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 with above-10% house price appreciation in 2020.

Policy makers throughout the world are under increasing pressure to improve affordability.[1] 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 a range of housing affordability policies improves welfare. In an incomplete markets model with risk and risk aversion, affordability 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 ef-

[1] Fifteen cities in California have rent regulation. A November 2018 California state ballot initiative proposed to overturn the 1995 Costa-Hawkins Act, clearing the way for more rent control. Oregon imposed statewide rent control in 2019. New York State passed the most sweeping expansion of rent regulation laws in a generation in June 2019. So did the District of Columbia. Bill de Blasio, the mayor of New York City, was elected on a platform to preserve or add 200,000 affordable housing units. Many local policymakers are trying to overturn preemption laws, on the books in in 36 U.S. States, that prevent local governments from adopting rent regulation laws.

fects, which often reverse partial equilibrium logic, 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. Commuting entails both an opportunity cost of time and a financial cost. Zones have different sizes, captured by limits on the housing stock, provide different amenity benefits, and households who live in the urban core enjoy higher productivity, capturing agglomeration benefits. The second metro serves as an alternative, naturally more affordable, location for residents of the first metro. We study migration between the two metros, which is subject to moving costs. The spatial aspects of the model are important since affordable housing policies affect the spatial allocation of labor and housing, both within and across metros.

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 both the distributional and 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. For example, in Manhattan, half of rentals are RS, a much larger share than in zone 2.

We study housing policy reform in a sequence of experiments. We 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).

In a first set of experiments, we study policies aimed at reducing the misallocation caused by RS. These policies hold the share of the housing stock that is RS constant. We introduce income qualification in various ways. Among these ways, 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 RS housing provides since new tenants start with much smaller rent discounts. Third, the policy results in a larger NY population increasing the competition for affordable housing units. 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 second set of policy experiments changes 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 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 explore both smaller and larger fractions of affordable housing units and find that welfare increases monotonically with the scope of the affordable housing mandate.

A third set of policy experiments operate on the spatial aspects of affordable housing. First, we relocate all RS housing from the urban core to the suburbs, which increases 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. In one variant we provide subsidized transit for RS tenants in addition at a cost of $800 million. The distortionary taxes needed to pay for the transit subsidy more than offset the higher benefits to the recipients in the model with migration.

The next policy experiment increases the maximum amount of housing that can be built in zone 1, 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 modest improvement in the plight of low-income households.

Housing vouchers are transfers provided to low-income households for housing expenditures. We find that a $800 million expansion of the voucher system produces no average welfare gain despite large 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.

Finally, a $800 million developer tax credit policy also generates no gain, and little additional housing. It suffers from similar taxation-induced distortions on labor supply and housing demand, underscoring the importance of considering 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.[2] Recent work in macro-finance has solved such models in general equilibrium, adding aggregate risk, endogenizing house prices and sometimes also interest rates.[3] 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 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 spatial location of households in urban areas in spatial equilibrium models. This literature studies the trade-off between the commuting costs and housing expenditures.[4] 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 of affordability policies.[5]

[2]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.

[3]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.

[4]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).

[5]Hizmo (2015) and Ortalo-Magné and Prat (2016) bridge some of the gap between these two literatures

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, 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).

Our model connects to an empirical literature that studies the effect of rent control 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 regulation, 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

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.

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 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.[6] We contrast housing policies to two cash transfer programs, similarly 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 that of other housing policies.

The rest of the paper is organized as follows. Section 2 sets up the model. Section 3 describes the calibration to the New York metropolitan area. Section 4 discusses the benchmark model's implications for quantities and prices, the distribution of households, and housing affordability. Section 5 studies the main counter-factual policy experiments. Section 6 concludes. Appendix A provide detail on the data, Appendix B on the calibration, and Appendix C studies the affordable housing policies in a model without inter-city migration, helping to isolate the role of migration. Appendix D contains sensitivity analysis.

2 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

[6] 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 exception for governments to conduct redistribution in-kind."

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.

2.1 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.

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

[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.

(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.

Affordable Housing 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. The discount is increasing in the length of tenure d.[8] We model the assignment of RS units to renters as a 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

[8] In reality, a government entity sets the rent growth increases at rates that are below the growth rate of market rents. Since our model is stationary, a growing discount with tenure in a stationary model is equivalent to a slower growth rate of RS rents. Appendix A.4 shows the discount in the data as a function of tenancy for the New York MSA. Our calibration below adopts this schedule.

[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.

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.

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:

$$V_{R,\ell}(x_t, z_t, a, d_t) = \max_{c_t, h_t, n_t, b_{t+1}} U(c_t, h_t, n_t, \ell_t) + (1 - p^a)\beta \mathbb{E}_t[V(x_{t+1}, z_{t+1}, a + 1, 0)]$$

s.t.

$$c_t + R_t^\ell h_t + Q b_{t+1} + \phi_F^\ell = \left(1 - \tau^{SS}\right) y_t^{lab} + \overline{\Psi}_t \psi^z + \pi_t + x_t - T\left(y_t^{tot}\right),$$

$$y_t^{lab} = W_t n_t \mathcal{A}^\ell G^a z_t,$$

$$y_t^{tot} = y_t^{lab} + \left(\frac{1}{Q} - 1\right) x_t + \pi_t,$$

$$x_{t+1} = b_{t+1} + \widehat{b}_{t+1} \geq 0,$$

and equations (1), (2), (3), (4).

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-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 (10) 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

[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 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 D 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 em-

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]

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 $E_t\left[V^*(x_{t+1}, z_{t+1}, a+1)\right]$.

2.2 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 $\overline{P}_t^\ell$:

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

pirically 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 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 $\sum_d \omega^\ell(d) = 1$.

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 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]

[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.

Profits Per capita profits from tradeable and construction sectors are:

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

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 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.

2.3 Equilibrium

Given parameters, a competitive equilibrium is a price vector $(W_t, P^\ell_t, R^\ell_t)$ and an allocation, namely aggregate residential demand by market renters $H^{R,\ell}_t$, RS renters $H^{RS,\ell}_t$, and owners $H^{O,\ell}_t$, aggregate investment demand by owners $\widehat{H}^\ell_t$, 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]

The following conditions characterize the equilibrium. First, given wages and average prices given by (6), firms optimize their labor demand, resulting in the first-order conditions:

$$N_{c,t} = \left(\frac{\rho_c}{W_t}\right)^{\frac{1}{1-\rho_c}} \quad \text{and} \quad N_{\ell,t} = \left(\frac{\left(1-\frac{H^\ell_{t-1}}{\overline{H^\ell}}\right)\overline{P}^\ell_t \rho_h}{W_t}\right)^{\frac{1}{1-\rho_h}}. \tag{8}$$

Second, labor demand equals labor supply in efficiency units:

$$n_f\left(N_{c,t} + \sum_\ell N_{\ell,t}\right) = N_t = \sum_{i,a,\ell} n^i_t z^i_t G^a \mathcal{A}^\ell. \tag{9}$$

Third, the housing market clears in each location ℓ:

$$(1-\delta^\ell)H^\ell_{t-1} + n_f\left(1-\frac{H^\ell_{t-1}}{\overline{H^\ell}}\right)N^{\rho_h}_{\ell,t} = H^{O,\ell}_t + \widehat{H}^\ell_t. \tag{10}$$

[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.

The left-hand-side is the supply of housing which consists of the non-depreciated housing stock and new residential construction. The right-hand-side is the demand for those housing units by owner-occupiers and landlords. Fourth, the supply of rental units in each location ℓ must equal the demand, from market tenants and RS tenants, respectively:

$$\widehat{H}_t^{\ell}(1-\eta^{\ell}) = H_t^{R,\ell}, \quad \widehat{H}_t^{\ell}\eta^{\ell} = H_t^{RS,\ell} \tag{11}$$

Fifth, total pension payments equal to total Social Security taxes collected:

$$\overline{\Psi}_t N_{ret} = \tau^{SS} N_t W_t, \tag{12}$$

where N_{ret} is the total number of retirees. Sixth, total profits collected equal total profits distributed to households. Seventh, the population of the gateway MSA is endogenously determined by the value functions of living in each MSA and the moving costs.[20] Eighth, the value of all bequests received is equal to the wealth of all agents who die. Ninth, the aggregate state (S_t, S_t^*) evolves according to rational expectations. We focus on the model's steady state where all aggregate quantities and prices are constant.

2.4 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:

$$\mathcal{W}_g = \left(\frac{\frac{1}{G}\sum_{i \in g_t} V_{i,t+1}(x(c), z, a, S(c); \theta_c)}{\frac{1}{G}\sum_{i \in g_t} V_{i,t}(x(b), z, a, S(b); \theta_b)} \right)^{\frac{1}{(1-\gamma)(1-\alpha_n)}} - 1. \tag{13}$$

[20] We assume that the population of the outside MSA is large and not affected by out-migration from the gateway MSA.

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 (13) to compute welfare for subgroups of g_t, for example by labor productivity type, by income quartile, or net worth quartile. This welfare 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.[21]

3 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 A. Table 1 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.[22]

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 A 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.

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

[22] 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.

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 B.3. Saiz (2010) reports a housing supply elasticity for the New York metro area of 0.76. 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 Recall that pre-tax labor income for household i of age a is $y_t^{lab} = W_t n_t^i G^a \mathcal{A}^\ell z_t^i$, where the household takes wages as given and chooses labor supply n_t^i. The choice of hours is subject to a minimum hours constraint, which is set to 0.5 times average hours worked. 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.

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 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. Since the outside region has only one zone, it does not have this parameter.

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 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 B.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 data are from the IPUMS Census data set. The model matches the persistence of labor income of 0.9. It matches how the variance of earnings rises with age in the SCF, and it delivers 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 next 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 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%.[23] This delivers $\lambda = 0.75$. Appendix B.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 (12) to balance the social security budget. Average retirement income $\overline{\Psi}$ is $33,189, which corresponds to 27% of average earnings.

[23]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.

Table 1: Calibration

Description	Parameter	Value	Target
Panel A: **Geography and Income**			
Agglomeration zone 1 NY	$\mathcal{A}^1$	1.095	Relative income NY vs. outside MSA
Productivity states NY	Z^{NY}	[0.191 0.901 1.923 4.187]	Income level & inequality - App. B
Productivity states outside	Z^*	[0.191 0.741 1.507 3.148]	Income level & inequality - App. B
Transition prob.	$(p_{11}, p_{22}, p_{33}, p_{44}, p^H)$	(0.93,0.92,0.28,0.64,0.02)	Pop. shares of income groups, income persistence - App. B
Tax progressivity	τ	0.17	Heathcothe et al. (16)
Tax burden	λ	0.75	Govt. spending to GDP
Average pension	τ^{SS}	0.10	Avg. contribution rate to social security
Pension distr.	ψ^z	[0.44 1.25 1.51 1.51]	U.S. pension progressivity rules
Available space NY	$(\overline{H^1}, \overline{H^2})$	(0.05,2.07)	Max. residential buildable area, pop. share Manhattan
Available space outside	$\overline{H^*}$	7.00	Housing supply elasticity avg. MSA, Saiz (10)
Time-Commuting cost	ϕ_T^2	0.037	Average commuting time NY
Financial-Commuting cost	ϕ_F^2	0.01	Average commuting cost NY
Panel B: **Production**			
Return to scale consumption sector	ρ_c	0.66	Labor income share of 2/3
Return to scale housing sector	ρ_h	0.66	Housing supply elasticity for NY, Saiz (10)
Panel C: **Preferences**			
Risk aversion	γ	5	Standard value
Leisure weight	α_n	0.63	Average work week
Housing consumption weight	α_h	0.41	Avg. rent/avg. income of 23%
CES parameter consumption/housing	ϵ	-0.50	Elasticity of substitution consumption/housing of 2/3
Minimum hours worked	$\underline{n}$	0.15	Min. hours worked 50% of available time
Time Preference (4yr)	(β^H, β^L)	(1.204,0.925)	Avg. wealth/income and wealth Gini in SCF
Extra utility NY	χ^{NY}	1.036	Avg. wealth/income in NY equal to outside
Extra utility zone 1	χ^1	1.036	Rent per sf ratio of zones in NY data
Extra utility zone 1 retirees	χ^R	1.071	Fraction of retirees ratio of zones in NY data
Panel D: **Finance, Housing, Construction**			
Bond Price (4yr)	Q	0.89	Price/rent ratio in NY metro
Property tax rate NY (4yr)	$(\tau^{P,1}, \tau^{P,2})$	(0.029,0.053)	Prop. tax rate zone 1 and 2 of NY MSA -Brookings
Property tax rate outside (4yr)	$\tau^{P,*}$	0.063	Prop. tax rate 74 largest MSAs - Brookings
Depreciation rate NY (4yr)	(δ^1, δ^2)	(0.058,0.096)	Res. depr. BEA, rel. depr by zone
Depreciation rate outside (4yr)	δ^*	0.095	Res. depreciation BEA
Maximum LTV	θ	0.90	Avg. mortgage downpayment
Minimum housing size	$\underline{h}$	0.20	Obs. minimum housing size
Panel E: **Affordable Housing**			
Fraction rent stabilization	(η^1, η^2)	(56.37%,29.72%)	Frac. of HHs in RS of 37.3% and 12.0%
Prob. to stay in RS	$p^{RS,exog}$	0.83	Fraction of RS HHss in same unit for $\geq$ 20 years
Rental discount	$\kappa_1(d)$	7%–45%	Observed rental discount - App. A.4
Income threshold for RS	κ_2	∞	No income testing in NY
Maximum RS house size	κ_3	0.50	Avg. size of RS and market rentals equal

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 per week.[24] 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.[25]

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%$\times$ 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.[26] 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

[24]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.

[25]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.

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

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 of agents has β^H, the rest has β^L. This delivers an average β of 0.99,[27] 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.[28]

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

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

[28]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.

zones 1 and 2 is chosen to match the relative fraction of buildings that were built before 1939.[29]

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

[29]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.

fraction of RS tenants who have lived in a RS unit for 20 years or more. That number in the data is 23.1%.[30] 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.

Moving Costs To compute migration rates, we sort households in each of six age groups (26-34, 35-44, 45-54, 55-64, 65 and up) 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 A.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.[31] The parameter σ^m is restricted to be the same in the in-migration as for out-migration moving cost function.

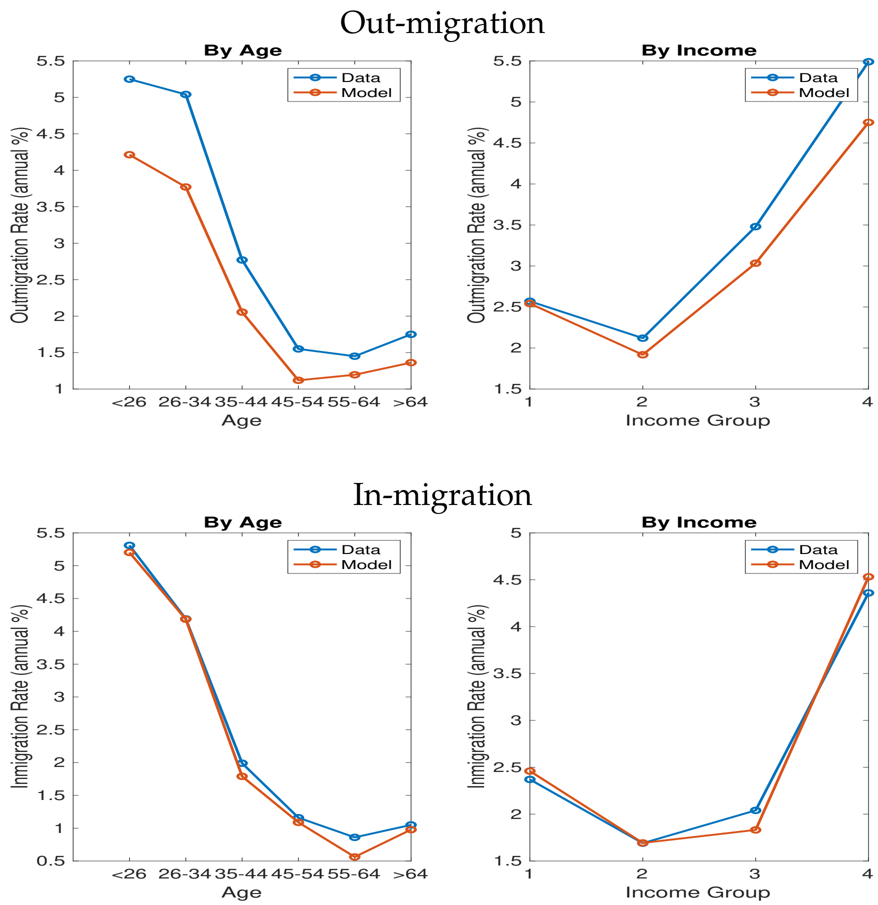
Figure 1 shows that the model closely matches the migration rates out of (top panel) and into (bottom panel) the New York MSA by age and income. Migration is declining in age and U-shaped in income. Among those 65 and older, out-migration exceeds in-migration.

