average New York metro area resident. This time cost is the average of all commutes, including those within Manhattan. We normalize commuting time for zone 1 residents to zero: $\phi_T^2 > \phi_T^1 = 0$. For ϕ_T^2, we target the additional commuting time of zone 2 residents. The additional commuting time amounts to 25 minutes per trip for 10 commuting trips

[24] For example, depending on what share of NY state and NJ state spending goes to the NY metro area, we get a different number in this range.

per week.[25] The 4.2 hours represent 3.7% of the 112 hours of weekly non-sleeping time. Hence, we set $\phi_T^2 = 0.037$. As we did for the time cost, we normalize the financial cost of commuting for residents of zone 1 to zero: $\phi_F^1 = 0$. The financial cost of commuting ϕ_F^2 is set to 1.8% of average labor earnings, or $2213 per household per year. This is a reasonable estimate for the commuting cost in excess of the commuting cost within Manhattan.[26] We assume that retirees have time and financial commuting costs that are 1/3 of those of workers. This captures that retirees make fewer trips, travel at off-peak hours, and receive transportation discounts.

Preferences The functional form for the utility function is given in equation (1). We set risk aversion $\gamma = 5$, a standard value in the macro-finance literature.

The observed average workweek is 42.8 hours or 38.2% of available non-sleeping time. Since there are 1.64 workers on average per household, household time spent working is 38.2%× 1.64/2=31.3%. We set α_n to match household time spent working. The model generates 29.3% of time worked.

We set the labor supply elasticity parameter $\eta = 1$. This generates an (endogenous) average Frisch elasticity of 1.08 when estimated from macro and 1.42 when estimated from micro data.[27] This is in line with estimates based on macro data and on the intensive margin of labor supply in micro data. This is an important object because the misallocation coming from workers' persistent location and labor supply decisions depends on how sensitive labor supply is to wage changes.

We set α_h in order to match the ratio of average market rent to metro-wide average income. The model generates 23.9%. This value is close to the 24% value calculated from decennial Census data for a cross-section of MSAs by Davis and Ortalo-Magne (2011).

We set the intratemporal elasticity of substitution between housing and non-housing consumption equal to 2/3 ($\epsilon = -0.5$), a value in the middle of the (wide) range of estimates in the literature.

We set $\beta^H = 1.204$ (1.047 per year) and $\beta^L = 0.925$ (0.981 per year). A 25% share

[25]The 25 minute additional commute results from a 15 minute commute within Manhattan and a 40 minute commute from zone 2 to zone 1. With 10.5% of the population living in Manhattan, the average commuting time is 37.4 minutes per trip or 6.2 hours a week. This is exactly the observed average for the New York metro from Census data.

[26]In NYC, an unlimited subway pass costs around $1,400 per year per person. Rail passes from the suburbs cost around $2400 per year per person, depending on the railway station of departure. If zone 1 residents need a subway pass while zone 2 residents need a rail pass, the cost difference is about $1000 per person. With 1.64 workers per household, the cost difference is $1640 per household. The cost of commuting by car is at least as high as the cost of rail once the costs of owning, insuring, parking, and fueling the car and tolls for roads, bridges, and tunnels are factored in.

[27]The [25%,75%] of the distribution of Frisch elasticities across agents is [0.86,1.92] in the model.

of agents has β^H, the rest has β^L. This delivers an average β of 0.99,[28] chosen to match the average wealth-income ratio which is 5.69 in the 1998-2010 SCF data. The model generates 6.00. The dispersion in betas delivers a wealth Gini coefficient of 0.74, close to the observed wealth Gini coefficient of 0.80 for the U.S.

Three parameters govern the amenity value of housing in (4). The taste-shifter for NY relative to the outside MSA, $\chi^{NY} = 1.0335$, is chosen to keep the ratio of net worth to average earnings equal between the NY metro and the outside metro. Living in Manhattan relative to the rest of the NY metro gives a utility boost $\chi^1 = 1.036$, chosen to match the 2.78 ratio of rents in zone 1 to zone 2 in the NY metro. Being a retiree in Manhattan gives an additional utility boost of $\chi^R = 1.071$, chosen to match the 0.91 ratio of retirees in zone 1 to zone 2 in the NY MSA. Retirees have lower time and financial costs of commuting, giving them a comparative advantage to living in zone 2. A retiree preference for living in Manhattan is needed to offset the commuting effect.

Housing The price of the one-period (4-year) bond $Q = 0.89$ targets the average house price to rent ratio for the New York MSA, which is 17.79. The model delivers 16.75. Under the logic of the user cost model, the price-to-rent ratio depends on the interest rate, the depreciation rate, and the property tax rate.

The property tax rate in Manhattan is $\tau^{P,1} = 0.029$ or 0.73% per year, and that in zone 2 is $\tau^{P,2} = 0.053$ or 1.33% per year. The property tax rate in the outside MSA $\tau^{P,*}$ is 1.60% per year. These match the observed tax rates averaged over 2007-2011 according to the Brookings Institution.[29]

The housing depreciation rate in Manhattan is $\delta^1 = 0.058$ or 1.45% per year, and that in zone 2 is $\delta^2 = 0.096$ or 2.41% per year. This delivers a metro-wide average depreciation rate of 2.39% per year. For the outside MSA, we set depreciation to 2.45%, equal to the average depreciation rate for privately-held residential property in the BEA Fixed Asset tables for the period 1972-2016. The annual depreciation wedge of 1.0% between NY zones 1 and 2 is chosen to match the relative fraction of buildings that were built before 1939.[30]

Given its higher property tax and depreciation rates, the outside metro has a lower

[28]Note that because of mortality, the effective time discount factor is $(1 - p(a))\beta$.

[29]The zone-2 property tax rate is computed as the weighted average across the 24 counties, weighted by the number of housing units. The outside property tax rate is computed as the population-weighted average of the property tax rates of the largest 74 MSAs outside NY using the same data source.

[30]Data from the 5-year American Community Survey from 2017 give the distribution of housing units by year built for each of the 25 counties in the New York MSA. In Manhattan, 42.8% of units are built before 1939. The housing-weighted average among the 24 counties of zone 2 is 26.6%. Assuming geometric depreciation, matching this fraction requires a 1.0% per year depreciation wedge.

price-rent ratio of 15.7.

We set the maximum loan-to-value ratio (LTV) at $\theta_{res} = 0.9$, implying a 10% down payment requirement. The observed mean combined LTV ratio at origination for U.S. mortgages in the U.S. is 87.3% as of October 2016 according to the Urban Institute and has consistently been above 80% since the start of the data in 2001.

Finally, we impose a minimum housing size of 506 square feet. This is 31% of the average housing unit size of 1644 square feet in NY and 26% of the average house size of the 1980 square feet in the outside MSA. This is a realistic value for New York given the model is solved at the household level (with 1.64 members on average). While the average NY house size is a normalization constant, set to match the data, the outside MSA house size is endogenously determined as is the house size distribution in NY. More on the model's house size implications below.

Affordable Housing Rent regulation plays a major role in the New York housing market, as discussed above. In this paper, we focus on rent stabilization which is by far the most prevalent affordable housing program in New York. We find that 37.3% of zone-1 households and 12.0% of zone-2 households live in RS units. Appendix B.4 contains a detailed description of data and definitions. We set the share of *square feet* of *rental* housing devoted to RS units, $\eta^1 = 56.37\%$ and $\eta^2 = 29.72\%$, to match the share of *households* in the *entire* population that are in RS units in each zone. This fraction is endogenous since housing size and ownership are choice variables.

We find that the rent discount on RS units depends strongly on tenure. The average discount is 7% for households who have lived in the unit for four years or less, and grows to 45% for tenure of 12 years or longer. The growing discount reflects smaller annual rent increases on RS than on market rental units, which cumulate as long as households remain in their RS unit. We use the observed discount-tenure schedules, computed in Appendix B.4, in the calibration of $\kappa_1(d)$.

RS housing units are available to anyone; there is no income qualification ($\kappa_2 = \infty$). We assume that households who were in RS in the previous period have a probability of 83.4% to qualify for RS in the same zone this period. The value is chosen to match the fraction of RS tenants who have lived in a RS unit for 20 years or more. That number in the data is 23.1%.[31] It is 26.1% in the model.

The maximum RS size κ_3^{ℓ} is set such that the average size of market and RS rentals is equal in that zone.

[31] See Table H of the NYU Furman Institutes' 2014 "Profile of Rent-Stabilized Units and Tenants in NYC."