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

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

[31] 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.

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.

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.[32]

4 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 2 shows some key

[32]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.

moments; moments in boldface are not directly targeted by the calibration.

4.1 Demographics, Income, and Wealth

Demographics The first three rows of Table 2 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 2: New York Metro Data Targets and Model Fit

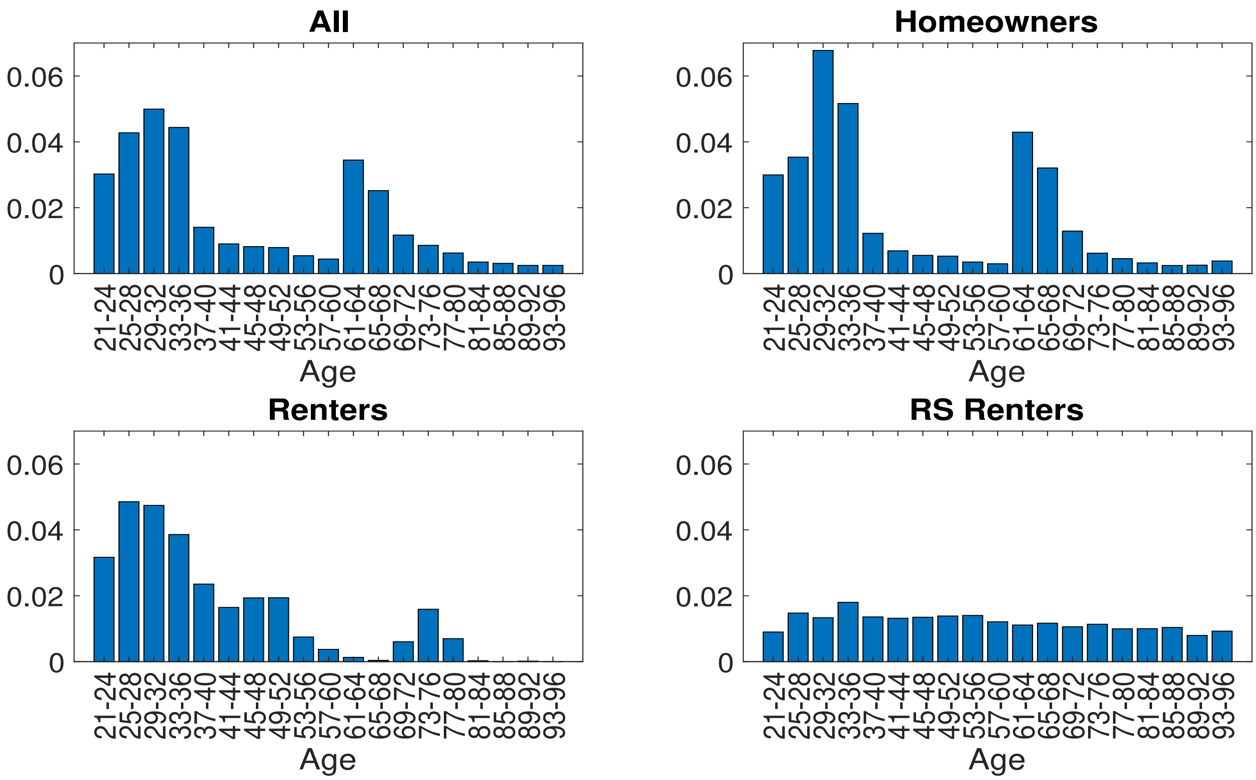
		Data		**Model**	
		metro	**ratio zone 1/zone 2**	**metro**	**ratio zone 1/zone 2**
1	Households (thousands)	7124.9	0.12	7124.9	0.12
2	Avg. hh age, cond. age > 20	47.6	0.95	**46.5**	**0.86**
3	People over 65 as % over 20	19.1	0.91	**19.5**	0.90
4	Avg. house size (sqft)	1644	0.59	1644	**0.63**
5	Avg. pre-tax 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 A. 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. Figure 2 shows that mobility in he model is highest for the young (ages 21–32). For these groups, the annual mobility rate is around 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 A.5.

Given the attractive rents, the model generates lower mobility rates for RS tenants at all ages. The same is true in the data.

Figure 2: Intra-MSA Moving Rates by Age in Model



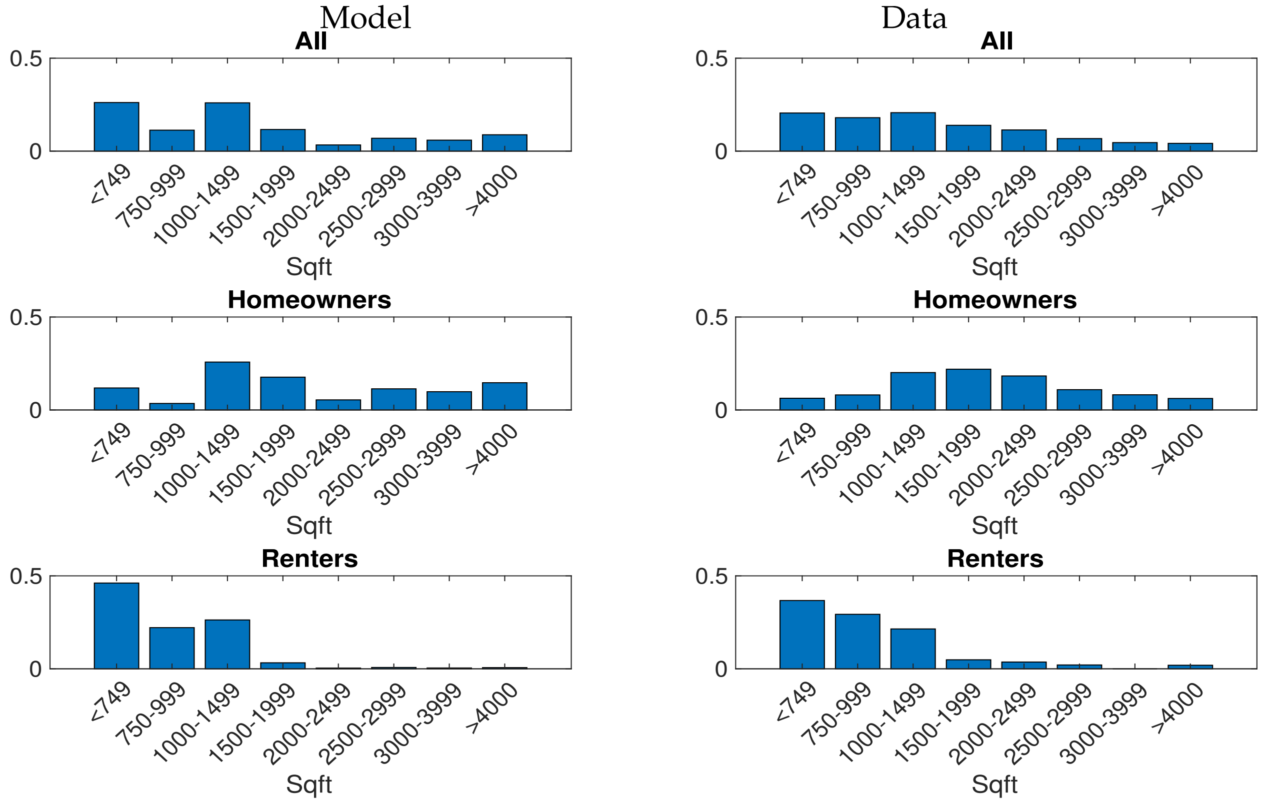
Note: Mobility rates are measured as the annual probability to move across zones.

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.

The top row of Figure 3 shows the distribution of house sizes. The model (left panel) matches the data (right panel) reasonably well, 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.

Figure 3: House Size Distribution New York

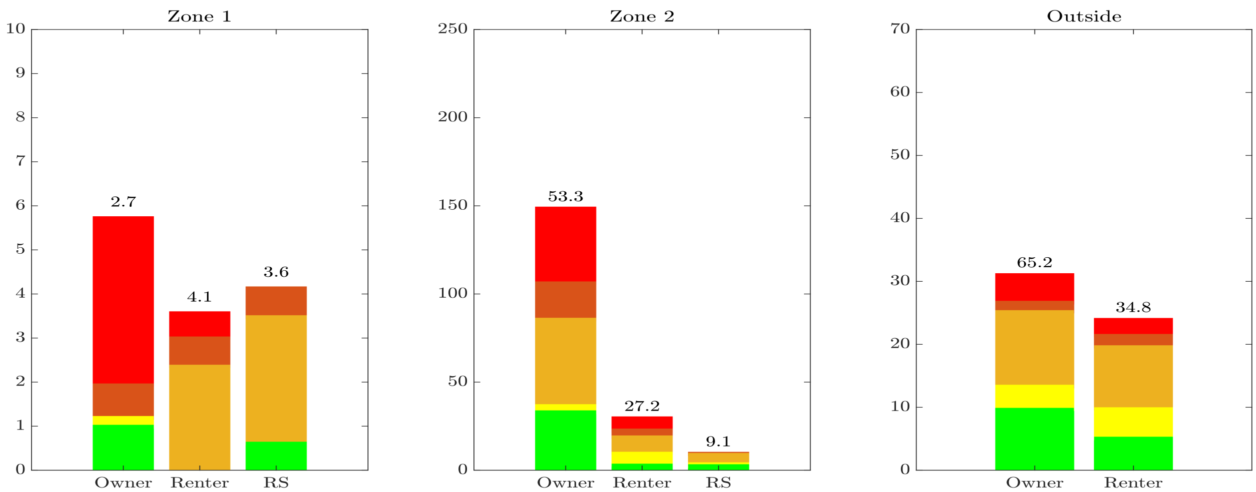


Note: Left panel: model. Right panel: data. Data source: American Housing Survey for the New York MSA, U.S. Census Bureau, 2015.

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 2). 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 4 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.

Figure 4: Geographic Distribution of Households by Productivity.



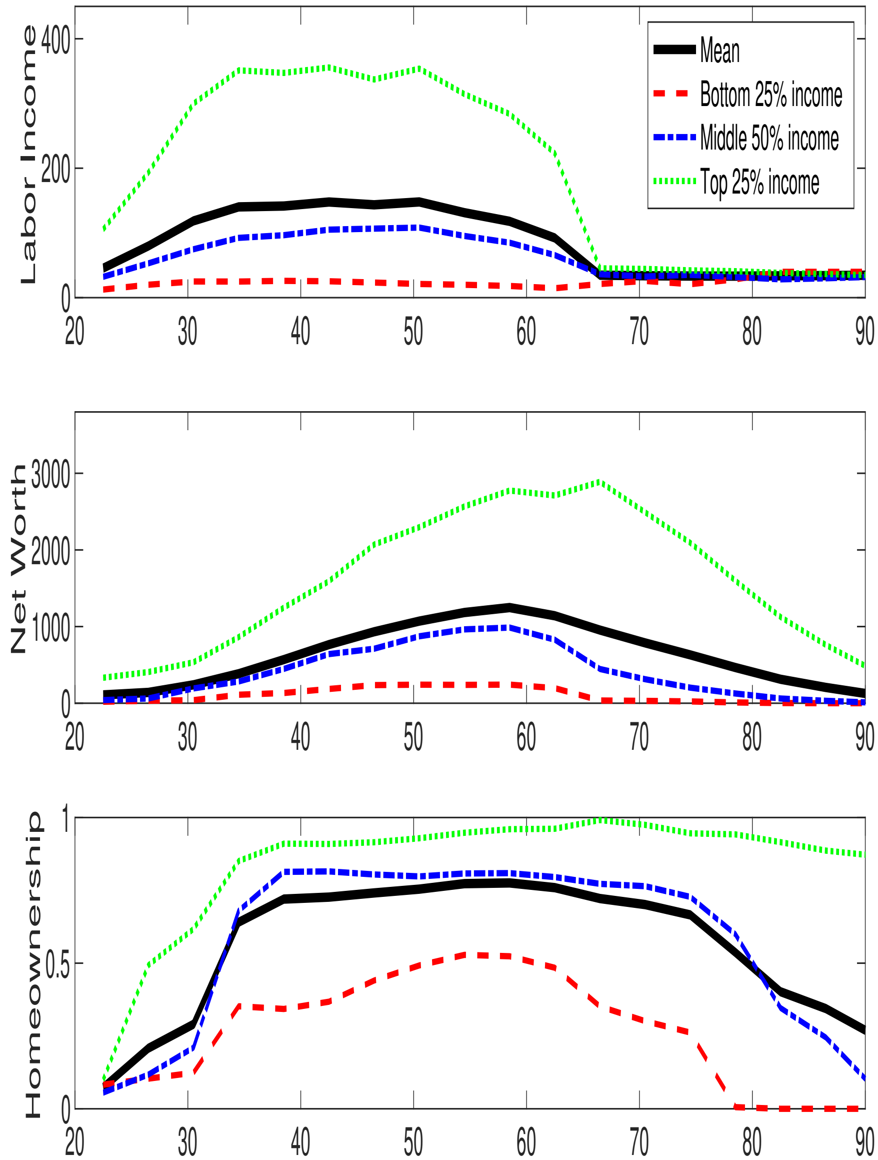
Note: The colors indicate productivity levels. For working-age households: red indicates a top 12.5% productivity household, brown a household in the next 12.5% of the productivity distribution, okra: a household in the middle 50% of productivity, and yellow a household in the bottom 25%. Retired households 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 top panel of Figure 5 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.

The middle panel of Figure 5 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.

Figure 5: 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.

4.2 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 5 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. These patterns are broadly consistent with the data.

Row 6 of Table 2 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 2 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.[33] 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.[34] Since the model matches the rent differences

[33]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.

[34]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

between zones well and rents are more directly linked to housing affordability, this is not a crucial miss for the model.

4.3 Housing Affordability

Price-Income and Rent-Income Row 12 of Table 2 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 preference parameter α^h. To get at the household-level rent burden, we compute two additional moments reported in rows 14-15 of Table 2, 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.[35] 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.

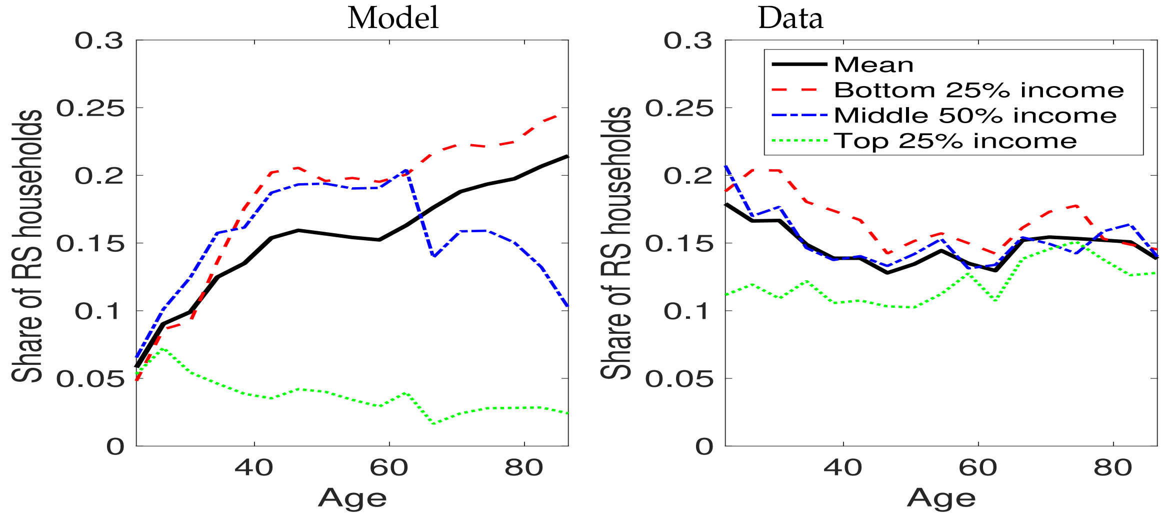
Rent Stabilization By virtue of the calibration, the model generates the right share of RS households in the population in each zone (row 16 of Table 2).

Figure 6 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

for a zone-specific sensitivity of the housing production function to the distance from the building limit may help.

[35] 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%.

Figure 6: 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.

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.

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 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.[36]

5 Affordability Policies

Having developed a quantitatively plausible dynamic stochastic spatial equilibrium model of the New York housing market, we now turn to policy counterfactuals. The first set of policies aims to improve the targeting of the rent stabilization system, the second set of policies changes the scope of the RS system, while the third set of policies affect the spatial aspects of housing. We highlight some differences with the same policy experiments conducted in a closed-economy model of the metropolitan area, where there is no migration to or from other metro areas. The "no migration" results are discussed in detail in Appendix C.

5.1 Improving the Targeting of RS

As shown above, RS in the benchmark model suffers from misallocation. The first set of policies we consider aim to improve the allocation of a given amount (square footage) of affordable housing by better targeting it on the most needy households.

Introducing Income Qualification Requirement The first experiment, reported in column (1) of Table 3, introduces an income qualification requirement for RS housing. This requirement is only imposed when households enter RS, not on existing tenants. Specifi-

[36]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.

cally, we lower κ_2 from ∞ to 60% of AMI in zone 1 and to 50% of AMI in zone 2.[37] As in the benchmark model, incumbents can remain in RS housing with exogenous probability far exceeding the endogenous entry probability for everyone else ($p^{RS,exog} >> p^{RS}$).

The policy is successful at allocating affordable housing units to low-income households. There is a 58.39% increase in the fraction of Q1-income households in RS (row 4) relative to the benchmark model. This number exceeds the increase in the fraction of all households in RS of 11.35% (row 3). Because the households in RS are lower-income, they choose smaller apartment units (rows 6 & 7), and the RS system can accommodate more households in the same square feet of affordable housing space.

RS becomes a better insurance device. Row 27 reports that lowering the income qualification threshold greatly improves *access to insurance* for lower-income households who have fallen on hard times (49.53%). Row 28 reports that income qualification leaves the *stability of insurance* nearly unaffected (0.86%). Rows 29 and 30 report the time-series standard deviation of marginal utility growth of non-housing and housing consumption, averaged across households. The policy lowers both but mostly the volatility of housing consumption (-2.68%). By offering households more housing stability, the policy brings the economy closer to complete markets.

Income targeting increases the share of households in the urban core (3.76%, row 10). Average income in zone 1 falls (-3.41%, row 20) since many of the new residents in zone 1 are lower-income households living in RS units. Many of those are of working age (the share of retirees in zone 1 falls; -5.51%, row 11).

Overall, this policy generates a modest welfare gain averaged across households that live in NY in the period prior to the reform ($\mathcal{W}_g = 0.39\%$, row 31). Figure 7 shows how welfare changes are distributed across age, productivity, income, and wealth groups. The policy benefits lower-productivity, low-income, and low-wealth households at the expense of the other groups.

Several factors work to offset the benefits from better targeting. First and foremost, a fraction $1 - p^{RS,exog}$ of existing RS tenants lose the right to stay, and are now subject to (i) the luck of the draw, and (ii) income qualification. Even if they qualify and regain access, their RS tenure clock restarts. They now receive a smaller rent discount (since the rent discount $\kappa_1(d)$ is rising in tenure d). In other words, some–possibly less needy–

[37] 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.

long-tenured tenants with large rent discounts are replaced by–more needy–tenants with small rent discounts. The welfare losses from the former offset the welfare gains from the latter group. Second, income qualification leads some to reduce labor supply in order to qualify. This effect is masked because of net in-migration (row 32) and more clearly visible in the no migration model. Third, by exempting most existing tenants from income qualification, there is little churn in the RS program and limited scope for income qualification to reduce misallocation. Fourth, changes in migration result in lower output (-0.42%, row 25), which hurts welfare. Fifth, the maximum house size cutoff for RS units already reduces misallocation by making RS unattractive for high-income households.[38]

The policy affects inter-city migration in two ways. First, it results in a larger population for the NY MSA (2.17%). This increases aggregate labor supply (row 23). Second, the composition of the population changes. There are fewer low-productivity and more higher-productivity households moving out than in the benchmark model; see left panel of Figure 8. Total hours worked in efficiency units declines (row 24), despite the large increase in total hours. Efficiency gains in the housing market from better targeting result in efficiency losses in the labor market.

Re-applying Each Period In the second policy experiment, we introduce income qualification at 60% of AMI in each zone but force each RS tenant to go through income testing each period (four years).[39] By setting the parameter $p^{RS,exog} = p^{RS}$, the endogenously determined probability of winning the RS lottery p^{RS} is now the same for everyone and increases substantially. The removes the persistent misallocation of tenants to RS units. The results in column (2) of Table 3 show that access to insurance improves dramatically (120.61%). The fraction of low-income households in RS grows strongly (59.82%), showing the improved targeting of the RS system. The overall fraction of households in RS also increases (19.23%), as poorer households choose much smaller RS unit sizes.

However, the policy experiment results in an aggregate welfare loss (-0.22%). First, the policy dramatically lowers the stability of RS insurance (-79.66%, row 28). Housing consumption becomes more volatile (+4.79%, row 30).

Second, the higher churn of RS residents lowers the average tenure and thereby the average rent discount that RS tenants enjoy. The policy makes the average RS housing

[38]In unreported results, we find that introducing an income cutoff leads to larger welfare gains if there is no RS size cutoff.

[39]Since RS housing becomes less attractive in this experiment, the RS housing market in zone 2 does not clear at a 50% of AMI income cutoff. Hence, for this experiment, we set the income limit at 60% of AMI in both zones. As in the previous experiments, these cutoffs reflect the point at which RS housing is in excess supply.

Table 3: Better Targeting of Rent Stabilization–Main Moments

		Benchm.	(1) Inc Qual New	(2) Inc Qual All	(3) Inc Qual Stay	(4) 0.50 RS discount	(5) RS size
1	Avg(rent/inc.) renters in Z1 (%)	39.5	-0.49%	12.12%	14.00%	-4.16%	-0.48%
2	Avg(rent/inc.) renters in Z2 (%)	32.8	5.54%	11.92%	11.24%	4.90%	-0.07%
3	Frac. of HHs in RS (%)	14.20	11.35%	19.23%	29.23%	7.05%	7.69%
4	Frac. in RS of those in inc. Q1 (%)	16.48	58.39%	59.82%	105.06%	19.36%	20.63%
5	Frac. rent-burdened (%)	54.7	12.10%	18.95%	22.28%	0.06%	2.02%
6	Avg. size of RS unit in Z1 (sf)	869	-16.89%	-43.31%	-48.65%	-11.59%	-5.77%
7	Avg. size of RS unit in Z2 (sf)	862	-17.22%	-22.27%	-38.04%	-8.35%	-10.37%
8	Avg. size of a Z1 mkt unit (sf)	1156	-0.21%	-2.33%	-2.52%	1.25%	0.48%
9	Avg. size of a Z2 mkt unit (sf)	1824	0.42%	1.54%	-2.61%	3.47%	-0.12%
10	Frac. of pop. living in Z1 (%)	10.5	3.76%	14.91%	10.61%	5.61%	0.48%
11	Frac. of retirees living in Z1 (%)	17.5	-5.51%	92.44%	114.80%	8.56%	3.33%
12	Housing stock in Z1	–	-0.42%	0.46%	0.37%	0.40%	-0.01%
13	Housing stock in Z2	–	0.23%	0.83%	1.17%	0.28%	-0.13%
14	Rent/sf Z1 ($)	3.55	2.07%	1.57%	6.94%	-1.61%	1.08%
15	Rent/sf Z2 ($)	1.28	2.25%	1.55%	7.48%	-1.99%	1.13%
16	Price/sf Z1 ($)	884	2.16%	1.62%	6.82%	-1.64%	1.10%
17	Price/sf Z2 ($)	249	2.33%	1.72%	7.65%	-2.01%	1.15%
18	Homeownership rate in Z1 (%)	34.8	-0.90%	-7.77%	-6.26%	-4.96%	0.52%
19	Homeownership rate in Z2 (%)	61.1	0.03%	0.35%	-2.62%	0.68%	-1.50%
20	Avg. inc. Z1 working-age HHs ($)	167840	-3.41%	-20.34%	-17.02%	-2.61%	0.35%
21	Avg. inc. Z2 working-age HHs ($)	99755	0.10%	0.46%	-0.64%	0.18%	-0.22%
22	Frac. of top-prod. HHs in Z1 (%)	21.6	1.35%	-0.61%	4.73%	-2.43%	1.11%
23	Total hours worked	–	1.88%	1.27%	6.69%	-1.28%	0.89%
24	Total hours worked in effic. units	–	-0.67%	-1.12%	-0.99%	-0.06%	-0.17%
25	Total output	–	-0.42%	-0.69%	-0.63%	-0.06%	-0.11%
26	Total commuting time	–	1.28%	2.12%	9.18%	-1.97%	0.94%
26	Developer profits	–	0.25%	2.52%	3.10%	0.88%	-0.06%
27	Access to RS insurance (%)	4.1	49.53%	120.61%	94.73%	7.06%	12.43%
28	Stability of RS insurance (%)	79.9	0.86%	-79.66%	2.03%	-0.01%	0.31%
29	Std. MU growth, nondurables	0.60	-1.25%	3.94%	2.80%	-0.51%	0.40%
30	Std. MU growth, housing	0.60	-2.68%	4.79%	3.51%	0.20%	0.42%
31	**Aggr. welfare change (NY pop)**	–	**0.39%**	**-0.22%**	**0.66%**	**-0.43%**	**0.18%**
32	NY population	7124.9	2.17%	3.73%	9.90%	-1.68%	1.09%
33	Aggr. welfare change (no migr.)	–	0.04%	-0.78%	0.32%	-0.96%	0.16%

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

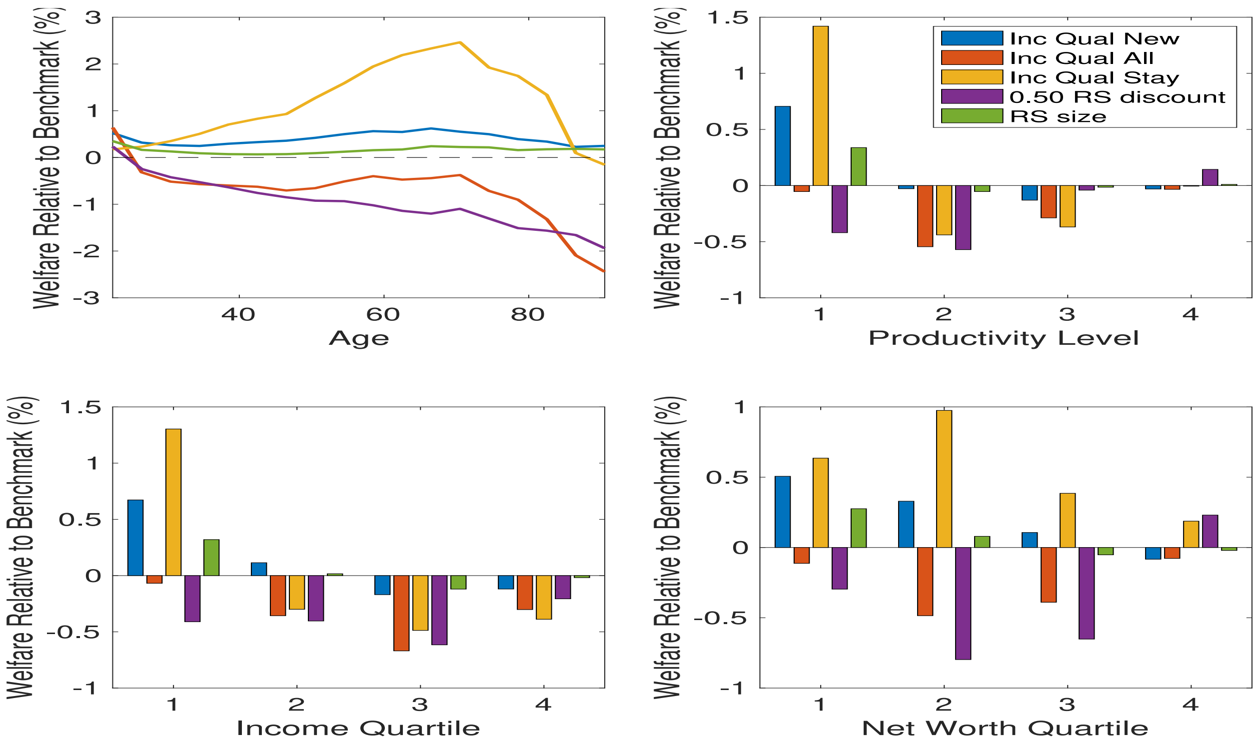
unit less affordable.

Third, the policy results in a larger NY MSA population (3.73%) since the likelihood of obtaining RS is higher now that the preference for incumbents is gone. As in the first policy experiment, the additional immigrants tend to be of lower average productivity than residents in the previous period. This lowers aggregate labor supply in efficiency units, and aggregate output falls by -0.69%. Figure 8 shows lower out-migration rates for low-income households, as well as high net in-migration for households in the second productivity group (the middle 50% of the productivity distribution).

The (endogenously) lower average rent discount in the RS system reduces distortions for developers. It results in higher developer profits (row 26) and higher housing supply.

But 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.

Figure 7: Better Targeting of Rent Stabilization–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.

Restoring the Preference for Insiders In the third experiment, we impose income qualification in each period on all tenants (60% of AMI in zone 1 and 50% of AMI in zone 2), but we allow existing tenants who qualify to remain in RS with high probability; $p^{RS,exog}$ is set to its baseline value. Compared to the baseline model, the experiment in Column (3) of Table 3 imposes an income cutoff on all RS residents in every period. Compared to the experiment in Column (1), the income cutoff now applies also to existing RS tenants. This experiment generates a welfare gain of 0.66%. It provides the fairness of income qualification while avoiding excessive churn in the RS system. The targeting of RS units to low income households improves further (105.06%, row 4). Access to insurance is much higher than in the baseline (94.73%), but now comes without loss in the stability of that insurance (2.03%). The welfare gains are larger than in column (1) since now income qualification is applied to existing tenants, reducing the misallocation that builds up over time as tenant income grows. The reform replaces high-income insiders with low-income outsiders. Like in the previous experiment, the fraction of all households in RS increases. In sum, the combination policy with income targeting and preference for insiders produces non-trivial welfare gains, yet requires no expansion of the scope of the RS program nor additional taxes.

Figure 7 shows that most of the benefits from this experiment flow to 50-80 year-olds. The policy redistributes from high-income and net-worth to low-income and low-net worth households.

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. 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.