Moving Costs To compute migration rates, we sort households in each of six age groups into four income groups (bottom 25%, middle 50%, next 12.5%, top 12.5%) and compute the out- and in-migration rates for each group. The migration data are described in Appendix B.5. While migration decisions are endogenous and depend on the full structure of the model, moving costs are crucial to hit the migration targets. The moving cost functions $m(a,z)$ for moving out of New York takes the following form:

$$m(a,z) = m_0 + m_1(a) + m_2(z) + \sigma^m u; \quad u \sim \mathcal{U}(0,1).$$

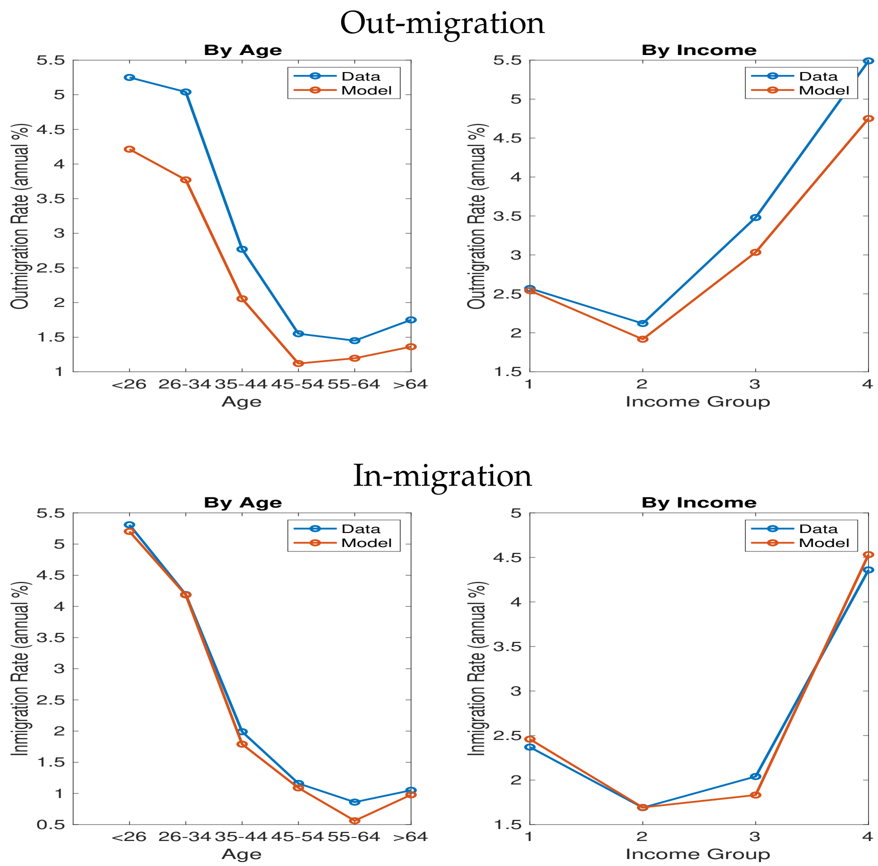
The coefficient m_0 is chosen to match the average of the out-migration and in-migration rates of 2.5%. The coefficients $m_1(a)$ and $m_2(z)$ are chosen to best match the out-migration profile by age-by-income groups. The volatility parameter governs the sensitivity of the moving rate to the moving shock u. This parameter helps the model to better fit the rent/income ratio in New York. The functional form for the moving cost function $m^*(a,z)$ for moving into New York is the same, but the parameters are chosen to match the in-migration rates instead.[32] The parameter σ^m is restricted to be the same in the in-migration as for out-migration moving cost function. Figure 1 shows that the model closely matches the migration rates out of (top panel) and into (bottom panel) the New York MSA by age and income. Migration is declining in age and U-shaped in income. Among those 65 and older, out-migration exceeds in-migration.

Profit Share Two-thirds of output in the data goes to labor, 27% to investment, and 7% goes to profits. Firms in the model also make profits. Since the model has no capital, we scale these profits so that they represent 7% of output in the model. These profits are distributed to local residents according to a profit distribution that depends on age and income. The latter is calibrated to how the share of private business income to total household income in the Survey of Consumer Finances depends on age and income.[33]

[32]Since the model is stationary, the average out- and in-migration rates must be the same. Therefore, we set m_0 to the average of these two numbers. The constant m_0^* is chosen to keep the population of the NY metro at an arbitrary constant of 2000. This helps make the model comparable to a model without migration with 2000 agents in New York. Note that when we conduct policy experiments, we do not recalibrate this parameter. Thus, the population of NY can rise or fall relative to the 2000 number in the baseline model.

[33]The business income shares from the SCF by age and income are rescaled such that, given the population distribution in the simulation of the model, total profit redistributed is equal to total profit generated. The redistribution differs slightly between NY and Outside because the age-income distribution is slightly different, and therefore also the normalization constant.

Figure 1: Inter-MSA Migration Rates by Age and Income



Note: The top panel reports annual out-migration rates out of New York into the Outside MSA. The bottom panel plots in-migration rates into the New York MSA from Outside. Migration in the data is computed based on IRS tax returns from New York State.

5 Baseline Model Results

We start by discussing the implications of the baseline model for the spatial distribution of population, housing, income, and wealth. We also discuss house prices and rents for the city as a whole and for the two zones. Then we look at the model's implications for income, wealth, and home ownership over the life-cycle. Table 1 shows some key moments; moments in boldface are not directly targeted by the calibration.

5.1 Demographics, Income, and Wealth

Demographics The first three rows of Table 1 show that the model matches basic demographic moments. In the model, we get 19.5%. The average NY resident above age 21 is 47.6 years old in the data and 46.5 years old in the model. In both model and data, zone 1 skews younger than zone 2. People age 65 and over comprise 19.1% of the NY population age 21 and over in the data; in the model this share is 19.9%. Migration decisions and mortality rates combine to produce these results.

Table 1: New York Metro Data Targets and Model Fit

		Data		Model	
		metro	**ratio zone 1/zone 2**	**metro**	**ratio zone 1/zone 2**
1	Households (thousands)	7124.9	0.12	7124.9	0.12
2	Avg. hh age, cond. age > 20	47.6	0.95	**46.5**	**0.86**
3	People over 65 as % over 20	19.1	0.91	**19.5**	0.90
4	Avg. house size (sqft)	1644	0.59	1644	**0.63**
5	Avg. pre-tax lab income ($)	124091	1.66	124165	1.69
6	Home ownership rate (%)	51.5	0.42	**58.4**	**0.57**
7	Median mkt price per unit ($)	510051	3.11	**496649**	**2.25**
8	Median mkt price per sqft ($)	353	5.24	**280**	**3.55**
9	Median mkt rent per unit (monthly $)	2390	1.65	**2471**	**1.76**
10	Median mkt rent per sqft (monthly $)	1.65	2.78	**1.39**	2.77
11	Median mkt price/median mkt rent (annual)	17.79	1.89	16.75	**1.28**
12	Mkt price/avg. income (annual)	3.99	1.86	**4.00**	**1.33**
13	Avg. rent/avg. income (%)	24.0	1.00	23.9	**1.04**
14	Avg. rent/income ratio for renters (%)	42.1	0.81	**33.9**	**1.21**
15	Rent burdened (%)	53.9	0.79	**54.7**	**1.32**
16	% RS of all housing units	14.63	3.11	14.20	3.28

Note: Columns 2-3 report the values for the data of the variables listed in the first column. Data sources and construction are described in detail in Appendix B. Column 3 reports the ratio of the zone 1 value to the zone 2 value in the data. Columns 4 and 5 are the corresponding moments in the model. Moments in boldface are not directly targeted by the calibration.

Mobility Within the New York MSA The model implies realistic moving rates from zone 1 to zone 2 and vice versa in the New York MSA, even though there are no moving costs within the MSA. Intra-MSA mobility rates are not targeted by the calibration. The model produces the highest mobility rates, around 4% per year, for the young (ages 21–36); see Appendix Figure A.4. The overall mobility rate across neighborhoods in the model is about 2% annually. These intra-MSA mobility rates are consistent with the 2.1% county-to-county migration rates in the New York MSA described in Appendix B.5. Given the attractive rents, the model generates lower mobility rates for RS tenants at all ages. The same is true in the data.

Housing Units In the data, the typical housing unit is much smaller in Manhattan than in the rest of the metro area. We back out the typical house size (in square feet) in each county as the ratio of the median house value and the median house value per square foot, using 2015 year-end values from Zillow. We obtain an average housing unit size of 1,021 sf in Manhattan and 1,718 sf in zone 2; their ratio is 0.59. In the model, households freely choose their housing size subject to a minimum house size constraint. The model generates a similar ratio of house size in zone 1 to zone 2 of 0.63. Appendix Figure A.5 confirms that the distribution of house sizes in the model is a good fit for the data, even though these moments are not targeted by the calibration. The size distribution of owner-occupied housing is shifted to the right from the size distribution of renter-occupied housing units in both model and data. The average house size in the outside MSA is 27% larger than in the NY MSA in the model, or 2089 versus 1644 square feet.

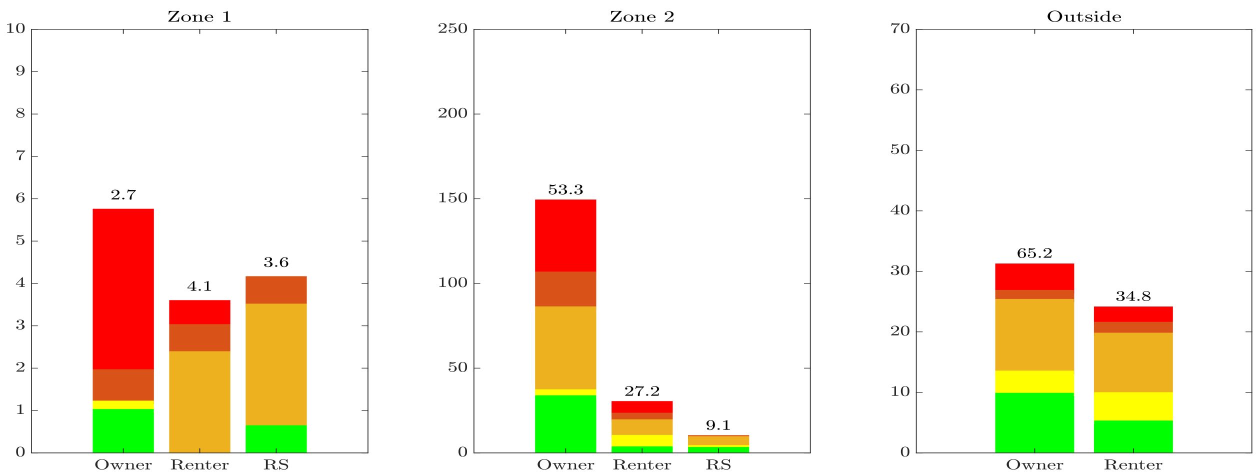
Income Average income in the NY MSA and the ratio of income in zone 1 to zone 2 are matched by virtue of the calibration (row 5 of Table 1). The model also matches the ratio of average income in the New York MSA to the Outside MSA of 1.26. It is informative to explore the underlying sorting by productivity type. Zone 1 contains workers that are on average 44% more productive than in zone 2. Only 21.6% of working-age, top-productivity households live in zone 1.

Figure 2 plots how households with different productivity sort across space and across tenure status. The vertical axes measures the total square footage devoted to the various types of *housing* in each zone. Values reported on the top of the bars correspond to the percentage of *households* in each category. These percentages add up to 100% across the six housing categories in NY. Colors correspond to productivity levels: increasing in shade from yellow (low, $z = 1$) to red (high, $z = 4$) for working-age households, and green for retirees. The graph shows that retirees and top-productivity households consume a disproportionate share of zone-1 housing. The graph also illustrates enormous housing inequality. The bottom 25% of households by productivity (yellow) consume a small share of the housing stock.

The top panel of Figure 3 shows household labor income over the life-cycle, measured as pre-tax earnings during the working phase and as social security income in retirement. We plot average income for the bottom 25%, for the middle (25-75%), and for the top 25% of the distribution, as well as the overall average income. The model's earnings Gini of 0.54 is close to the 0.47 value in the 2015 NY metro data. Earnings inequality in New York in the model is lower within zone 1 (Gini of 0.49) than within zone 2 (Gini of 0.54).

Wealth The model makes predictions for average wealth, the distribution of wealth across households, as well as how that wealth is spatially distributed. Average wealth to average total income (y^{tot}) in New York is 6.00. Wealth inequality is high, with a wealth Gini coefficient of 0.74 in New York and 0.78 in the Outside MSA. They are close to the data by virtue of the calibration.

Figure 2: Geographic Distribution of Households by Productivity.



Note: The colors indicate productivity levels. For working-age households: red indicates a top 12.5% productivity household, brown a household in the next 12.5% of the productivity distribution, okra: a household in the middle 50% of productivity, and yellow a household in the bottom 25%. Retired households of all productivity levels are indicated by green. The vertical axes measures the total square footage devoted to the various types of *housing* in each zone. Numbers reported atop each of the six vertical bars are the percentage of *households*; they sum to 100% across the six housing status categories in zone 1 and zone 2, and they sum to 100% across the two housing status categories in the outside MSA.

The middle panel of Figure 3 shows household wealth over the life cycle for the same *income* groups as in the top panel. These moments are not targeted. The graph shows that the model generates substantial wealth accumulation as well as a large amount of wealth inequality between income groups. Wealth inequality grows with age during the working phase.

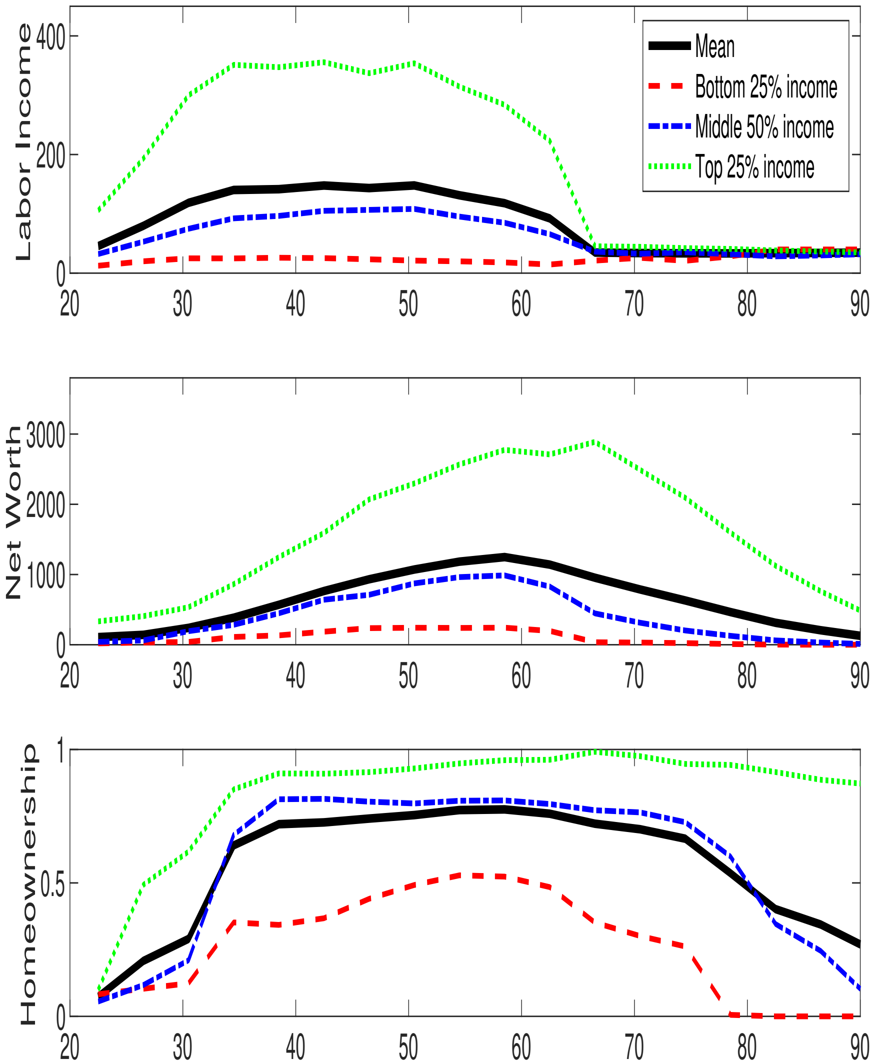
5.2 Home Ownership, House Prices, and Rents

Next, we discuss the model's predictions for home ownership, house prices, and rents. The model manages to drive a large wedge between house prices, rents, and home ownership rates between zones 1 and 2 for realistic commuting costs.

Home Ownership The model generates a home ownership rate of 58.4% in New York, fairly close to the 51.5% in the New York data. The home ownership rate in the Outside MSA is 65.2%, close to the nationwide average over the past 50 years.

The bottom panel of Figure 3 plots the home ownership rate over the life-cycle. It displays a hump-shape over the life-cycle with variation across income groups. High-income households become home owners at a younger age than low-income households, achieve a higher ownership rate, and remain home owners for longer during retirement.

Figure 3: Income, Wealth, and Home Ownership Over the Life-Cycle



Note: The figure plots the model-implied income distribution (top row), wealth distribution (middle row), and home ownership distribution (bottom row) for he New York metropolitan area. The different lines in each panel refer to the different income groups.

These patterns are broadly consistent with the data.

Row 6 of Table 1 shows that the ratio of the home ownership rate in Manhattan to zone 2 is 0.42 in the data. The model also generates a much lower home ownership rate in zone 1 than in zone 2, with a ratio of 0.56.

House Prices and Rents Table 1 shows the median price per housing unit (row 7), the median price per square foot (row 8), the median rent per unit (row 9), and the median rent per square foot (row 10).

The model closely matches the price and rent levels in the NY metro. While these moments are not directly targeted, they follow fairly directly from the calibration which targets the NY price-rent ratio and the aggregate housing expenditure share. The median house value in the NY metro area is \$510,051 in the data compared to \$496649 in the model.[34] The data indicate a monthly rent on a typical market-rate unit of \$2,390 per month in the metro area; the model predicts \$2471.

The model understates the ratio of house prices and price-rent ratios in zone 1 to zone 2, mostly because it understates the ratio of price per square foot. The price-rent ratio in the model is well approximated by the user cost formula $(1 - Q \times (1 - \delta - \tau^P))^{-1}$. Differences in the price-rent ratio between zones must arise from the wedges between depreciation and property tax rates. These wedges are too small to generate the observed gap in the price-rent ratio across zones.[35] Since the model matches the rent differences between zones well and rents are more directly linked to housing affordability, this is not a crucial miss for the model.

5.3 Housing Affordability

Price-Income and Rent-Income Row 12 of Table 1 reports the ratio of the median value of owner-occupied housing to average earnings in each zone. Average earnings are pre-tax and refer to all working-age residents in a zone, both owners and renters. The median home price to the average income is an often-used metric of housing affordability. In the NY metro data, the median owner-occupied house costs 3.99 times average income. Price-income is 6.7 in Manhattan compared to 3.6 outside Manhattan, a ratio of 1.86. The model generates a price-income ratio of 4.00 for the MSA, very close to the data. It generates a ratio across zones of 1.33, understating the ratio for the reason noted above.

Row 13 reports average rent paid by market renters divided by average income of all residents in a zone; 24% in the data. This moment was the target for the housing

[34]To ensure consistency with the empirical procedure, we calculate the median house size in each zone in the model from both owner- and renter-occupied units but excluding RS units. Call these $\bar{h}^\ell$. We form the median price per unit as the product of the market price times the typical unit size $P^\ell \bar{h}^\ell$. The market rent is $R^\ell \bar{h}^\ell$. The price-rent ratio is simply $P^\ell \bar{h}^\ell / R^\ell \bar{h}^\ell = P^\ell / R^\ell$. To form metro-wide averages, we use the number housing units in each zone as weights, just like in the data.