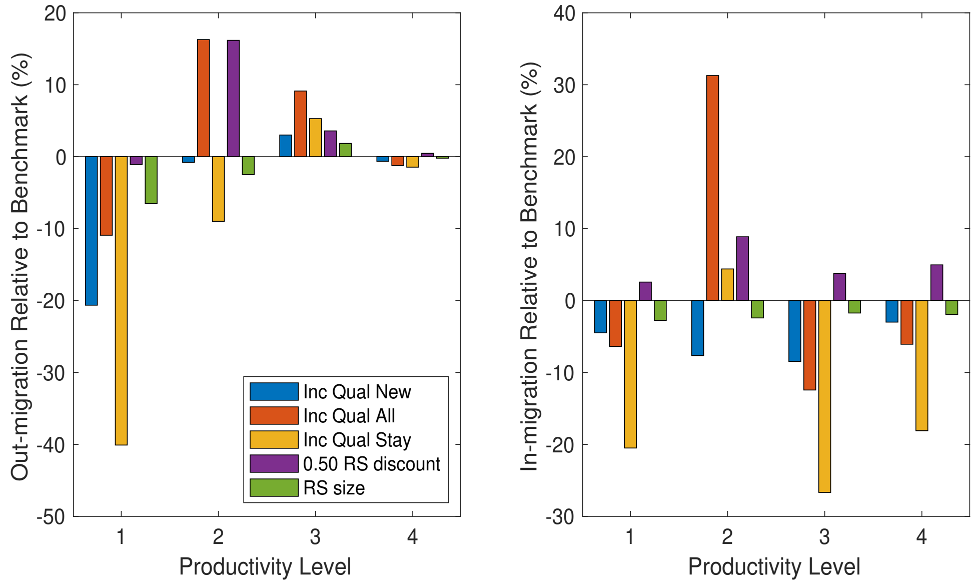
The spatial allocation of labor productivity worsens. The policy results in a much larger share of retirees, a smaller share of top-productivity households, and lower average income in zone 1. There is more "income mixing" in the urban core.

The policy attracts significant net in-migration (9.90%). While the chances of gaining access to RS conditional on receiving a negative income shock are not as high as in the previous experiment, low-income households have a higher unconditional probability of ending up in a RS unit. Also, the value of the RS insurance is now higher due to the preference for insiders. For both reasons, there is much less out-migration of poor households (Q1). Out-migration offers a way for some of those who are adversely affected to escape the adverse consequences of the policy. Indeed, Figure 8 shows more out-migration in productivity group 3. The migration option ends up raising the welfare gains of this policy for the NY population (row 33 versus 31). The policy triggers less in-migration, which can be understood from the much higher cost of living in NY after the reform.

Varying the RS Discount Column (4) of Table 3 reports on an experiment that changes the size of the rent discount for RS units relative to the market rent. We multiply the entire discount schedule $\kappa_1(d)$ by a factor of 0.5. Reducing the discount by half results in a large welfare loss (-0.43%). Figure 7 shows that a smaller discount hurts older and low-productivity households the most. The age effect arises because the discounts are increasing in tenure and the effects on rent are therefore largest in absolute magnitude for the old.

There are interesting equilibrium effects on targeting. Making RS *less* generous makes it less attractive, which reduces competition for it in the absence of income qualification,

Figure 8: Better Targeting of Rent Stabilization–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.

and results in *more* bottom-quartile households ending up in it (19.36%). Access to insurance improves, while the stability of that insurance does not deteriorate.

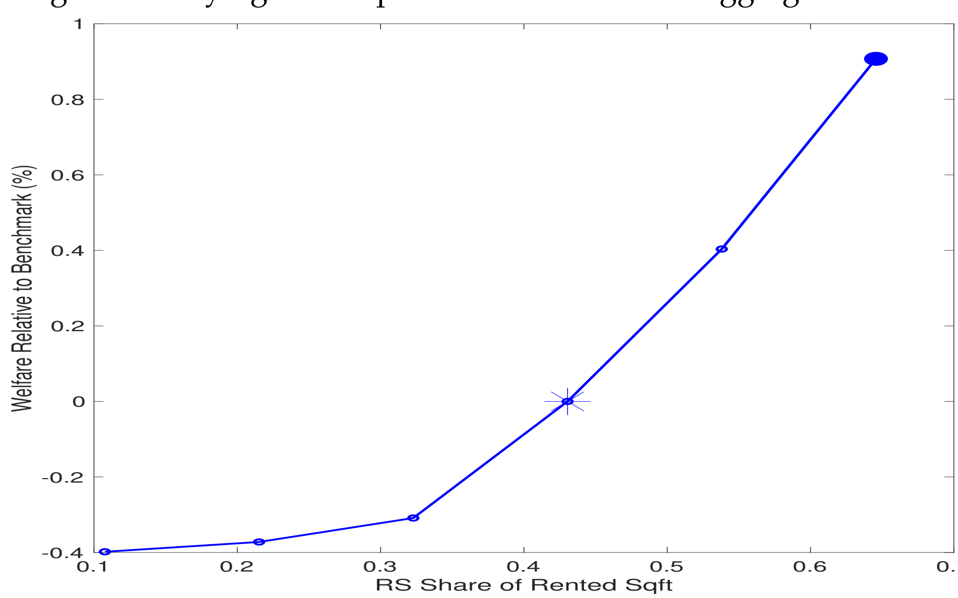
The policy reduces distortions to development, traditionally emphasized in the rent regulation literature. The reform results in higher developer profits, a larger housing stock, and lower rents. Finally, labor supply and output are nearly unchanged despite a reduction in the NY population. Out-migration is high for second-quartile productivity households, relative to the benchmark economy, since many of these households had valuable RS housing prior to the reform but lost that benefit. Lower rents and house prices attract more high-productivity households to the NY MSA. In sum, the policy that reduces the subsidies to RS housing has several benefits, but its average welfare effect is negative.

Maximum Size of Rent Stabilized Unit Because it is subsidized and not income-tested, some higher-income residents in RS may over-consume housing. Column (5) of Table 3 studies a reduction in the maximum size of a RS housing unit by 10% compared to the baseline. The average size of RS units falls by less than 10% in zone 1 and by slightly more than 10% in zone 2. The average welfare effect is a gain of 0.18%, and is concentrated on low-income households. Making RS units smaller is a reasonably effective way of targeting RS units to low-income households, simply because higher-income households do not want to live in small housing units. Because units are now smaller but the same total square feet are devoted to RS, more households qualify. For both reasons, access to insurance improves. Since low-income households benefit, they are less likely to move out of the metro area.

5.2 Varying the Scope of the Rent Stabilization Mandate

The second policy instrument we study is the scope of the affordable housing mandate. We symmetrically change η^ℓ in each zone, the fraction of rental square footage that must be set aside for affordable units, varying it from 0.25× to 1.5× its benchmark value. Table 4 reports the results. Average welfare rises monotonically in the scope of the RS mandate. Higher welfare is associated with higher fractions of households and of bottom-income quintile households in RS. Both access to RS insurance and the stability of that insurance increase in the share of rentals that are rent stabilized. Figure 9 plots average welfare as a function of η^ℓ and confirms the increasing pattern. At 1.5×, all households who want RS have access to it, so that further increases would lead to excess supply and lack of market clearing in the RS segment.

Figure 9: Varying the Scope of the RS Mandate–Aggregate Welfare



Notes: The baseline model has the following parameters: $\eta^1 = 56.37$, $\eta^2 = 29.72$, $\kappa_1 = 7\%$, $\kappa_2 = 1000.00$, $\kappa_3 = 0.50$. The share of RS rented sf is calculated as a (total sf-)weighted average of η^1, η^2. The larger dots on the right-hand side of the graph represent the maximum RS share above which markets do not clear. The welfare changes are measured as consumption equivalent variations for an average household.

Increasing RS is not without cost. It induces increasing distortions to housing and labor markets, both in terms of supply and spatial misallocation. We discuss these in turn.

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 traditional view on rent regulation and 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 decontrolled areas (Autor et al., 2014; Diamond et al., 2019).

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

A proportional increase in RS in both zones shifts the population towards the urban core (14.09% in column 5). The home ownership rate in zone 1 is much lower 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, increasing density in the urban core. The different population mix in zone 1 is reflected in a much lower average income, much fewer top-productivity households, and more retirees. 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 is 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.

There is a substantial reduction in individual labor supply by those in RS who face lower rent. The resulting reduction in aggregate labor supply can be seen clearly in the model without migration 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. But these costs are outweighed by the benefits to the RS recipients. RS policy completes markets by reducing the volatility of marginal utility growth of housing and non-housing consumption (rows 29 and 30).

Figure 10 studies the heterogeneity in welfare changes. Expanding rent stabilization benefits younger and especially low-productivity and low-income households the most.

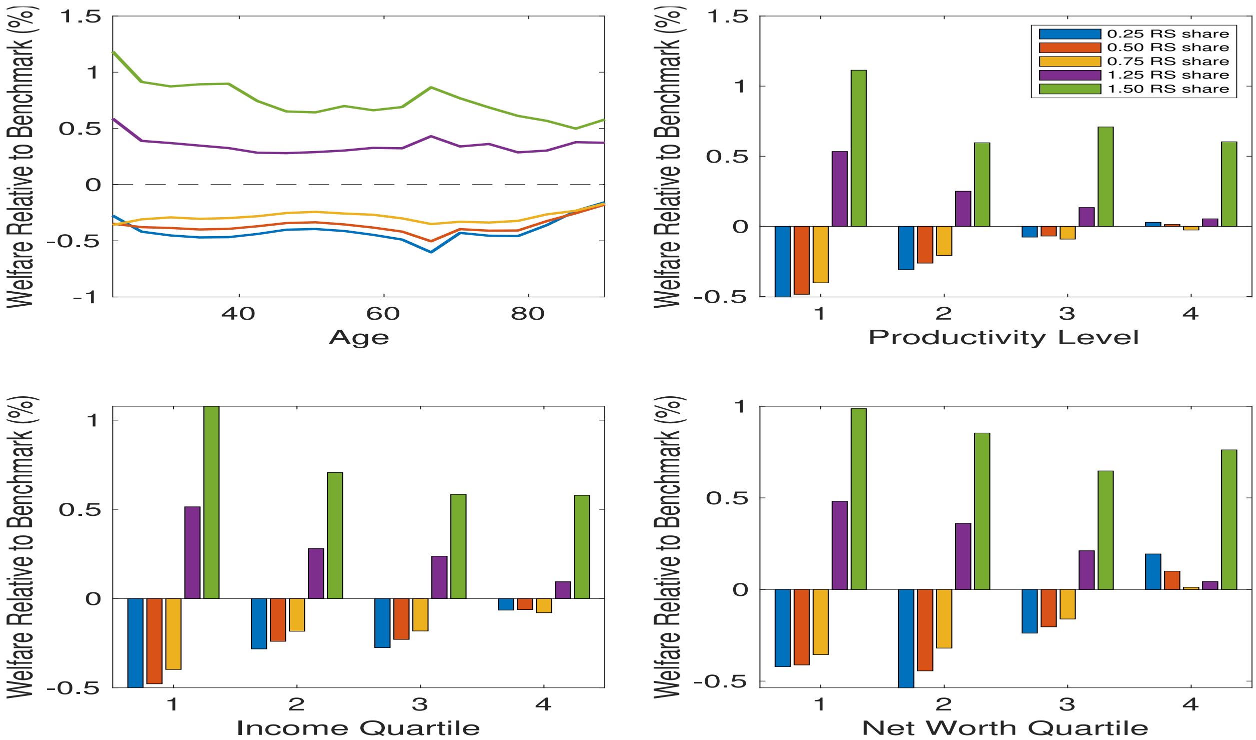
Table 4: Varying the Scope of the RS Mandate–Main Moments

		Benchm.	(1) 0.25×	(2) 0.50×	(3) 0.75×	(4) 1.25×	(5) 1.50×
1	Avg(rent/inc.) renters in Z1 (%)	39.5	-1.91%	-0.93%	0.49%	1.85%	-0.58%
2	Avg(rent/inc.) renters in Z2 (%)	32.8	4.74%	3.24%	1.58%	-1.36%	-2.58%
3	Frac. of HHs in RS (%)	14.20	-160.70%	-86.22%	-37.97%	32.40%	64.47%
4	Frac. in RC of those in inc. Q1 (%)	16.48	-155.46%	-81.30%	-35.17%	32.13%	58.72%
5	Frac. rent-burdened (%)	54.7	-1.32%	-0.88%	-0.89%	2.04%	3.97%
6	Avg. size of RC unit in Z1 (sf)	869	1.45%	1.09%	0.40%	-0.68%	-3.82%
7	Avg. size of RC unit in Z2 (sf)	862	0.21%	0.28%	0.19%	-0.70%	-1.27%
8	Avg. size of a Z1 mkt unit (sf)	1156	-3.63%	-2.81%	-1.25%	2.62%	-6.54%
9	Avg. size of a Z2 mkt unit (sf)	1824	-1.18%	-0.95%	-0.67%	1.05%	5.50%
10	Frac. of pop. living in Z1 (%)	10.5	-0.35%	-0.54%	-0.64%	2.14%	14.09%
11	Frac. of retirees living in Z1 (%)	17.5	-39.20%	-29.92%	-15.81%	16.87%	22.88%
12	Housing stock in Z1	–	0.65%	0.49%	0.46%	0.21%	0.36%
13	Housing stock in Z2	–	0.39%	0.25%	0.04%	-0.29%	-0.25%
14	Rent/sf Z1 ($)	3.55	-5.81%	-4.50%	-2.34%	3.10%	12.03%
15	Rent/sf Z2 ($)	1.28	-4.01%	-3.09%	-1.40%	1.85%	3.21%
16	Price/sf Z1 ($)	884	-5.69%	-4.37%	-2.28%	3.04%	11.28%
17	Price/sf Z2 ($)	249	-4.00%	-3.05%	-1.42%	1.88%	3.17%
18	Homeownership rate Z1 (%)	34.8	43.06%	35.61%	23.31%	-30.06%	-116.32%
19	Homeownership rate Z2 (%)	61.1	9.80%	6.84%	3.65%	-5.11%	-10.75%
20	Avg. inc. Z1 working-age HHs ($)	167840	17.76%	14.49%	9.56%	-13.87%	-42.47%
21	Avg. inc. Z2 working-age HHs ($)	99755	-3.54%	-2.77%	-1.62%	2.40%	6.69%
22	Frac. of top-prod HHs in Z1 (%)	21.6	22.31%	18.54%	12.53%	-17.68%	-82.31%
23	Total hours worked	–	-2.72%	-1.91%	-1.11%	1.12%	1.58%
24	Total hours worked in effic. units	–	0.08%	0.12%	-0.01%	-0.16%	0.02%
25	Total output	–	0.03%	0.06%	-0.02%	-0.09%	0.03%
26	Total commuting time	–	-3.69%	-2.67%	-1.42%	1.29%	0.49%
26	Developer profits	–	1.29%	0.90%	0.51%	-0.68%	-0.55%
27	Access to RC insurance (%)	4.1	-171.61%	-89.22%	-40.93%	37.33%	68.83%
28	Stability of RC insurance (%)	79.9	-10.75%	-1.03%	-0.16%	0.44%	0.21%
29	Std. MU growth, nondurables	0.60	2.14%	1.03%	0.92%	-0.46%	-1.21%
30	Std. MU growth, housing	0.60	1.38%	0.84%	0.95%	-1.18%	-4.14%
31	**Aggr. welfare change (NY pop)**	–	**-0.40%**	**-0.37%**	**-0.31%**	**0.40%**	**0.91%**
32	NY population	–	-3.46%	-2.54%	-1.28%	1.29%	1.89%
33	Aggr. welfare change (no migr.)	–	-0.98%	-0.90%	-0.68%	0.53%	1.36%

Notes: Column "Benchmark" reports values of the moments for the baseline model. The other columns report log differences between the moments in the policy experiment and in the baseline. The different columns scale down or up the share of square feet that developers must set aside for RS housing.

Interestingly, it also benefits high-income and high-wealth households. The reason is that RS now directly benefits several higher-income households given that there is no income or wealth qualification. Also, the increase in house prices benefits home owners who tend to be the wealthy. This benefit is partially offset by lower values for investment homes (due to the growing gap between primary and investment housing κ_4), and by lower developer profits (which disproportionately flow to the high-wealth households). 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 profit, which mostly flows to wealthy households, and more rent regulation reduces that profit.

Figure 10: Varying the scope of RS – 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.