[35]Several factors outside of the model may help bridge the gap. First, houses in Manhattan may be less risky than in zone 2 which would increase the price-rent ratio wedge in a richer model with meaningful risk premia. Second, owner-occupied housing in Manhattan may be of higher quality than in zone 2 in ways not fully captured by the lower depreciation rate in zone 1 than in zone 2. Third, price-inelastic out-of-town investors may well be pushing up relative prices since they are disproportionately active in Manhattan (Favilukis and Van Nieuwerburgh, 2021). Fourth, the higher price of a Manhattan apartment may partly stem from its value as a shared/part-time rental via platforms such as AirBnB. Fifth allowing for a zone-specific sensitivity of the housing production function to the distance from the building limit may help.

preference parameter α^h. To get at the household-level rent burden, we compute two additional moments reported in rows 14-15 of Table 1, using PUMS-level data from the American Community Survey. The first statistic computes household-level rent to income ratio for renters with positive income, caps the ratio at 101%, and takes the average across households. For this calculation, income is earnings for working-age households and social security income for retirees. The observed average share of income spent on rent by renters is 42.1% in the metro area. The model generates an average rent-income ratio for renters of 33.9%, which is lower than in the data.[36] The second statistic computes the fraction of renters with positive income whose rent is over 30% of income. These households are known as rent-burdened. In the data, 53.9% of households are rent-burdened; in the model this fraction is 54.7%. The model generates a large "housing affordability crisis," with more than half of renters spending more than 30% of their income on rent.

Rent Stabilization By virtue of the calibration, the model generates the right share of RS households in the population in each zone (row 16 of Table 1).

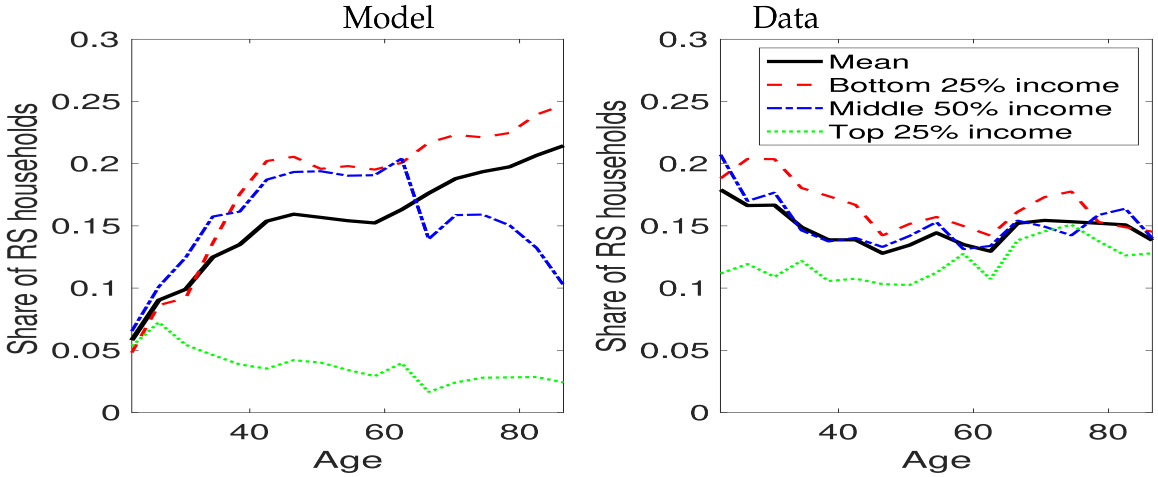
Figure 4 zooms in on the allocation of RS housing units by age and income. It plots the fraction of households that are in RS for the bottom 25%, middle 50% and top 25% of the income distribution at each age. The model is on the left, the data on the right. In both model and data, high-income households are less likely to be in RS. At young ages, both low and middle-income households are about equally likely to be in RS in both the model and the data. The difference in the RS share between high and low-income households is larger in the model than in the data. In the model, the prevalence of RS is increasing in age. In the data, it is declining at young ages and flat thereafter. In sum, there appears to be tremendous misallocation of RS housing units in the data. Even though the model offers RS housing units to households randomly and without income qualification, and matches the observed RS rent discounts as well as the persistence in RS tenancy, it still generates less misallocation than in the data. This will bias downward the model-implied welfare gain from reforms that reduce the misallocation or expand the scope of the RS mandate.[37]

Affordable housing acts as an insurance device in our incomplete markets model. We calculate the probability of getting a RS unit in the current period for a household that

[36] Within the class of homothetic preferences over housing and non-housing consumption it is difficult to generate large deviations in the housing expenditure ratio without preference heterogeneity in α_h. Nevertheless, the model generates a rent-to-income ratio for renters that is 10% points above the average rent-to-average income ratio of 24%.

[37] If the model has too many low-income and too many high-income households in RS initially relative to the data, an expansion of RS would add too few low-income households to the RS system and understate the welfare benefit. The welfare gains obtained below from these reforms are conservative.

Figure 4: Prevalence of Rent Stabilization



Note: The figure plots the share of households in rent stabilized rental housing units out of all housing units. Age is on the horizontal axis. At each age, we split households into the bottom-25% of income, the middle 50%, and the top-25%. The results for the model are plotted on the left. The results from the data are plotted on the right. Since RS status by age and income is only available from the New York City Housing and Vacancy Survey, the data only pertains to the five counties of New York City rather than to the full MSA. For the purposes of this graph only, we include rent-controlled units in the numerator of the RS share. The shares are rescaled to deliver the overall RS share in the entire MSA.

was not in a RS unit in the previous period and that suffered a negative productivity shock from the second to the first or from the third to the second productivity level. This probability measures *access to* the *insurance* that RS provides for middle- and low-income households who fall on hard times. If it is difficult for such a household to get into the RS system, then the value of that insurance is low. The access to insurance metric is 5.4% in the metro area. This breaks down into 0.3% for zone 1 and 5.2% for zone 2 RS housing. Including low-income households that already were in RS, the likelihood of getting RS housing is 16.5%.

We also define the *stability* of insurance as the probability of staying in a RS unit for a household that was in a RS unit in the previous period and that currently is in the bottom quartile of the income distribution. This probability is 79.9% in the baseline model. Risk averse households prefer a stable housing situation, i.e., low volatility of changes in the marginal utility of housing. In a complete market, households can perfectly smooth consumption and marginal utility ratios are constant over time; their volatility is zero. Our benchmark model displays severe incompleteness with volatilities of 0.60 for both the marginal utility growth of non-housing consumption and housing consumption.[38]

[38]The volatilities of marginal utility growth ignore the risk of being born as a low productivity household. The housing policies we study below play a role in insuring this risk.

6 Affordability Policies

Having developed a quantitatively plausible dynamic stochastic spatial equilibrium model of the New York housing market, we now turn to policy counterfactuals. This section focuses on five main policies; Appendix D discusses several more. To highlight the role of migration, we conduct the same policy experiments in a closed-economy model of the metropolitan area. The detailed no-migration model results are in Appendix E.

6.1 Expanding the Rent Stabilization Mandate

The first policy we study is an expansion of the affordable housing mandate. We symmetrically increase η^ℓ in each zone, the fraction of rental square footage that must be set aside for affordable units, to 1.5$\times$ its benchmark value. At 1.5$\times$, all households who want RS have access to it in equilibrium. Further increases would lead to excess supply and lack of market clearing in the RS segment. Column (1) of Table 2 reports the results.

A main result in the paper is that expanding rent stabilizaton increases aggregate welfare substantially, by $\mathcal{W}_g = 0.91\%$ in CEV units (row 31). This welfare measure averages over all households who lived in the main MSA in the period before the reform, regardless on where they live in the period after the reform. The reform is associated with a large increase in the fraction of households living in RS housing (row 3) and in the fraction of bottom-income quintile households in RS (row 4). Our measure of access to RS insurance rises dramatically (row 27) while the stability of that insurance does not deteriorate (row 28). Insurance provision improves, as indicated by the decline in both volatility of marginal utility growth rates (rows 29 and 30). Expanding RS reduces market incompleteness.

Appendix Table A.5 and Figure A.8 report results for other values of the fraction of rental housing that is rent stabilized, η^ℓ. Average welfare rises monotonically in the scope of the RS mandate.

The literature emphasizes that expanding RS is not without cost, and the same is true in our model. RS induces increasing distortions to housing and labor markets, both in terms of supply and spatial misallocation. We discuss these in turn.

First and foremost, an increase in the RS mandate weakens developers' incentives to build since it lowers the average sale price they earn on new housing units and hence their profits. The overall housing stock decreases. This is consistent with the empirical literature, which finds that increased incentives of landlords to renovate their properties and of developers to invest in new construction generate a modest housing boom in de-controlled areas (Autor et al., 2014; Diamond et al., 2019).

The lower housing stock results in higher market rents (12.03% in zone 1 (row 14) and 3.21% in zone 2 (row 15). Developers "pass through" the increased housing affordability mandate into the market rent. The fraction of rent-burdened renters in the MSA increases by 3.97% (row 5). The increased rent burden reflects the fact that renter households who do not win the RS lottery face higher rents. Since many more households now enjoy the lower and more stable rents that come with RS, the rent burden metric must be interpreted cautiously.

Second, the wider availability of subsidized affordable housing leads households to consume more housing than they otherwise would, and leads other, richer households to choose a RS unit even though it is smaller than the market rental they would otherwise choose. There is misallocation of housing quantities.