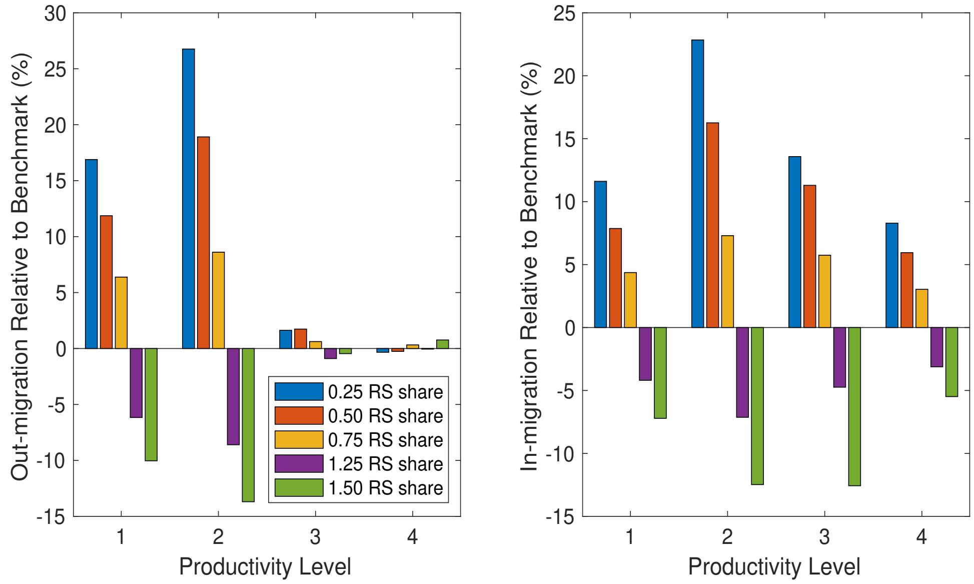
Higher prices and rents in turn dissuade in-migration, as can be seen in the right panel of Figure 11. The NY population rises solely because of reduced out-migration for bottom-half productivity households. Migration provides an extra margin of adjustment and dampens the welfare effects from either reducing or increasing the scope of the RS mandate (compare rows 31 and 33 of Table 4).

5.3 Geographic Location of Affordable Housing

Columns (1) and (2) of Table 5 conduct two policy experiments that shift all RS housing from zone 1 to zone 2. The experiment in Column (2) is coupled with subsidized public transit for RS tenants. The aggregate transit subsidy is $800 million and the subsidy is the same for all recipients at about $800 per year. It is akin to a discounted metro/rail pass for RS tenants. The subsidy is paid for by higher income taxes on all NY residents, engineered through a lower λ. By construction, the experiment keeps the number of households in RS constant.

In both experiments, the urban core gentrifies with more high-income and top-productivity

Figure 11: Varying the scope of RS – 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.

households and a much higher home ownership 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 are still 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. Market rents rise due to higher aggregate demand for rentals in zone 2. Rent-income ratios fall in both zones, and the share of rent-burdened households falls.

There is an aggregate welfare gain of 0.25% in Column (1) and 0.18% in column (2). A consequence of the reform is that the targeting of RS improves; the fraction of Q1-income households in RS increases substantially. Figure 12 shows that this policy benefits low-income households the most. Their benefit is even larger with subsidized transit. There is a welfare loss for high-income residents who shoulder most of the cost of the transit subsidy, which explains why the welfare gain is not larger in the experiment with than the one without transit subsidy.

The welfare effects are dampened relative to the no-migration model (row 33), where the benefit of the policy with transit subsidy far exceeds that without. Tax rates must rise much more in the model with migration than in the model without to raise the $800 tax revenue for the transit subsidy. The policy increases the population of NY (row 32).

Since the policy benefits lower income households, there is reduced out-migration for this group. Figure 13 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.

Table 5: Spatial Housing Policies–Main Moments

		Benchm.	(1) All RS in Z2	(2) All RS in Z2 + transit	(3) Zoning	(4) Vouchers	(5) LIHTC	(6) Cash transfer V	(7) Cash transfer P
1	Avg(rent/inc.) renters in Z1 (%)	39.5	-4.74%	-5.13%	0.28%	-0.36%	0.34%	-0.41%	-1.39%
2	Avg(rent/inc.) renters in Z2 (%)	32.8	-0.87%	-0.67%	-0.09%	0.63%	-0.26%	0.79%	4.10%
3	Fraction of HHs in RS (%)	14.20	–	–	0.14%	4.44%	0.93%	3.21%	5.11%
4	Frac. in RS of those in inc. Q1 (%)	16.48	22.43%	21.23%	0.16%	6.18%	2.21%	4.52%	5.98%
5	Frac. rent-burdened (%)	54.7	-3.96%	-0.92%	-0.18%	3.88%	0.18%	4.08%	4.12%
6	Avg. size of RS unit in Z1 (sf)	869	–	–	0.19%	-0.17%	-0.01%	-0.26%	-0.29%
7	Avg. size of RS unit in Z2 (sf)	862	-0.13%	0.09%	0.02%	-1.76%	-0.27%	-1.60%	-1.86%
8	Avg. size of a Z1 mkt unit (sf)	1156	-3.30%	-5.17%	0.40%	-1.13%	0.08%	-1.35%	-0.77%
9	Avg. size of a Z2 mkt unit (sf)	1824	-2.05%	-4.70%	-1.04%	-4.61%	0.08%	-5.14%	-4.99%
10	Frac. of pop. living in Z1 (%)	10.5	-8.43%	-7.67%	6.95%	-1.95%	0.46%	-1.95%	-3.01%
11	Frac. of retirees living in Z1 (%)	17.5	-34.48%	-21.96%	4.14%	3.13%	1.30%	2.91%	0.65%
12	Housing stock in Z1	–	0.62%	0.19%	8.80%	-0.50%	0.58%	-0.44%	-0.20%
13	Housing stock in Z2	–	-0.65%	-2.41%	-0.62%	-2.69%	0.12%	-2.74%	-1.86%
14	Rent/sf Z1 ($)	3.55	-1.55%	-1.32%	-0.29%	1.79%	-0.36%	2.01%	2.38%
15	Rent/sf Z2 ($)	1.28	1.45%	1.45%	0.24%	1.80%	-0.45%	1.97%	2.44%
16	Price/sf Z1 ($)	884	-1.38%	-1.06%	-0.27%	1.72%	-0.37%	1.89%	2.41%
17	Price/sf Z2 ($)	249	1.48%	1.60%	0.23%	1.69%	-0.43%	1.87%	2.45%
18	Homeownership rate in Z1 (%)	34.8	54.26%	54.10%	8.30%	4.26%	-0.08%	4.07%	5.09%
19	Homeownership rate in Z2 (%)	61.1	-6.30%	-9.43%	-0.64%	-6.13%	-0.45%	-4.98%	-8.03%
20	Avg. inc. Z1 working-age HHs ($)	167840	29.20%	28.37%	2.70%	4.60%	-0.11%	4.54%	5.83%
21	Avg. inc. Z2 working-age HHs ($)	99755	-6.39%	-7.75%	-1.31%	-2.09%	-0.20%	-2.37%	-2.26%
22	Frac. of top-prod HHs in Z1 (%)	21.6	32.35%	33.58%	10.10%	5.85%	0.56%	6.26%	6.07%
23	Total hours worked	–	1.69%	0.62%	0.76%	0.56%	-0.11%	0.53%	1.56%
24	Total hours worked in effic. units	–	-0.06%	-2.77%	0.28%	-3.48%	-0.07%	-3.68%	-2.69%
25	Total output	–	-0.08%	-1.83%	0.16%	-2.24%	-0.06%	-2.37%	-1.73%
26	Total commuting time	–	2.36%	1.81%	0.05%	1.10%	-0.05%	1.25%	2.28%
26	Developer profits	–	-0.24%	-2.74%	0.21%	-3.37%	0.98%	-3.69%	-2.78%
27	Access to RS insurance (%)	4.1	13.55%	13.54%	1.24%	2.42%	1.14%	3.80%	8.28%
28	Stability of RS insurance (%)	79.9	0.90%	1.23%	-0.10%	0.62%	0.21%	0.55%	-0.06%
29	Std. MU growth, nondurables	0.60	3.42%	6.45%	0.78%	2.73%	0.71%	3.72%	0.41%
30	Std. MU growth, housing	0.60	1.42%	3.75%	1.13%	1.45%	0.61%	2.08%	-1.09%
31	**Aggr. welfare change (NY pop)**	–	**0.25%**	**0.18%**	**0.11%**	**-0.00%**	**0.01%**	**-0.02%**	**3.90%**
32	NY population	7124.9	2.66%	3.32%	1.18%	2.12%	0.06%	2.37%	3.06%
33	Aggr. welfare change (no migr.)	–	0.37%	0.96%	0.40%	0.53%	0.05%	0.56%	4.66%

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

5.4 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 (3) of Table 5. 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%). The average income and home ownership rate 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 is welfare increasing with a modest average benefit of 0.11%. As can be seen in Figure 12, the upzoning policy brings positive benefits to all age, productivity, income, and wealth groups, unlike most of the other policies which disproportionately benefit the poor. 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.

Zoning reform increases the NY population (1.18%). Figure 13 shows a reduction in out-migration rates that is more pronounced for agents in the 25th–87.5th percentiles of the productivity distribution.

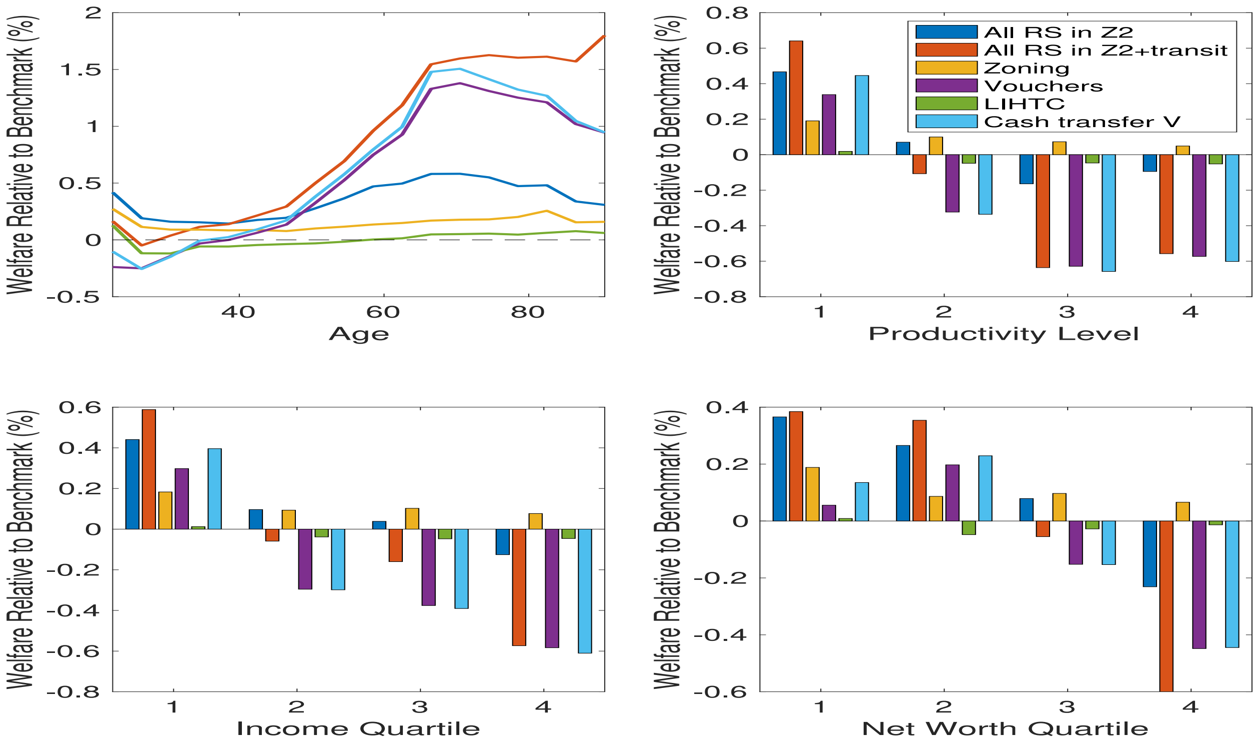
5.5 Housing Vouchers

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, the same amount as was spent on the free transit experiment above and the tax credit experiment below. 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.[40] 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.[41] The experiment pays for

[40]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.

[41]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

Figure 12: Spatial Housing Policies–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.

96,385 vouchers, or about 1.35% of NY households in the baseline model. The program is paid 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 (4) of Table 5 shows a zero welfare change for the voucher program (-0.00%). Figure 12 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

constraint from being unrealistically tight in our model where the voucher amount is fixed, we reduce the own contribution to 20% of household income.

NY, resulting in a lower income tax base, and a higher equilibrium tax increase needed to pay for the voucher program. The same Laffer-curve phenomenon was at work in the subsidized transit experiment. In the no-migration economy, the tax changes needed to pay for the vouchers are not nearly as pronounced. Output does not fall and the welfare gain from the voucher policy is substantially larger (0.53%) than in the migration economy.

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

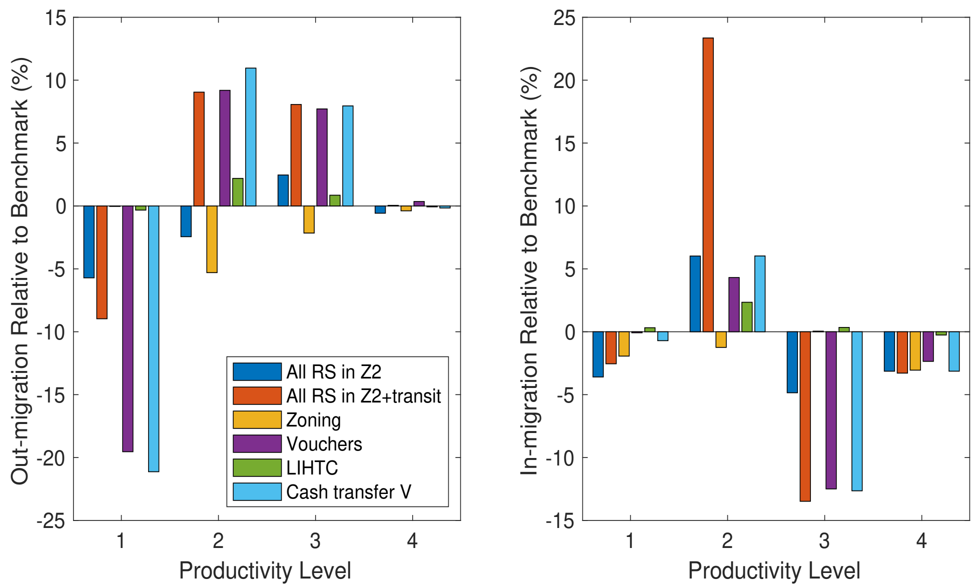
The voucher expansion, which is location-neutral in its design, has interesting spatial equilibrium effects. The policy leads to a reduction in the population share of zone 1 (-1.95%) and an increase in commuting (1.10%). It increases the average income of zone 1 (4.60%), the fraction of top-productivity 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.

5.6 Housing Tax Credits

The last housing policy we study is a version of the low-income housing tax credit (LIHTC) program. As explained in detail in Appendix B.4, the program subsidizes construction costs associated with affordable housing development. For comparability with the previous policies, the policy is sized to also cost \$800 million. The tax credit raises the average price $\overline{P}^{\ell}$ developers earn by 4.07% in zone 1 and 1.22% in zone 2, thereby stimulating new construction. The envisioned increase in the housing stock materializes in

Figure 13: Spatial Housing Policies–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.

equilibrium, and is stronger in zone 1 than in zone 2. Equilibrium rents fall in both zones, which helps with housing affordability. However, the effects are small. Tax credits in difficult-to-develop gateway cities, like New York, create too few additional affordable housing units to make a meaningful dent in the welfare of low-income households. In addition, there is the aforementioned welfare offset from the distortions resulting from the tax increases needed to pay for the tax credits. All told, we find that the tax credit program does not generate a welfare gain (0.01%). The same is true for the LIHTC experiment in the no-migration economy. This experiment underscores the importance of targeted policies and how housing affordability programs are financed.

5.7 Comparison to Cash Transfers

Finally, it is useful to contrast the housing policies to cash transfer program. Columns (6) and (7) of Table 12 study two cash transfer policies. Both of them raise the income tax rate (by lowering λ) and collect the same additional \$800 million in tax revenues as in the housing voucher, tax credit, and subsidized transit experiments. Both of them redistribute that extra tax revenue to households who earn less than 50% of AMI.