Third, a symmetrical increase in RS in both zones shifts the population towards the urban core (14.09% in row 10). The homeownership rate in zone 1 falls substantially as there are now many more RS tenants in zone 1. Zone 1 residents choose smaller housing units both in the market and RS rental segments (rows 8 and 6), increasing the density in the urban core. The different population mix in zone 1 is reflected in a much lower average income (row 20), much fewer top-productivity households of working age (rwo 22), and more retirees (row 11). In other words, the spatial allocation of labor productivity deteriorates. The reallocation of the housing stock towards affordable units pushes some middle- and upper-middle-income households out of the urban core. The socio-economic make-up of the urban core becomes more diverse. This pattern is consistent with the empirical evidence in Autor et al. (2014), who show that richer households moved into units previously occupied by poorer RS tenants after a reduction in control in Cambridge, MA.

Fourth, there is a substantial reduction in individual labor supply by those in RS who face lower rents. The resulting reduction in aggregate labor supply can be seen clearly in the model without migration (Table A.8) but is fully offset by the increase in labor supply due to the rising NY population in the model with migration. Effective labor supply and output are unchanged.

In summary, the model generates the well-known distortions in labor supply and housing associated with expansions of RS. The main quantitative finding is that these costs are outweighed by the benefits to the RS recipients.

Figure 5 studies how the RS expansion affects different types of households (blue

Table 2: Policy Experiments: Main Moments

		Benchm.	(1) RS share 1.50×	(2) Inc Qual Stay	(3) All RS in Z2	(4) Zoning	(5) Vouchers	(6) Cash transfer P
1	Avg(rent/inc.) renters in Z1 (%)	39.5	-0.58%	14.00%	-4.74%	0.28%	-0.36%	-1.39%
2	Avg(rent/inc.) renters in Z2 (%)	32.8	-2.58%	11.24%	-0.87%	0.63%	0.79%	4.10%
3	Fraction of HHs in RS (%)	14.20	64.47%	29.23%	–	0.14%	4.44%	5.11%
4	Frac. in RS of those in inc. Q1 (%)	16.48	58.72%	105.06%	22.43%	0.16%	6.18%	5.98%
5	Frac. rent-burdened (%)	54.7	3.97%	22.28%	-3.96%	-0.18%	3.88%	4.12%
6	Avg. size of RS unit in Z1 (sf)	869	-3.82%	-48.65%	–	0.19%	-0.17%	-0.29%
7	Avg. size of RS unit in Z2 (sf)	862	-1.27%	-38.04%	-0.13%	0.02%	-1.76%	-1.86%
8	Avg. size of a Z1 mkt unit (sf)	1156	-6.54%	-2.52%	-3.30%	0.40%	-1.13%	-0.77%
9	Avg. size of a Z2 mkt unit (sf)	1824	5.50%	-2.61%	-2.05%	-1.04%	-4.61%	-4.99%
10	Frac. of pop. living in Z1 (%)	10.5	14.09%	10.61%	-8.43%	6.95%	-1.95%	-3.01%
11	Frac. of retirees living in Z1 (%)	17.5	22.88%	114.80%	-34.48%	4.14%	3.13%	0.65%
12	Housing stock in Z1	–	0.36%	0.37%	0.62%	8.80%	-0.50%	-0.20%
13	Housing stock in Z2	–	-0.25%	1.17%	-0.65%	-0.62%	-2.69%	-1.86%
14	Rent/sf Z1 ($)	3.55	12.03%	6.94%	-1.55%	-0.29%	1.79%	2.38%
15	Rent/sf Z2 ($)	1.28	3.21%	7.48%	1.45%	0.24%	1.80%	2.44%
16	Price/sf Z1 ($)	884	11.28%	6.82%	-1.38%	-0.27%	1.72%	2.41%
17	Price/sf Z2 ($)	249	3.17%	7.65%	1.48%	0.23%	1.69%	2.45%
18	Homeownership rate in Z1 (%)	34.8	-116.32%	-6.26%	54.26%	8.30%	4.26%	5.09%
19	Homeownership rate in Z2 (%)	61.1	-10.75%	-2.62%	-6.30%	-0.64%	-6.13%	-8.03%
20	Avg. inc. Z1 working-age HHs ($)	167840	-42.47%	-17.02%	29.20%	2.70%	4.60%	5.83%
21	Avg. inc. Z2 working-age HHs ($)	99755	6.69%	-0.64%	-6.39%	-1.31%	-2.09%	-2.26%
22	Frac. of top-prod HHs in Z1 (%)	21.6	-82.31%	4.73%	32.35%	10.10%	5.85%	6.07%
23	Total hours worked	–	1.58%	6.69%	1.69%	0.76%	0.56%	1.56%
24	Total hours worked in effic. units	–	0.02%	-0.99%	-0.06%	0.28%	-3.48%	-2.69%
25	Total output	–	0.03%	-0.63%	-0.08%	0.16%	-2.24%	-1.73%
26	Total commuting time	–	0.49%	9.18%	2.36%	0.05%	1.10%	2.28%
26	Developer profits	–	-0.55%	3.10%	-0.24%	0.21%	-3.37%	-2.78%
27	Access to RS insurance (%)	4.1	68.83%	94.73%	13.55%	1.24%	2.42%	8.28%
28	Stability of RS insurance (%)	79.9	0.21%	2.03%	0.90%	-0.10%	0.62%	-0.06%
29	Std. MU growth, nondurables	0.60	-1.21%	2.80%	3.42%	0.78%	2.73%	0.41%
30	Std. MU growth, housing	0.60	-4.14%	3.51%	1.42%	1.13%	1.45%	-1.09%
31	**Aggr. welfare change (NY pop)**	–	**0.91%**	**0.66%**	**0.25%**	**0.11%**	**-0.00%**	**3.90%**
32	NY population	7124.9	1.89%	9.90%	2.66%	1.18%	2.12%	3.06%
33	Aggr. welfare change (no migr.)	–	1.36%	0.32%	0.37%	0.40%	0.53%	4.66%

Notes: Column "Benchmark" reports values of the moments for the baseline model.

bars and lines). Expanding rent stabilization benefits younger households more (top left panel), and especially low-productivity (top right panel) and low-income households (bottom left panel). It is a regressive policy. More more surprisingly, the reform generates positive welfare changes for high-income and high-wealth households (bottom right panel). Since RS has no income- or wealth-based qualification, some richer households choose to live in RS housing. Also, the equilibrium increase in house prices (rows 16 and 17) benefits homeowners who tend to be wealthier. This benefit is partially offset by lower values for investment homes–a higher value for η increases the gap between primary and investment housing κ_4,–and by lower developer profits which disproportionately flow to the high-wealth households (row 26). Arnott (1995) argues that developers exert market power and that rent regulation is a way to limit this market power. Our model has a flavor of this in that developers make profits and more rent regulation reduces that profit.

Higher equilibrium house prices and rents, resulting from the expansion of RS, dissuade in-migration, as shown in the right panel of Figure 6. The NY population rises, despite the reduced in-migration, because of reduced out-migration rates for bottom-75% productivity households (left panel). The availability of RS housing and the reduced rents it affords, especially as housing tenure increases, reduces incentives for low-income households to leave the city. The same RS expansion policy results in even larger welfare gains in the model without migration (compare rows 31 and 33 of Table 2). Migration provides an extra margin of adjustment and dampens the welfare effects from either reducing or expanding the scope of the RS mandate; see Tables A.5 and A.8 for a detailed comparison.

6.2 Improving the Targeting of RS

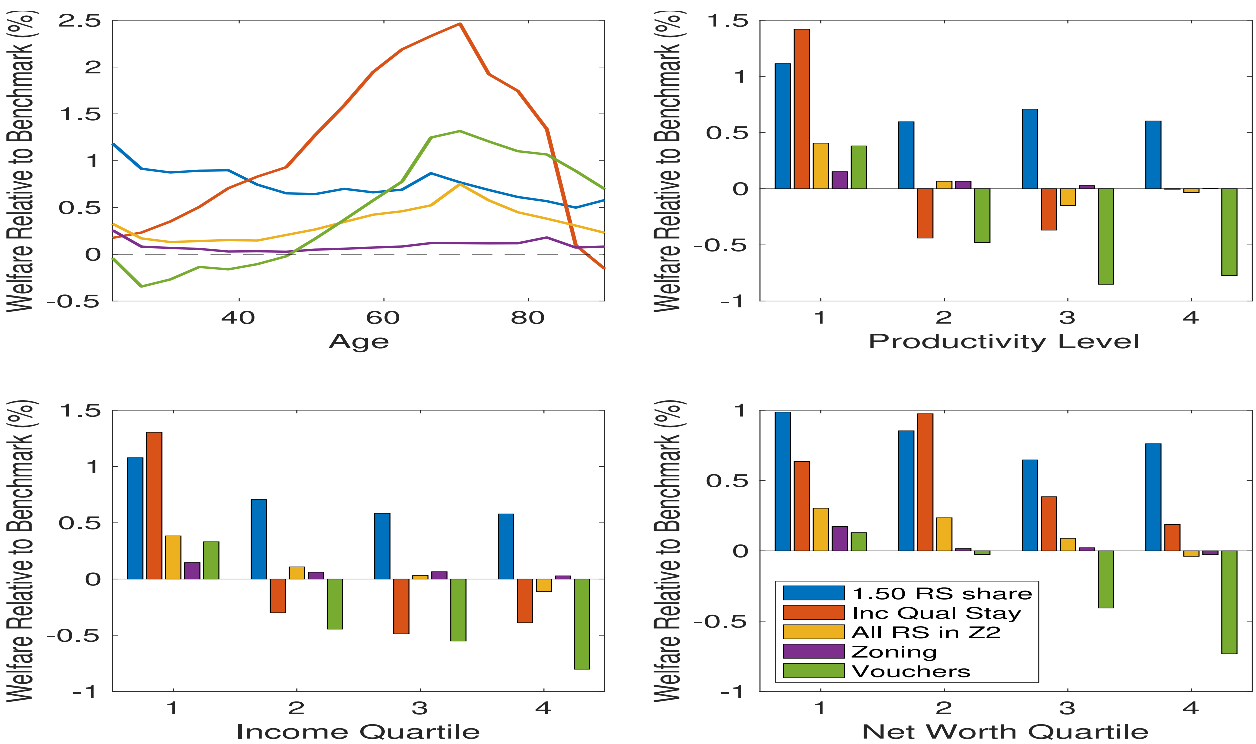
RS in the benchmark model suffers from misallocation. The next policy we consider aims to improve the allocation of a given amount (square footage) of RS housing by better targeting it on the most needy households. The policy introduces income qualification for al RS tenants. The results are reported in column (2) of Table 2. Table A.6 considers several additional policies that reduce the misallocation of RS housing. Table A.9 discusses said policies in the no-migration model.