The policy in column (6) is identical in its benefit allocation to the housing voucher experiment of column (4). It simply removes the minimum housing expenditure constraint, thereby replacing the in-kind transfer with a cash transfer. The aggregate welfare effect of the "Cash transfer V" experiment (V stands for voucher) is -0.02%, close to the welfare gain in the housing voucher experiment. This goes to show that the housing constraint does not distort consumption allocations very much in the housing voucher experiment. Figures 12 and 13 confirm that the distributional and migration consequences of the voucher-like cash transfer program are also similar to the housing voucher program. We note that several of the housing policy reforms discussed above produce strictly larger welfare benefits than this cash transfer program.

The policy in column (7) aims to improve on the design of the cash transfer by changing the benefit allocation. 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 $1,1000 per year) than the cash transfer V ($8,300 per year), the cash transfer P policy is better targeted, both at the extensive margin (7% of the population are recipients versus 1.35%) and intensive margins (progressive nature of the benefit). While the benefit fluctuates over time as household income changes, it is more stable than the cash transfer V. 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 optimal targeting may be difficult in practice.

Enacting meaningful tax-and-transfer reform may be outside of the remit of local policy makers. (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. As already discussed in the context of housing vouchers, cash transfers also result in a lower long-run housing stock (-0.20% in zone 1 and -1.86% in zone 2 in column 7), 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 gain. Transfer policies have (unintended) spatial consequences, resulting in gentrification of the urban core (more high-income residents, less density, and more homeownership).

6 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 wealth effects and rich household heterogeneity that allows us to quantify 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, an expansion of the housing voucher system, and tax credits for the development of affordable housing. These policies have quantitatively important aggregate, distributional, and spatial implications. General equilibrium effects are sometimes at odds with partial equilibrium logic.

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 and housing voucher systems are also welfare improving. 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 of affordability points towards advantages from better targeting of RS 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.

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A Data Appendix

A.1 The New York Metro Area

U.S. Office of Management and Budget publishes the list and delineations of Metropolitan Statistical Areas (MSAs) on the Census website (`https://www.census.gov/population/metro/data/metrodef.html`). The current delineation is as of July 2015. New York-Newark-Jersey City, NY-NJ-PA MSA (NYC MSA) is the most populous MSA among the 382 MSAs in the nation.

NYC MSA consists of 25 counties, spanning three states around New York City. The complete list of counties with state and zone information is presented in Table 6. As previously defined, only New York County (Manhattan borough) is categorized as zone 1; the other 24 counties are categorized as zone 2. For informational purposes, the five counties of New York City are appended with parenthesized borough names used in New York City.

Table 6: Counties in the New York MSA

County	**State**	**Zone**
New York (Manhattan)	NY	Zone 1
Bergen	NJ	Zone 2
Bronx (Bronx)	NY	Zone 2
Dutchess	NY	Zone 2
Essex	NJ	Zone 2
Hudson	NJ	Zone 2
Hunterdon	NJ	Zone 2
Kings (Brooklyn)	NY	Zone 2
Middlesex	NJ	Zone 2
Monmouth	NJ	Zone 2
Morris	NJ	Zone 2
Nassau	NY	Zone 2
Ocean	NJ	Zone 2
Orange	NY	Zone 2
Passaic	NJ	Zone 2
Pike	PA	Zone 2
Putnam	NY	Zone 2
Queens (Queens)	NY	Zone 2
Richmond (Staten Island)	NY	Zone 2
Rockland	NY	Zone 2
Somerset	NJ	Zone 2
Suffolk	NY	Zone 2
Sussex	NJ	Zone 2
Union	NJ	Zone 2
Westchester	NY	Zone 2

A.2 Population, Housing Stock, and Land Area

The main source for population, housing stock and land area is US Census Bureau `American FactFinder` (`http://factfiner.census.gov`). `American FactFinder` provides comprehensive survey data on a wide range of demographic and housing topics. Using the Advanced Search option on the webpage, topics such as population and housing can be queried alongside geographic filters. We select the DP02 table (selected social characteristics) for population estimates, the DP04 table (selected housing characteristics) for housing estimates, and the GCT-PH1 table (population, housing units, area and density) for land area information. Adding 25 counties separately in the geographic filter, all queried information is retrieved at the county level. We then aggregate the 24 columns as a single zone 2 column.

Since the ACS (American Community Survey) surveys are conducted regularly, the survey year must be additionally specified. We use the 2015 1-year ACS dataset as it contains the most up-to-date numbers available. For Pike County, PA, the 2015 ACS data is not available and we use the 2014 5-year ACS number instead. Given that Pike County accounts only for 0.3% of zone 2 population, the effect of using lagged numbers for Pike County is minimal.

The ratio of the land mass of zone 1 (Manhattan) to the land mass of zone 2 (the other 24 counties of the NY MSA) is 0.0028. However, that ratio is not the appropriate measure of the relative maximum availability of housing in each of the zones since Manhattan zoning allows for taller buildings, smaller lot sizes, etc.

Data on the maximum buildable residential area are graciously computed and shared by Chamna Yoon from Baruch College. He combines the maximum allowed floor area ratio (FAR) to each parcel to construct the maximum residential area for each of the five counties (boroughs) that make up New York City. Manhattan has a maximum residential area of 1,812,692,477 square feet. This is our measure for $\overline{H}^1$. The other four boroughs of NYC combine for a maximum buildable residential area of 4,870,924,726 square feet. Using the land area of each of the boroughs (expressed in square feet), we can calculate the ratio of maximum buildable residential area (sf) to the land area (sf). For Manhattan, this number is 2.85. For the other four boroughs of NYC it is 0.62. For Staten Island, the most suburban of the boroughs, it is 0.32. We assume that the Staten Island ratio is representative of the 20 counties in the New York MSA that lie outside NYC since these are more suburban. Applying this ratio to their land area of 222,808,633,344 square feet, this delivers a maximum buildable residential square feet for those 20 counties of 71,305,449,967 square feet. Combining that with the four NYC counties in zone 2, we get a maximum buildable residential area for zone 2 of 76,176,377,693 square feet. This is $\overline{H}^2$. The ratio $\overline{H}^1/\overline{H}^2$ is 0.0238. We argue that this ratio better reflects the relative scarcity of space in Manhattan than the corresponding land mass ratio.

A.3 House Prices, Rental Prices, and Home Ownership

Housing prices and rental prices data come from `Zillow` (http://www.zillow.com/research/data) indices. Zillow publishes Zillow Home Value Index (ZHVI) and Zillow Rent Index (ZRI) monthly. The main advantage of using Zillow indices compared to other indices is that it overcomes sales-composition bias by constantly estimating hypothetical market prices, controlling for hedonics. Zillow uses a machine-learning algorithm that ensures that the ZHVI and ZRI pertain to the same, typical, constant-quality unit, in a particular geography. We use 2015 year-end data to be consistent with the ACS dataset. There are a few missing counties in ZHVI and ZRI. For the five counties with missing ZHVI index price, we use the median listing prices from the `Zillow` website instead. For the two counties with missing ZRI index price, we estimate the rents using the price/rent ratio of comparable counties. Zillow excludes non-arms' length transactions and rent-regulated rentals. To aggregate across the 24 counties in zone 2, we calculate the median price as the weighted average of the median prices in each county, where the weights are the shares of

Table 7: New York City Housing Units by Type

Type	Number of Units	Share
owner occupied		**31.6%**
owner occupied condo, coop, conventional	950,404	29.8%
Mitchell lama or Article 4 coop	57,064	1.8%
market rental	936,660	**29.4%**
rent stabilized (RS)	966,442	**30.3%**
rent controlled (RC)		**8.8%**
public housing	186,175	5.8%
rent controlled	21,751	0.7%
Mitchell lama or Article 4 Rental	43,529	1.4%
HUD or other regulated (Loft Board, Municipal Loan Program)	26,845	0.8%
In rem housing	1,661	0.1%

housing units. Similarly, for the median rent of zone 2, we average median rents of the 24 counties using housing unit shares as weights.

Home ownership data is directly from `American FactFinder`. In table DP04 (selected housing characteristics), the *Total housing units* number is divided by *Occupied housing units* and *Vacant housing units*. *Occupied housing units* are further classified into *Owner-occupied* and *Renter-occupied* housing units, which enables us to calculate the home ownership ratio.

A.4 Rent Regulation

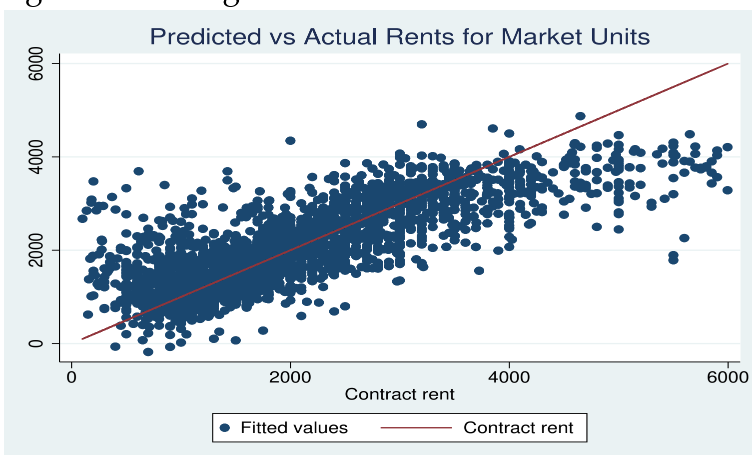
The main source for rent regulation data is US Census Bureau New York City Housing and Vacancy Survey (NYCHVS; `http://www.census.gov/housing/nychvs`). NYCHVS is conducted every three years to comply with New York state and New York City's rent regulation laws. We use the 2017 survey data table, which is the most recent survey data. This survey also corrects a misclassification in the type of housing units in earlier surveys. Table 7 below lists the non-vacant housing units by type. In New York City, owner-occupied units make up 31.6% of the housing units, market rentals make up 29.4%, rent stabilized units (RS) make up 30.3%. We group the remaining housing units (8.8%), under the auspices of seven different affordable housing programs, into a category we call rent controlled (RC) units. Most of those are public housing units; only 0.7% of the housing stock are actual rent controlled units.

Rent stabilization generally applies to apartments in buildings with six or more units constructed before 1974. Rent stabilized units are restricted in terms of their annual rent increases, which is set by the Rent Guidelines Board. The vast majority of units built after 1974 that are rent stabilized are so voluntarily. They receive tax abatement in return for subjecting their property to rent stabilization for a defined period of time. 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, 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 July 2019. Our data do not include the period after July 2019.

A.4.1 Measuring the Discount in RS Housing Units

To measure the extent of the rental subsidy in RS and RC rental units, we perform the following exercise. We first estimate a hedonic model for market rental units, where we regress the out-of-pocket rent (which equals the contract rent for this group) on a list of unit characteristics. We omit all apartments whose rent is top-coded; they have rents above $5,995 per month. Figure 14 plots the actual rent against the predicted rent by this hedonic model; the R^2 from this regression is 63.9%. The figure notes list the characteristics included in the regression.

Figure 14: Fitting Market Rent for Market Rental Units



Notes: Horizontal axis: contract market rent (in dollars per month). Vertical axis: predicted market rent from a linear regression of market rent on a set of characteristics: sub-borough area, categorical variables for number of bedrooms, number of bathrooms, year built, number of units in the building, number of stories in the building, elevator, complete kitchen, working kitchen, complete plumbing, peeling paint, deep-wear floors, cockroaches, heating breakdowns, maintenance deficiencies, any holes in walls, any holes in floors, air conditioning, cable/internet, condition of the building, missing brick in walls, years living in the unit, household interest income, and householder race. Data are from the 2017 New York City Housing and Vacancy Survey.

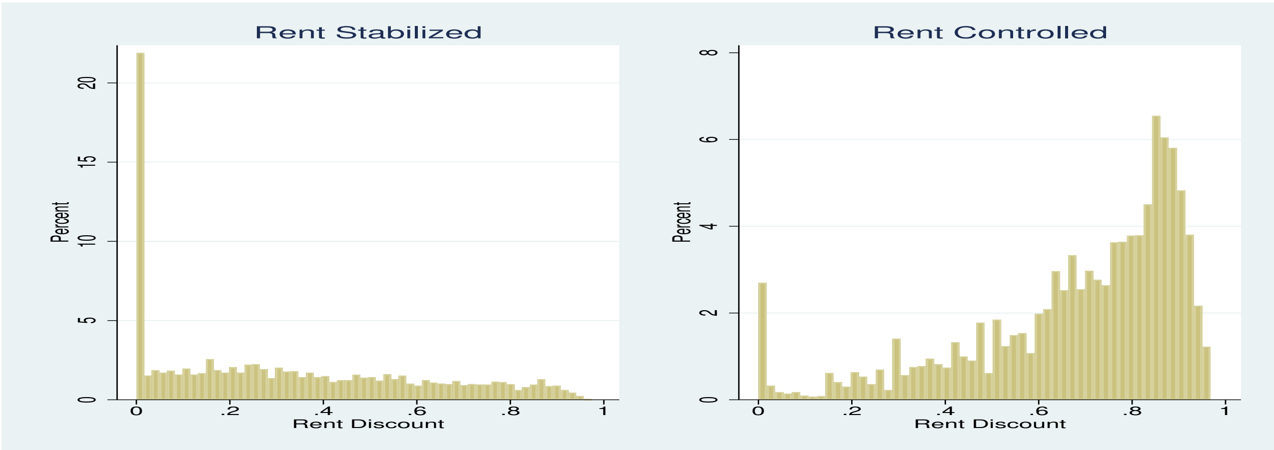
In the next step, we use the hedonic coefficients estimated from market rentals and multiply them by the characteristics of the RC and RS units to obtain an "imputed market rent." We set a unit's actual contract rent as the floor for the imputed market rent. We define the "discount" as 1 - (out-of-pocket rent/imputed market rent). Figure 15 plots a histogram for the discount on RS units (left panel) and RC units (right panel). The median discount for RS units is 26.2% with interquartile range of [0.5,53.5%]. For RC units, the median discount is 77.7% with interquartile range [61.4,86.4%].

Finally, we analyze the distribution of the discount, conditional on how long the tenant has lived in the unit. We sort tenants in four groups: 0-4 years in the unit, 4-8 years, 8-12 years, and 12 or more years. The box plot on the left of Figure 16 is for RS tenants while the plot on the right is for RC tenants. For RS units the discount is strongly increasing in length of tenancy, while for RC units it is not. For RS, the discount rises from 7% for tenancies between 0 and 4 years, 20% for 4-8years, 27% for 8-12 years, and 45% for 12 or more years. In unreported results, we find that considering additional breakdowns beyond 16 years are not statistically different from one another. This is the discount schedule we use in the calibration.

A.4.2 Measuring Share of RS Units

The NYHVS provides the number of all renter-occupied units and the number of RS units for New York City, as reported in Table 7, for each of the five counties in New York City. The share

Figure 15: Rent Discount



Notes: Histogram of rent discounts for rent stabilized units (left panel) and rent controlled units (right panel). The discount for a housing unit is defined as 1 - out-of-pocket rent/imputed market rent. The implied market rent uses the characteristics of the units and the hedonic coefficients estimated from the sample of market rentals. The floor for the imputed market rent is the contract rent for the unit. Data are from the 2017 New York City Housing and Vacancy Survey.

of all housing units that are rent-stabilized in Manhattan (zone 1) is 37.29% in 2017. The share of renter-occupied units that are RS in Manhattan is 49.48%. To measure the number and share of RS units for zone 2 of the New York metro, we need data on total renter-occupied and RS units for the remaining twenty counties outside New York City. For the other 20 counties outside of New York City, we measure the total stock of renter-occupied units from the 2018 American Community Survey (5-year survey). We obtain the number of rent stabilized units from `Affordable Housing Online` (http://affordablehousingonline.com) at the county level. We add up the total number of RS units and the total number of occupied units across the 24 counties of zone 2. The resulting RS share out of all housing units in zone 2 is 12.01%. The share of RS units out of renter-occupied units in zone 2 is 26.65%.