Compared to the baseline model, which had no income qualification for RS housing, this experiment imposes an income cutoff on all RS residents in every period. Specifically, RS tenants must make less than 60% of AMI in zone 1 and 50% of AMI in zone 2.[39] Existing RS tenants who income-qualify remain in RS with high probability $p^{RS,exog}$.

This experiment generates a substantial average welfare gain of 0.66%. It provides the fairness of income qualification while avoiding housing instability, excessive churn in the RS system. The targeting of RS units to low income households improves (105.06%, row 4). Access to insurance for lower-income households who have fallen on hard times is much higher than in the baseline (94.73%), and comes without loss in the stability of that insurance (2.03%).

[39] For the purposes of income qualification, household income is defined as total pre-tax household income, including labor income, pension income, and financial income. AMI is the area median income among all households in the entire metropolitan area, including retirees. 60% of AMI is a common income threshold in affordable housing policy. Setting the income cutoff to 50% of AMI in both zones would lead to excess supply of RS housing in zone 1 and lack of market clearing. Intuitively, RS housing in zone 1 is still relatively expensive for low-income households.

Figure 5: Policy Experiments: Welfare Heterogeneity



Notes: The baseline model has the following parameters: $\eta^1 = 56.37$, $\eta^2 = 29.72$, $\kappa_1 = 7\%$, $\kappa_2 = 1000.00$, $\kappa_3 = 0.50$. Policy experiments, each panel: Top left panel: by age. Top right panel: by productivity level. Bottom left panel: by income quartile. Bottom right panel: by net worth quartile. The welfare changes are measured as consumption equivalent variations for an average household in each group.

The red line and bars in Figure 5 shows how welfare changes are distributed across age, productivity, income, and wealth groups. Better targeting RS units on low-income households naturally benefits lower-productivity and low-income households, and comes at the expense of the other groups. The benefit from the reform increases in age until about age 70, before falling back down.

Since income qualification applies to all existing tenants, it reduces the misallocation that builds up over time as tenant income grows.[40] The reform replaces high-income insiders with low-income outsiders. The policy is successful at allocating affordable housing units to low-income households without creating excessive churn.[41] Since lower-income households demand smaller housing units (rows 6 & 7), the fraction of households in RS increases (29.23%, row 3) even though the total square feet of RS housing stays the same.

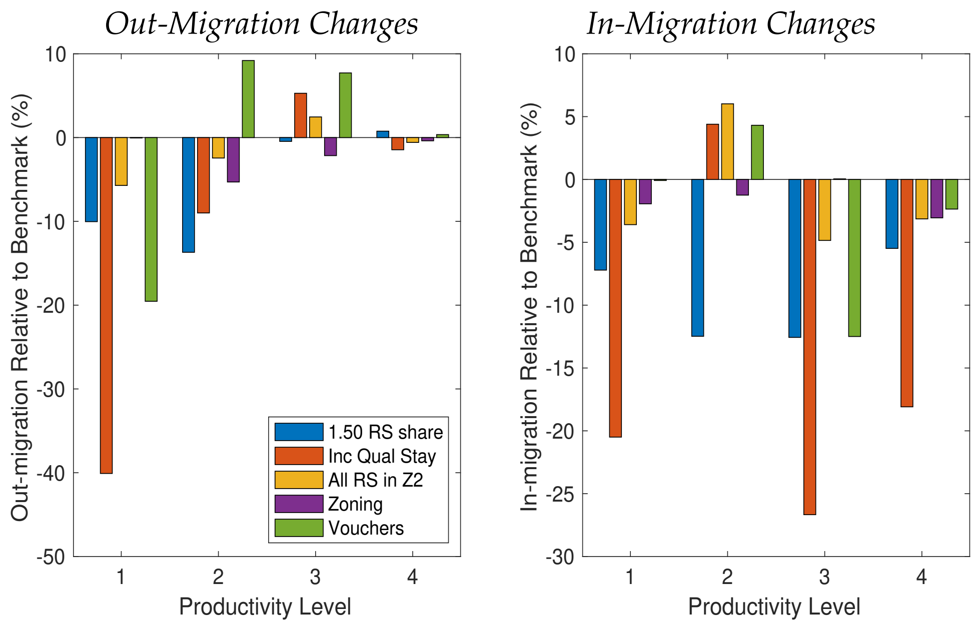
Income targeting increases the share of households in the urban core (10.61%). Av-

[40]For comparison, the appendix considers a policy that only income-tests at first entry. It has a smaller welfare gain.

[41]For comparison, the appendix considers a policy that forces all tenants to go through the housing lottery each period. It results in lower average welfare due to excessive churn, i.e., housing instability.

erage income in zone 1 falls (-17.02%) since many of the new residents in zone 1 are lower-income households living in small RS units.

Figure 6: Policy Experiments: Migration



Notes: The left (right) panel reports the percentage difference in out-migration (in-migration) rates between the experiment and the benchmark model for each productivity group.

Rent-income ratios among renters increase in zone 1 (14.00%, row 1) and in zone 2 (11.24%, row 2). These changes reflect the new socio-economic make-up of the two zones; there is more "income mixing" in the urban core. The fraction of rent-burdened households increases (22.28% , row 5). This suggests that rent-income ratios and rent burden, the most common metrics of housing affordability, must be interpreted carefully as they reflect equilibrium rents and the income of the people who have sorted into each area in spatial equilibrium.

A better-targeted RS system results in an endogenously lower average rent discount, as explained below. This reduces distortions for developers. It results in higher developer profits (row 26) and higher housing supply (rows 12 and 13). Since housing demand also rises–due to less misallocation in the RS system,–both housing stock and rents go up in equilibrium in both zones (rows 14 and 15). So do prices (rows 16 and 17). Put differently, misallocation in the RS housing system depresses both the housing stock and the price of market housing in equilibrium.

Several factors work to offset the benefits from better targeting. First, some households who have lived in a RS unit for a long time but no longer qualify because their income has risen above the cutoff enjoyed a large rent discount (since the rent discount $\kappa_1(d)$

is rising in tenure d). They are replaced with new lower-income tenants with a new RS tenure clock and hence a small discount. The welfare loss from the former group partially offsets the welfare gain of the latter group.

By the same logic, income qualification results in a lower average rent discount since it prevents households whose incomes rise (e.g., for life-cycle reasons) to enjoy subsidies that grow with tenure. As pointed out before, this lowers distortions on developers.

Second, income qualification leads some to reduce labor supply in order to qualify, a force that was absent in the benchmark model. This labor supply effect is masked by the strong net in-migration (population growth is 9.90%, row 32) but is visible in the no-migration model.

Figure 6 shows that the reform discourages low-productivity out-migration and high-productivity in-migration and encourages high-productivity out-migration and middle-productivity in-migration. Total hours worked in efficiency units declines (row 24), despite the large increase in total hours (row 23). Total output falls (-0.63%, row 25). Efficiency gains in the housing market from better targeting result in efficiency losses in the labor market.

Third, the large increase in the share of retirees in the urban core and the increase in aggregate commuting time shows that the spatial allocation of labor deteriorates.

Fourth, the maximum house size for RS units limits the benefits from better targeting. The size cutoff reduces misallocation by making RS unattractive for high-income households. In unreported results, we find that introducing an income cutoff leads to larger welfare gains if there is no RS size cutoff.

Returning to the migration results, the sharp reduction in out-migration for low-productivity households is due to the fact that both the access to insurance and the value of RS insurance have improved. The higher out-migration rates of productivity group 3, who are adversely affected by the policy change, show that out-migration offers a way for some to escape the adverse consequences of the policy. The policy triggers less in-migration, which can be understood from the much higher cost of living in NY after the reform. Overall, the migration option ends up raising the welfare gains of this policy for the NY population (row 33 versus 31).

In conclusion, carefully-designed income targeting produces substantial welfare gains, yet requires no expansion of the scope of the RS program. Appendix D discusses four other policies aimed at improving the targeting, including a policy that further restricts the maximum size of a RS unit and one that lowers the rent discount. All have lower welfare gains than the targeting policy discussed here.