A.4.3 Rent-Stabilization by Age and Income

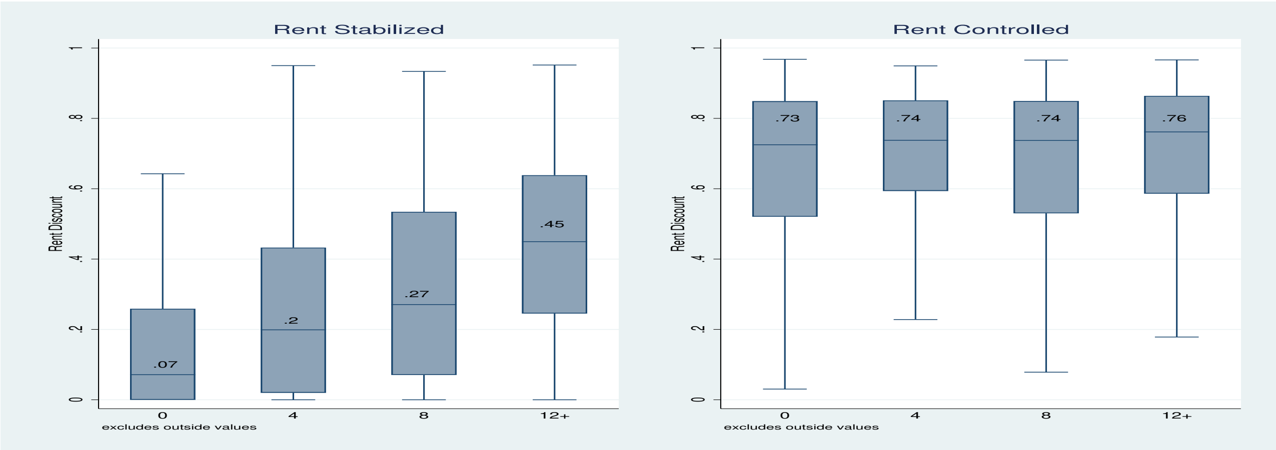
We calculate the prevalence of rent stabilization for renter households of various ages and income levels. We perform this analysis using microdata available from the NYHVS, i.e., for the five counties in New York City. For the purposes of this graph, we compute define the RS share as the ratio of RS plus RC units to the sum of RS plus RC plus market rental units. This is plotted in the right panel of Figure 6 in the paper.

A.5 Migration Data

A.5.1 Migration Out and Into New York MSA

The best available data to measure migration by age and income out-of and into the New York MSA comes from the Internal Revenue Service SOI Tax Stats Migration data 2011-2012 (https://www.irs.gov/statistics/soi-tax-stats-migration-data-2011-2012). The file computes migration rates by comparing address of residency in two successive tax returns in 2011 and 2012. The data universe is the universe of individuals who file Tax Form 1040. Tax returns are matched on the taxpayer identification number of the primary, secondary, and dependent filers. Since only the state-level migration data contain information on age and income, we use the New York State

Figure 16: Rent Discount Conditional on Tenancy



Notes: Histogram of rent discounts for rent stabilized units, conditional on tenancy (left panel) and rent controlled units, conditional on tenancy (right panel). The discount for a housing unit is defined as 1 - out-of-pocket rent/imputed market rent. Tenancy is defined as the number of years a tenant has lived in the unit. We define four tenancy groups: 0-4 years, 4-8 years, 8-12 years, and more than 12 years. Data are from the 2017 New York City Housing and Vacancy Survey.

file as a proxy for the New York MSA. The in-migration rate is defined as the ratio of the number of inflow tax returns to the sum of same-state tax returns plus non-migrant tax returns plus inflow tax returns. The out-migration rate is defined as the ratio of the number of outflow tax returns to the sum of same-state tax returns plus non-migrant tax returns plus inflow tax returns.

A.5.2 Migration Within New York MSA

We use county-to-county migration data for 2006-2010 and 2010-2014 from the 5-year American Community Survey for the 25 counties in the New York metropolitan area. For Manhattan (zone 1), we compute the frequency of moves to one of the 24 counties in zone 2. For each of the 24 counties in zone 2, we compute the likelihood of moving to Manhattan. We aggregate these mobility rates by computing the population-weighted average across the 25 counties. We compute the annual probability of moving by 4-year age groups, and also separately for home owners and renters. The resulting mobility rates are plotted in Figure 2.

B Calibration Appendix

B.1 Earnings Calibration

Before-tax earnings for household i of age a is given by:

$$y_{i,a}^{lab,\ell} = W_t n_t^i G^a z^i \mathcal{A}^\ell$$

where G^a is a function of age and z^i is the idiosyncratic component of productivity. Since endogenous labor supply decisions depend on all other parameters and state variables of the model, exactly matching earnings in model and data is a non-trivial task.

Age Profile We determine G^a as follows. For each wave of the Survey of Consumer Finance (SCF, every 3 years form 1983-2010), we compute average earnings in each 4-year age bucket (above age 21), and divide it by the average income of all households (above age 21). This gives us an average relative income at each age. We then average this relative age-income across all 10 SCF waves.

Income Dispersion by Age We also use SCF data to determine how the dispersion of income changes with age. We choose four grid points for income, corresponding to fixed percentiles (0-25, 25-75, 75-87.5, 87.5-100). To compute the idiosyncratic income $z_{a,i}$ of each group $i \in \{1,2,3,4\}$ at a particular age a, relative to the average income of all households of that age we do the following:

Step 1: For each positive-earnings household, we compute which earnings group it belongs to among the households of the same age.

Step 2: For each 4-year age bucket, we compute average earnings of all earners in a group.

Step 3: We normalize each group's income by the average income in each age group, to get each group's relative income.

Step 4: Steps 1-3 above are done separately for each wave of the SCF. We compute an equal-weighted average across all 10 waves to get an average relative income for each age and income group. This gives us four 11x1 vectors $z_{a,i}$ since there are 11 4-year age groups between ages 21 (entry into job market) and 65 (retirement). Note that the average z across all households of a particular age group is always one: $E[z_{a,j}|a] = 1$.

Step 5: We regress each vector, on a linear trend to get a linearly fitted value for each group's relative income at each age. The reason we perform Step 5, rather stopping at Step 4 is that the relative income at age 4 exhibits some small non-monotonicities that are likely caused by statistical noise (sampling and measurement error). Step 5 smoothes this out.

The steps above apply to both the New York and Outside MSA income profiles.

Income Dispersion by Productivity - New York The four productivity grid points at the average age are chosen to match the NY metro income distribution. The data is the 2018 U.S. Census Bureau's `IPUMS`. For all countries in the New York metro, we obtain total pre-tax household income of all household members older than 15. The data are not top-coded. We compute average income of the bottom 25%, the middle 50%, the next 12.5%, and the top 12.5%. The resulting averages in each bin are reported in Panel B of Table 8. We divide these numbers by \$90,234, which is the average in the Outside region defined below, to arrive at the productivity grid $z^i \in Z^{NY} =$ [0.1907, 0.9012, 1.9227, 4.1867]. The average income in the NY metro area is \$113,883, which is 26.2% higher than the average income Outside. Hence, the mean productivity in NY is 1.262, while mean productivity is normalized to 1.00 Outside.

Income Dispersion by Productivity - Outside MSA For the outside MSA, we use the Office of Management and Budget MSA definitions and include 261 MSAs, excluding NYC. Household income is measured from the same 2018 IPUMS data set we use for New York. Average pre-tax household income by group is reported in Panel C of Table 8. We divide by average income of \$90,234, so that the grid averages to 1. This results in states: $z^i \in Z^{Outside} =$ [0.1906, 0.7410, 1.5067, 3.1480].

Income Risk The 4×4 transition probability matrix for z^i is age-invariant, but is allowed to depend on β type. Specifically, the expected duration of the highest productivity state is higher for the more patient agents. The transition probability matrix for z is $\mathbb{P}$ for β^L agents. We impose the following restrictions:

$$\mathbb{P} = \begin{bmatrix} p_{11} & 1-p_{11} & 0 & 0 \\ (1-p_{22})/2 & p_{22} & (1-p_{22})/2 & 0 \\ 0 & (1-p_{33})/2 & p_{33} & (1-p_{33})/2 \\ 0 & 0 & 1-p_{44} & p_{44} \end{bmatrix}$$

For β^H types, the transition probability matrix is the same, except for the last two entries which are $1 - p_{44} - p^H$ and $p_{44} + p^H$, where $p^H < 1 - p_{44}$. We pin down the five parameters

$$(p_{11}, p_{22}, p_{33}, p_{44}, p^H) = (0.93, 0.92, 0.28, 0.64, .02)$$

to match the following five moments. We match the population shares in each of the four income groups, which are fixed at 25%, 50%, 12.5%, and 12.5%. Given that population shares sum to one, that delivers three moments. We match the persistence of individual labor income to a value of 0.9, based on evidence form the PSID in Storesletten, Telmer, and Yaron (2006). Finally, we choose p^H to match the fraction of high-wealth households in the top 10% of the income distribution. The transition probability matrix is identical in the two MSAs.

Table 8 summarizes the results. Average earnings are reported annually. Earnings autocorrelation and volatility are reported for 4 years.

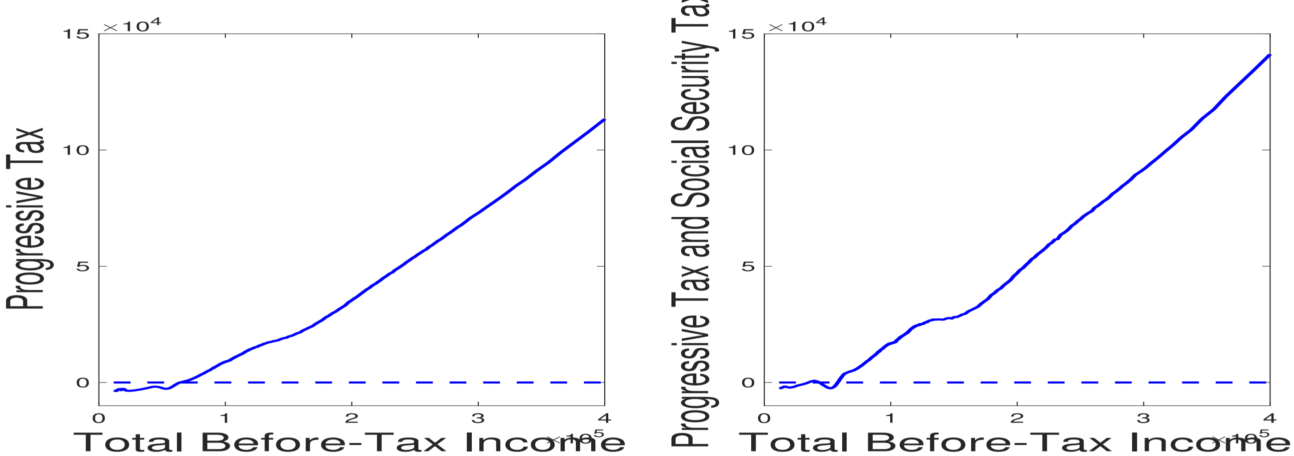
Table 8: Labor Earnings Calibration

	All	Group 1	Group 2	Group 3	Group 4
		Panel A: Common Parameters			
Earnings autocorr.	0.77				
Earnings vol.	0.125				
Corr. (income,wealth)	0.23				
Pop. shares Model		25%	50%	12.5%	12.5%
Pop. shares Data		25%	50%	12.5%	12.5%
		Panel B: New York Metropolitan Area			
Avg. earnings Model		15,257	71,247	158,526	375,374
Avg. earnings Data		17,207	81,333	173,526	377,848
		Panel C: Outside Metropolitan Area			
Avg. earnings Model		16,699	65,500	129,118	292,959
Avg. earnings Data		17,200	66,872	135,972	284,089

B.2 Progressive Taxation

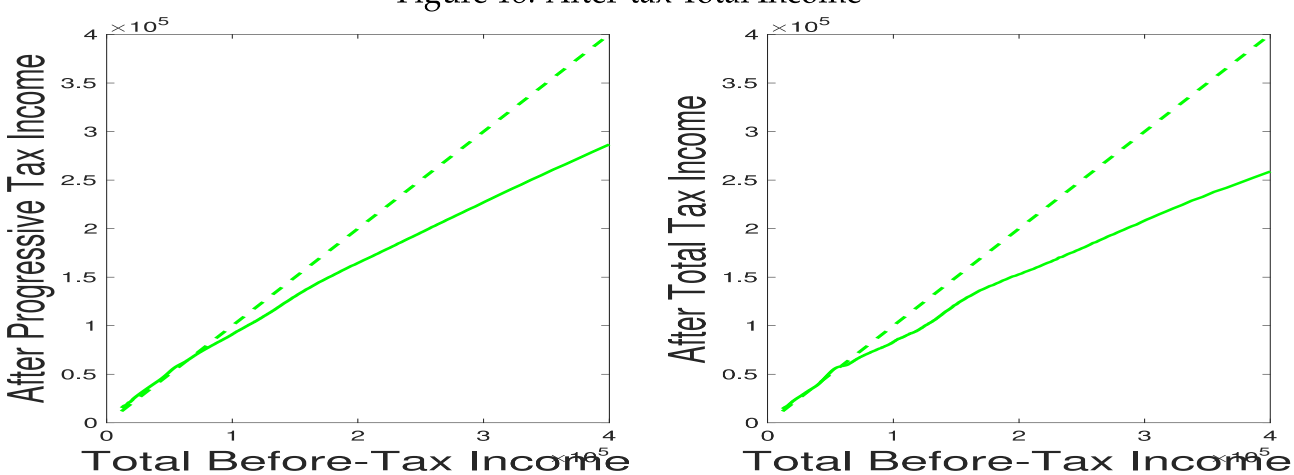
Following Heathcote et al. (2017), households with income $y^{tot} < y_0^{tot} = \lambda^{\frac{1}{\tau}}$ receive transfers $T(y^{tot}) < 0$, and those with $y^{tot} \geq y_0^{tot}$ pay taxes $T(y^{tot}) \geq 0$. We set $\tau = 0.17$ and $\lambda = 0.75$, as discussed in the calibration section. As a result of our calibration, 39% of households are subsidized by the progressive tax system, and 35% receive a subsidy after subtracting Social Security taxes. Figure 17 describes the progressive taxation system. At low total income values, some households receive a subsidy, which progressively decreases. At higher incomes, taxes increase faster than income. This is reflected in households' after-tax income, shown in Figure 18.

Figure 17: Progressive Taxes



Notes: Horizontal axis: total income (in dollars, annual), measured as the sum of labor earnings, pensions, and financial income. Vertical axis: taxes minus transfers excluding Social Security taxes (in dollars, annual; left panel), total taxes minus transfers including Social Security taxes (in dollars, annual; left panel). The dashed line plots the zero-tax case.

Figure 18: After-tax Total Income



Notes: Horizontal axis: total income (in dollars, annual). Vertical axis: post-tax income excluding Social Security taxes (in dollars, annual; left panel), post-tax income including Social Security taxes (in dollars, annual; left panel). The dashed line is the 45 degree line.

B.3 Housing Supply Elasticity Calibration

We compute the long-run housing supply elasticity. It measures what happens to the housing quantity and housing investment in response to a 1% permanent increase in house prices. Define housing investment for a given zone, dropping the location superscript since the treatment is parallel for both zones, as:

$$Y_t^h = \left(1 - \frac{H_{t-1}}{\overline{\overline{H}}}\right) N_t^{\rho_h}.$$

Note that $H_{t+1} = (1-\delta)H_t + Y_t^h$, so that in steady state, $Y^h = \delta H$. Rewriting the steady state housing investment equation in terms of equilibrium quantities using (8) delivers:

$$H = \frac{1}{\delta}\left(1 - \frac{H}{\overline{\overline{H}}}\right)^{\frac{1}{1-\rho_h}} \rho_h^{\frac{\rho_h}{1-\rho_h}} \overline{P}^{\frac{\rho_h}{1-\rho_h}} W^{\frac{-\rho_h}{1-\rho_h}}$$

Rewrite in logs, using lowercase letters to denote logs:

$$h = -\log(\delta) + \frac{1}{1-\rho_h}\log(1 - \exp(h - \overline{h})) + \frac{\rho_h}{1-\rho_h}\overline{p} - \frac{\rho_h}{1-\rho_h} w$$

Rearrange and substitute for $\overline{p}$ in terms of the market price $\overline{p} = \log(ho + (1-ho)\kappa_4) + p$:

$$p = \frac{1-\rho_h}{\rho_h} h - \frac{1}{\rho_h}\log(1 - \exp(h - \overline{h})) + k$$

where

$$k \equiv \frac{1-\rho_h}{\rho_h}\log(\delta) + w - \log(ho + (1-ho)\kappa_4)$$

Now take the partial derivative of p w.r.t. h:

$$\frac{\partial p}{\partial h} = \frac{1-\rho_h}{\rho_h} + \frac{1}{\rho_h}\frac{\exp(h-\overline{h})}{1-\exp(h-\overline{h})} + \frac{\partial k}{\partial h}$$

Invert this expression delivers the housing supply elasticity:

$$\frac{\partial h}{\partial p} = \frac{\rho_h}{1 - \rho_h + \frac{\exp(h-\overline{h})}{1-\exp(h-\overline{h})} + \left[\rho_h \frac{\partial w}{\partial h} - \rho_h \frac{(1-\kappa_4)}{ho+(1-ho)\kappa_4}\frac{\partial ho}{\partial h}\right]} \tag{14}$$

If (i) the elasticity of wages to housing supply is small ($\frac{\partial w}{\partial h} \approx 0$) and either the RC distortions are small ($\kappa_4 \approx 1$) or the home ownership rate is inelastic to the housing supply ($\frac{\partial ho}{\partial h} \approx 0$), or (ii) if the two terms in square brackets are positive but approximately cancel each other out, then the last two terms are small. In that case, the housing supply elasticity simplifies to:

$$\frac{\partial h}{\partial p} \approx \frac{\rho_h}{1 - \rho_h + \frac{\exp(h-\overline{h})}{1-\exp(h-\overline{h})}}$$

Since, in equilibrium, $Y^h = \delta H$, $\partial y^h/\partial p = \partial h/\partial p$.