6.3 Geographic Location of Affordable Housing

Column (3) of Table 2 conducts a policy experiment that shifts all RS housing from zone 1 to zone 2. Appendix D.3 studies the same experiment coupled with subsidized public transit for all RS tenants. By construction, the experiment keeps the number of households in RS constant. This policy generates an aggregate welfare gain of 0.25%.

The urban core gentrifies, attracting more high-income and top-productivity households and obtaining a much higher homeownership rate. There are also a lot fewer retirees in zone 1. Moving affordable housing to the suburbs improves the spatial allocation of labor.

The reform eliminates developer distortions in zone 1, which results in a higher housing stock in zone 1 and lower market rents. However, rents remain much higher in zone 1 than in zone 2. The urban core actually loses population share and sees reduced density. Developer distortions increase in zone 2, lowering the housing stock and increasing market rents rise in zone 2. Rent-income ratios fall in both zones, and the share of rent-burdened households falls.

A consequence of the reform is that the targeting of RS improves; the fraction of Q1-income households in RS increases substantially. Higher-income households may not want to live in a modest-sized RS unit in zone 2 even when they win the RS lottery.

Figure 5 shows that this policy (in yellow) benefits low-income households the most. There is a welfare loss for high-income residents, some of whom lose RS housing subsidies after the reform.

The welfare effects are dampened by migration (rows 33 versus 31). The policy increases the population of NY (row 32) and lowers its average productivity. Since the policy benefits lower-income households, out-migration for this group falls. Figure 6 also shows higher in-migration for agents in the second productivity group and lower in-migration rates for households in the top-25% of the productivity distribution.

6.4 Upzoning the Urban Core

The next experiment studies a zoning change that allows for more housing in the city center in an effort to capture the agglomeration benefits associated with higher density in the urban core ($\mathcal{A}^1 > 1$). We think of this policy as relaxing height (increasing allowable floor-area ratios) or other land use restrictions. We increase $\overline{H}^1$ by 10%. The equilibrium housing stock in Manhattan increases by 8.80%, as shown in Column (4) of Table 2. Since a fixed fraction of square feet must still be set aside for RS units, the expansion in the housing stock also creates more affordable units in zone 1. This is akin to a mandatory inclusionary housing policy.

Because of the increased housing supply, rents (-0.29%) and prices (-0.27%) in zone 1 fall, making housing in the urban core more affordable. The reform brings more top-productivity households to zone 1 (10.10%). Average income and homeownership rise in the core. In zone 2, the housing stock falls (-0.62%) and rents rise (0.24%) as developers shift their activity towards zone 1.

Upzoning increases welfare with a modest average benefit of 0.11%. Figure 5 shows that the upzoning policy (in purple) brings positive benefits to all age, productivity, and income groups, and all wealth groups except for the top-wealth quartile which suffers only a minor loss. This is in contrast with the prior policies which disproportionately benefited the poor often at the expense of the rich. Zoning reform appears to be a (near-)Pareto improvement. Real-world resistance to upzoning ("NIMBYism") can be understood in the model by observing the lower equilibrium house prices in zone 1. They represent capital losses to existing homeowners. The main quantitative difference with the first two policies is that upzoning does not generate meaningful improvements in the welfare of poor, high marginal-utility agents.

Zoning reform attracts more people to the gateway MSA; the NY population rises by 1.18%. Figure 6 shows a reduction in out-migration rates that is more pronounced for agents in the 25th–87.5th percentiles of the productivity distribution.

6.5 Housing Vouchers

An important pillar of U.S. affordable housing policy is the Section 8 voucher program, housing assistance provided by the federal government to low-income households. We consider a policy that spends $800 million on vouchers in the New York metro. In the model and in the data, vouchers are allocated by lottery to households who make less than 50% of AMI. The voucher amount is set to $8,300, the observed amount in the data.[42] Households who win the voucher lottery and accept must spend the voucher amount plus 20% of household income on housing. They can choose to turn down the voucher if they do not wish to abide by this housing constraint.[43] The experiment pays for 96,385 vouchers, or about 1.35% of NY households pre-reform. The program is paid

[42] Data compiled from the Housing and Urban Development department show that the housing authorities responsible for the 25 counties in the New York MSA disbursed $2.06 billion in 246,000 Section 8 vouchers in the year 2013 (latest available). This amounts to an average of $8,300 per year per voucher.

[43] In the data, the housing expenditure constraint is the voucher amount plus 30% of household income. Lower-income households may choose a lower voucher amount to alleviate the constraint. To prevent the constraint from being unrealistically tight in our model where the voucher amount is fixed, we reduce the own contribution to 20% of household income.

for by higher labor income taxes, engineered by a decline in λ. The voucher lottery is independent from the RS lottery in the model. As in the real world, the voucher can be used to pay for rent-stabilized housing.

Column (5) of Table 2 shows a zero welfare change for the voucher program (-0.00%). Figure 5 shows that older, low-productivity, low-income, and low-wealth households gain substantially from the policy at the expense of middle-class and rich households.

Several effects work to offset the large welfare benefits to the poor. Chief among them are labor supply distortions. First, since vouchers are income-tested, they affect the labor supply of the recipients.

Second, in the model as in data, vouchers are paid for with distortionary labor income taxes, reducing labor supply among non-recipients as well. Total hours worked in efficiency units fall sharply (-3.48%), as does output (-2.24%), despite NY MSA population growth. Lower out-migration of low-productivity households and higher out-migration of high-productivity households reduces average productivity in NY, resulting in a lower income tax base. A higher equilibrium tax increase is needed to raise enough tax revenue to pay for the voucher program. The possibility of migration substantially amplifies this Laffer-curve effect. In the no-migration model, the tax changes ($\Delta\lambda$) needed to raise the $800 million for the vouchers are much smaller. Output does not fall and the welfare gain from the voucher policy is substantially larger (0.53%) than in the migration model. This result underscores the importance of how housing affordability programs are financed as well as the interaction with migration.

Third, further limiting the welfare benefit of housing vouchers is the fact that the voucher amount is not contingent on income, conditional on qualifying (income below 50% of AMI). Because many households qualify, the chances of winning the voucher lottery are slim, reducing its insurance benefit.

Fourth, households must re-apply for the voucher each period, resulting in housing instability.

The voucher expansion, which is location-neutral in its design, has interesting spatial equilibrium effects. The policy leads to a reduction in the population share of zone 1 (-1.95%) and an increase in commuting (1.10%). It increases the average income of zone 1 (4.60%), the fraction of top-productivity households who live there (5.85%), and the homeownership rate. In other words, the urban core gentrifies. In equilibrium, low-income households are *not* more likely to live in zone 1, where they can take advantage of the agglomeration effects on current and future labor income ($\mathcal{A}^1 > 1$). This is consistent with the empirical evidence in Collinson and Ganong (2018) that vouchers do not "move" lower-income households "to opportunity." Rather, lower-income households end up living in the neighborhoods were they were already living prior to the voucher expansion. In fact, some middle-income households leave the urban core, whose size shrinks, and even the metro area. The voucher program "removes them from opportunity." This experiment underscores the importance of studying housing vouchers in general equilibrium.

Finally, a change to one housing affordability program may affect the benefits from other programs. Expanding vouchers results in more (low-income) households in RS housing, each occupying a smaller unit on average.

Appendix D.4 discusses a tax credit program for developers with the same total cost as the voucher program. It too generate no average welfare gain for reasons that are very similar to those in the voucher experiment.

6.6 Comparison to Cash Transfers

Finally, it is useful to contrast the housing policies to cash transfer program. Appendix D.5 studies a policy that is identical in its benefit allocation to the housing voucher experiment but removes the minimum housing expenditure constraint. The aggregate welfare effect of this cash transfer policy is nearly identical to that of its in-kind cousin. This goes to show that the housing constraint does not distort consumption allocations very much in the housing voucher experiment. Several of the housing policy reforms discussed above produce strictly larger welfare benefits than this cash transfer program.

The policy in column (6) of Table 2 aims to improve on the design of the cash transfer by changing the benefit allocation, leaving the total amount raised unchanged at \$800 milion. Specifically, each household with income below 50% of AMI receives a recurring cash transfer for the maximum of zero and X-30% of pre-tax household income. The parameter X is set such that the program costs exactly the targeted amount in the aggregate. When $X = \$5,530$, the program costs \$800 million in equilibrium. Note that the transfer is larger the lower is the household's income; the cash transfer is progressive (hence the label P). There is no lottery. The policy distributes dollars from the lowest income level upwards, until the money runs out. While the average benefit amount is much lower (about \$1,100 per year) than the first cash transfer program (\$8,300 per year), the second cash transfer policy is better targeted than the first, both at the extensive margin (7% of the population are recipients versus 1.35%) and the intensive margin (progressive nature of the benefit). While the benefit fluctuates over time as household income changes, it is more stable than the first cash transfer. This policy creates a large aggregate welfare gain of 3.90%. Hence, it is possible to conceive of cash transfer policies that dominate the housing policies we study.

Achieving this superior targeting and sizing of the benefit may be difficult in practice. Moreover, enacting meaningful tax-and-transfer reform may be outside of the remit of local policymakers. Currie and Gahvari (2008) offer several explanations for the widespread adoption of in-kind transfers, including in the realm of housing. Whether they are the constrained optimal policy or just an important practical alternative to tax policy, housing policies are important to analyze given their prevalence.

Finally, cash transfer policies interact in powerful ways with the housing market through taxation and migration. Similarly to the housing voucher experiment, cash transfers also result in a lower long-run housing stock (-0.20% in zone 1 and -1.86% in zone 2 in column 6 of Table 2), despite the population growth, and in much higher rents (2.38% and 2.44%) and house prices (2.41% and 2.45%). The higher cost of living reduces in-migration and accelerates out-migration of high-productivity households. The latter reap the capital gains on housing wealth and leave. Transfer policies may also have (unintended) spatial consequences. This policy results in gentrification of the urban core, with more high-income residents, less density, and more homeownership.

7 Conclusion

In a world with rising urbanization rates, the high cost of housing has surfaced as a daunting challenge. Existing affordable housing policy tools affect the supply of housing, how the housing stock is used (owned, rented, affordable), and how it is distributed in space. Households of different tenure status, age, income, and wealth are differentially affected by changes in policy. This paper develops a novel dynamic stochastic spatial equilibrium model with risk, wealth effects, and rich household heterogeneity that allows a quantification of the welfare implications of the main housing affordability policy tools.

The model is calibrated to the New York metropolitan area, but allows for migration to another metro area. It matches patterns of average earnings, wealth accumulation, and home ownership over the life-cycle, delivers realistic house prices, rents, and wages, as well as large spatial differences in income and rents between the urban core and the periphery. The calibration captures the key features of New York's affordable housing system as well as restrictions on residential land use.

We use the model to evaluate changes to the rent stabilization system, zoning policy, and an expansion of the housing voucher system. These policies have quantitatively important aggregate, distributional, and spatial implications. Consistent with conventional wisdom, increasing the housing stock in the urban core by relaxing zoning regulations is welfare improving. Contrary to conventional wisdom, increasing the scope of rent stabilization also improves welfare, and much more so than upzoning. The main reason is that housing affordability policies generate important insurance benefits which trade off against the larger housing and labor market distortions. Increasing the housing safety net for the poorest households creates welfare gains for society. How the affordability policies are financed has first-order effects on welfare gains. Finally, the insurance view points towards important advantages from better targeting of affordable housing towards the neediest households.

These results underscore the need for rich models of household heterogeneity to understand both the aggregate and the distributional implications of place-based policies. Future work could use this framework to analyze investment in transit infrastructure, the effects of working from home or driverless cars on commuting costs, or the effects of local tax changes on migration. Applying this framework to study other cities with different institutional features is another useful direction for future inquiry.

References

Andrews, I., M. Gentzkow, and J. M. Shapiro (2017, November). Measuring the sensitivity of parameter estimates to estimation moments. *Quarterly Journal of Economics 132*(4).

Arnott, R. (1995). Time for revisionism on rent control? *Journal of Economic Perspectives 9*(1), 99–120.

Atkinson, A. and J. E. Stiglitz (1976). The design of tax structure: Direct versus indirect taxation. *The Journal of Public Economics 6*, 55–75.

Autor, D. H., C. J. Palmer, and P. A. Pathak (2014). Housing market spillovers: Evidence from the end of rent control in cambridge, massachusetts. *Journal of Political Economy 122*(3), 661–717.

Autor, D. H., C. J. Palmer, and P. A. Pathak (2017, September). Gentrification and the amioneity value of crime reductions: Evidence from rent deregulation.

Baum-Snow, N. and J. Marion (2009). The effects of low income housing tax credit developments on neighborhoods. *Journal of Public Economics 93*, 654–666.

Behrens, K., G. Duranton, and F. Robert-Nicoud (2014, June). Productive cities: Sorting, selection, and agglomeration. *Journal of Political Economy 122*(3), 507–553.

Berger, D., V. Guerrieri, G. Lorenzoni, and J. Vavra (2017). House prices and consumer spending. *Review of Economic Studies 85*, 1502–1542.

Bilal, A. and E. Rossi-Hansberg (2021, April). Location as an asset. Working Paper University of Chicago.

Brueckner, J. (1987). *Handbook of Regional and Urban Economics*, Chapter The Structure of Urban Equilibria: A Unified Treatment of the Muth-Mills Model. Amsterdam: North-Holland.

Campbell, J. Y. and J. Cocco (2003). Household risk management and optimal mortgage choice. *Quarterly Journal of Economics 118*, 1449–1494.

Cocco, J. F. (2005). Portfolio choice in the presence of housing. *Review of Financial Studies 18*(2), 535–567.

Collinson, R. and P. Ganong (2018). How do changes in housing voucher design affect rent and neighborhood quality? *American Economic Journal: Economic Policy 10*, 62–89.

Couture, V., C. Gaubert, J. Handbury, and E. Hurst (2018). Income growth and the distributional effects of urban spatial sorting. Working Paper University of Chicago Booth.

Currie, J. and F. Gahvari (2008, June). Transfers in cash and in-kind: Theory meets the data. *Journal of Economic Literature 46*(2), 333–383.

Davis, M. A., J. Gregory, and D. A. Hartley (2018). The long run effects of low income housing on neighborhood composition.

Davis, M. A., J. Gregory, D. A. Hartley, and K. T. K. Tan (2017). Neighborhood choices, neighborhood effects and housing vouchers.

Davis, M. A. and F. Ortalo-Magne (2011). Household expenditures, wages, rents. *Review of Economic Dynamics 14 (2)*, 248–261.

Davis, M. A. and S. Van Nieuwerburgh (2015). *Handbook of Regional and Urban Economics*, Chapter Housing, Finance, and the Macroeconomy, pp. Chapter 12. North Holland.

Diamond, P. and E. Saez (2011). The case for a progressive tax: From basic research to policy recommendations. *Journal of Economic Perspectives 25*, 165–190.

Diamond, R. and T. McQuade (2019). Who wants afordable housing in their backyard? an equilibrium analysis of low income property development. *Journal of Political Economy*.

Diamond, R., T. McQuade, and F. Qian (2019, March). The effects of rent control expansion on tenants, landlords, and inequality: Evidence from san francisco.

Eeckhout, J., R. Pinheiro, and K. Schmidheiny (2014, June). Spatial sorting. *Journal of Political Economy 122*(3), 554–620.

Favilukis, J., S. C. Ludvigson, and S. Van Nieuwerburgh (2017). The macroeconomic effects of housing wealth, housing finance and limited risk sharing in general equilibrium. *Journal of Political Economy 125*(1), 140–222.

Favilukis, J. and S. Van Nieuwerburgh (2021, October). Out-of-town investors and city welfare. *The Journal of Finance*.

Freedman, M. and E. Owens (2011). Low-income housing development and crime. *Journal of Urban Economics 70*, 115–131.

Gomes, F. and A. Michaelides (2008, January). Asset pricing with limited risk sharing and heterogenous agents. *Review of Financial Studies 21 (1)*, 415–449.

Guerrieri, V., D. Hartley, and E. Hurst (2013, April). Endogenous gentrification and housing price dynamics. *Journal of Public Economics 100*, 45–60.

Guren, A. and T. McQuade (2019). How do foreclosures exacerbate housing downturns? *Review of Economic Studies*.

Heathcote, J., K. Storesletten, and G. L. Violante (2017). Optimal tax progressivity: An analytical framework. *Quarterly Journal of Economics 132*(4), 1693–1754.

Hizmo, A. (2015, November). Risk in housing markets: An equilibrium approach. Working Paper New York University.

Hsieh, C.-T. and E. Moretti (2019). Housing constraints and spatial misallocation. *American Economic Journal: Macroeconomics 11*(2).

Imrohoroglu, A., K. Matoba, and S. Tuzel (2016, September). Proposition 13: An equilibrium analysis. Working Paper University of Southern California.

Joint Center for Housing Studies of Harvard University (2018). The state of the nation's housing 2018.

Kaplan, G., K. Mitman, and G. Violante (2019, March). Consumption and house prices in the great recession: Model meets evidence. Working Paper New York University.

Krusell, P. and A. A. Smith (1998). Income and wealth heterogeneity in the macroeconomy. *Journal of Political Economy 106*(5), 867–896.

Landvoigt, T., M. Piazzesi, and M. Schneider (2015). The housing market(s) of san diego. *American Economic Review 105*(4), 1371–1407.

Luque, J., N. Ikromov, and W. Noseworthy (2019). *Affordable Housing Development: Financial Feasibility, Tax Increment Financing, and Tax Credits*. Springer.

Ortalo-Magné, F. and A. Prat (2016, January). Spatial asset pricing: A first step. *Economica 83*, 130–171.

Rappaport, J. (2014, November). Monocentric city redux. Working Paper Federal reserve Bank of Kansas City.

Roback, J. (1982). Wages, rents, and the quality of life. *The Journal of Political Economy 90*(6), 1257.

Rosen, S. (1979). Wage-based indexes of urban quality of life. *Current issues in urban economics 3*.

Rossi-Hansberg, E., P. D. Sarte, and R. Owens (2010). Housing externalities. *Journal of Political Economy 118*(3), 485–535.

Saiz, A. (2010). The geographic determinants of housing supply. *Quarterly Journal of Economics*, 1253–1296.

Storesletten, K., C. Telmer, and A. Yaron (2006). Asset pricing with idiosyncratic risk and overlapping generations. *Review of Economic Dynamics Forthcoming*. Working Paper, University of Oslo.

Van Nieuwerburgh, S. and P.-O. Weill (2010, October). Why has house price dispersion gone up? *Review of Economic Studies 77*(4), 1567–1606.

Yao, R. and H. H. Zhang (2004). Optimal consumption and portfolio choices with risky housing and borrowing constraint. *Review of Financial Studies*.

Data Availability Statement

The data and code underlying this research are available on Zenodo at https://doi.org/10.5281/zenodo.6374288.