Note that $h - \overline{h}$ measures how far the housing stock is from the constraint, in percentage terms. As H approaches $\overline{H}$, the term $\frac{\exp(h-\overline{h})}{1-\exp(h-\overline{h})}$ approaches $+\infty$ and the elasticity approaches zero. This is approximately the case in zone 1 for our calibration. If H is far below $\overline{H}$, that term is close to zero and the housing supply elasticity is close to $\frac{\rho_h}{1-\rho_h}$. That is approximately the case for zone 2 in our calibration. Since zone 2 is by far the largest component of the New York metro housing stock, zone 2 dominates the overall housing supply elasticity we calibrate to.

In the calibration, we use equation (14) to measure the housing supply elasticity and set $\frac{\partial w}{\partial h} = 0.05$ based on evidence from Favilukis and Van Nieuwerburgh (2021), who study a model with aggregate shocks to housing demand driven by out-of-town home buyers.

B.4 Tax Credits

Tax credits directly incentivize the development of affordable housing units by giving developers subsidies to offset the cost of affordable housing construction.

B.4.1 Institutional Background

Developers who receive tax credits for affordable housing development can sell them to other profitable firms; they fetch prices above 90 cents on the dollar. In other words, they are (nearly) equivalent to cash subsidies. The main program, the federal Low Income Housing Tax Credit (LIHTC) subsidizes 30% of the construction cost associated with affordable housing units. This is known as the 4% program. A 4% subsidy of construction costs is given over a 10-year period, and is worth 30% of construction costs in present-value terms. There is a second program, the 9% subsidy for 10 years, which is worth 70% in present-value terms, which is aimed at more deeply affordable housing units. We focus on the 4% LIHTC program. Total spending on LIHTC is \$9 billion annually nationwide; about \$50 million in the New York MSA. Additional programs, like Tax Incremental Financing, are ran by municipal governments. LIHTCs are often used to subsidize mixed market rate-affordable housing projects. In practice, it is up to the states to decide how to spend their federal LIHTC allocations depending on which areas and which points of the income distribution they want to target. In places like Manhattan with high costs of land and high construction costs, the only way to break even on an affordable housing development through tax credits, given the rules of the LIHTC, is to build a mixed property with market-rate and affordable units. Such areas are known as *Difficult to Develop Areas*. They are our focus. Davis et al. (2017) study instead low-income tracts with a poverty rate above 25%, the so-called QRT areas.

B.4.2 Modeling Tax Credits

Our experiment considers an expansion of the LIHTC in the New York MSA. In the model, developers in a given zone earn a price per sf built equal to the market price times a discount; recall equation (6), repeated here for convenience:

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

The discount depends on the fraction of units that are owned (ho_t^{ℓ}) and the rent discount due to RS housing κ_4^{ℓ}. We now assume that developers receive a subsidy to help offset the rent discount due to RS:

$$\kappa_4^{\ell} = 1 - \eta^{\ell} + \eta^{\ell}\overline{\kappa_1}^{\ell}(1 + LIHTC),$$

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 $\sum_d \omega^\ell(d) = 1$.

In the benchmark model, the parameter $LIHTC = 0$. In the LIHTC experiment, we subsidize 30% of the construction costs for 50% of the development. Thus we choose $LIHTC$ such that the total value of LIHTC subsidies, aggregated first across all firms within each zone and then across zones, is equal to $50\% \times 30\% = 15\%$ of the construction costs associated with the construction of RS housing. We compute the construction costs of RS housing as follows. Since the only input is labor, we take the total wage bill in each zone (aggregating across firms) and multiply it by the share of RS sf to compute the construction costs associated with RC housing in that zone; then we sum across zones and multiply by 15%. That gives us the total value of LIHTC subsidies. Matching the construction costs of RC housing requires a value for the parameter $LIHTC$ of 0.14. We assume it is identical across zones. When accounting for ownership rates and shares of RC sf in each zone, the tax credits increases the average price $\overline{P}_t^\ell$ earned by developers by 4.07% in zone 1 and 1.22% in zone 2. We then change the value of λ in the tax-and-transfer function to generate enough additional tax revenue to exactly pay for the aggregate tax credit outlay. The policy is budget neutral, like the previous experiments. The size of the program, the extra tax dollars raised (and spent), is calibrated to be the same as for the voucher program and equals \$800m. Hence, these two programs are directly comparable. Developers continue to build market rate and affordable units in proportions $1 - \eta^\ell$ and η^ℓ.

C No Migration Model

This appendix discusses the results for a model where there is no migration in or out of the metropolitan area. The model consists of just the gateway MSA with its zone 1 and zone 2, but no outside location. We begin by discussing the calibration, to the extent that it differs from the baseline model with migration. Then, we show baseline results for the no migration model. Finally, we revisit the same policy experiments we studied in the migration model.

C.1 Calibration

We set $\overline{H^2} = 1.69$ 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. The ratio $\overline{H^1}/\overline{H^2}$ is the same as in the benchmark model. The no migration model delivers 0.63. The housing supply elasticity is much lower in zone 1 (0.07) than in zone 2 (0.65), because in zone 1 the housing stock is much closer to $\overline{H}$ (10% from the constraint) than in zone 2 (66% from the constraint).

The minimum hours constraint is the same, but now binds for 10.05% of workers in the no migration equilibrium.

The agglomeration parameter that governs the extra productivity a household derives from living in the urban core $\mathcal{A}^1 = 1.047 > \mathcal{A}^2 = 1$ is chosen to help the model match the 1.66 ratio of average income in zone 1 to zone 2 in NY.

The financial cost of commuting ϕ_F^2 is set to 1.9% of average labor earnings, or \$2393 per household per year.

The values for β^H and β^L are the same as in the benchmark. The no-migration model implies an average wealth-income ratio of 6.25, compared to 5.69 in the 1998-2010 SCF data. The model's wealth Gini coefficient is 0.77, close to the observed wealth Gini coefficient of 0.80 for the U.S. Both numbers are slightly higher than in the migration model.

Two parameters govern the amenity value of housing in (4); since there is no Outside region, $\chi^{NY} = 1.000$. Living in Manhattan relative to the rest of the NY metro gives a utility boost $\chi^1 = 1.063$. And being a retiree in Manhattan gives an additional utility boost of $\chi^R = 1.050$. We choose these parameters to match the 2.78 ratio of rents in zone 1 to zone 2, and the 0.91 ratio of retirees in zone 1 to zone 2. In the model, these ratios 2.78, and 0.92, respectively.

We impose a minimum housing size of 544 square feet. This is 33% of the average housing unit size of 1644 square feet in NY.

We set the share of *square feet* of *rental* housing devoted to RS units, $\eta^1 = 56.92\%$ and $\eta^2 = 31.63\%$, to match the observed share of *households* in the *entire* population that are in RS units in each zone, namely 37.3% in zone 1 and 12.0% in zone 2. Households who were in RS in the previous period have a probability of 83.7% to qualify for RS in the same zone this period. As in the benchmark model, this value is chosen to match the fraction of RS tenants who have lived in an RS unit for 20 years or more, which is 23.1% in the data and 25.7% in the model.

C.2 Baseline Model Results for No Migration Model

Table 9 shows that the no migration model matches demographic, income, house size, home ownership, rent, and house price moments well.

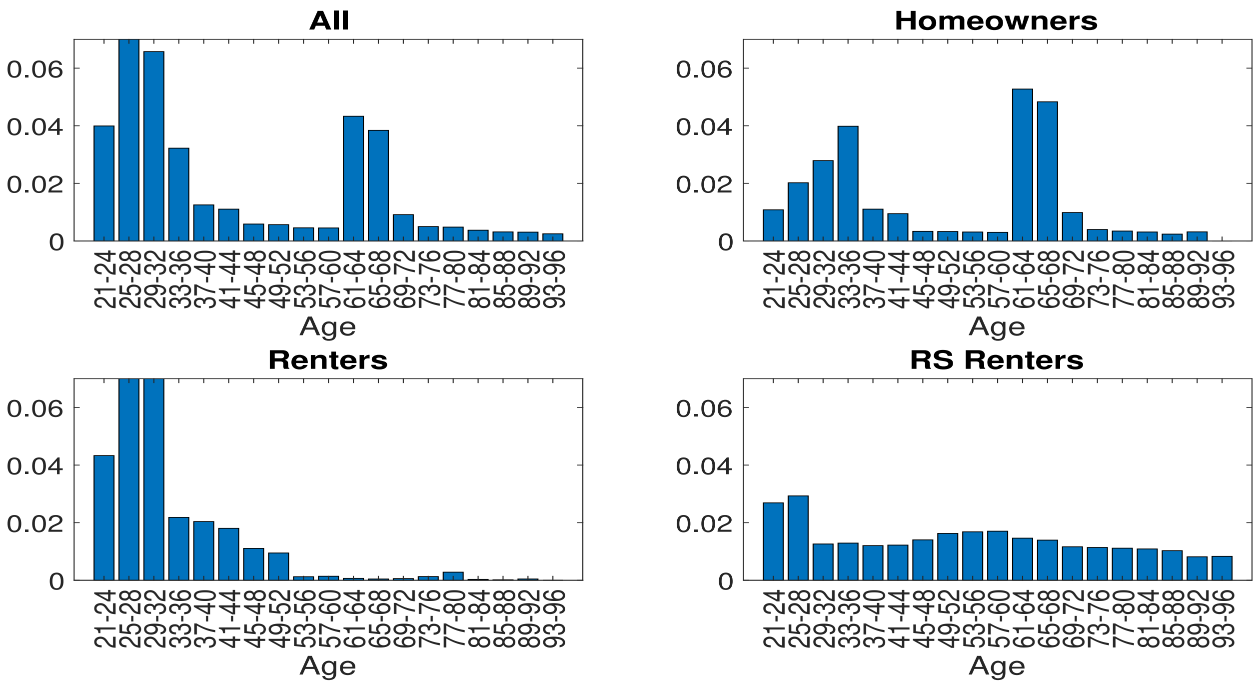
Table 9: New York Metro Data Targets and Model Fit, No Migration Model

		Data		**No Migration 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	47.2	0.86
3	People over 65 as % over 20	19.1	0.91	21.4	0.92
4	Avg. house size (sqft)	1644	0.59	1644	0.55
5	Avg. pre-tax lab income ($)	124091	1.66	124203	1.66
6	Home ownership rate (%)	51.5	0.42	59.3	0.55
7	Median mkt price per unit ($)	510051	3.11	560308	2.07
8	Median mkt price per sqft ($)	353	5.24	311	3.57
9	Median mkt rent per unit (monthly $)	2390	1.65	2792	1.61
10	Median mkt rent per sqft (monthly $)	1.65	2.78	1.55	2.78
11	Median mkt price/median mkt rent (annual)	17.79	1.89	16.72	1.28
12	Mkt price/avg. income (annual)	3.99	1.86	4.52	1.24
13	Avg. rent/avg. income (%)	23.0	1.00	27.0	0.97
14	Avg. rent/income ratio for renters (%)	42.1	0.81	34.9	0.90
15	Rent burdened (%)	53.9	0.79	58.5	0.80
16	% RS of all housing units	14.63	3.11	14.60	3.20

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. Column 4 and 5 are for the no migration model. Column 5 reports the same ratio in the model.

Mobility Intra-MSA mobility rates are shown in Figure 19. The overall mobility rate across zones in the model is about 3% annually, consistent with the 2.1% county-to-county migration rates in the New York MSA.

Figure 19: Intra-MSA Moving Rates by Age, No Migration Model



Note: Mobility rates are measured as the annual probability to move across zones.

House Sizes Figure 20 shows the distribution of house sizes. The model (left panel) matches the data (right panel) quite well, 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.

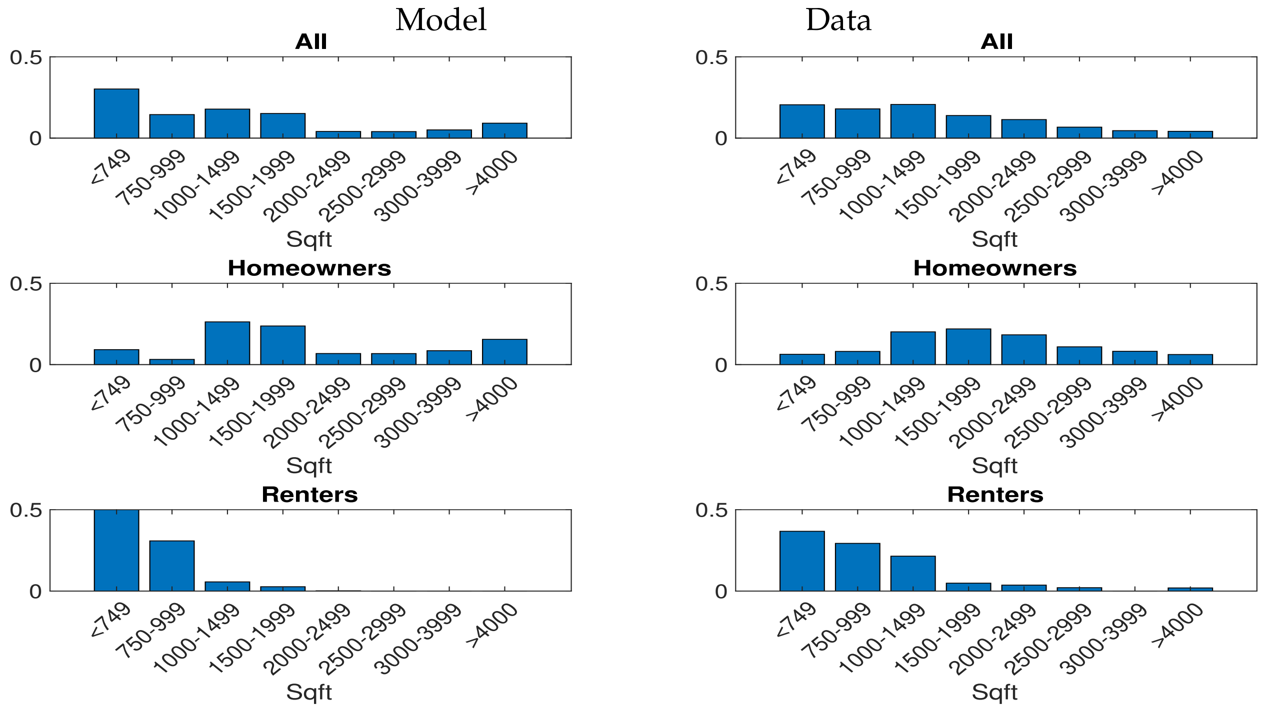
Income The New York productivity distribution is substantially different in the two zones. Zone 1 contains workers that are on average 40% more productive than in zone 2. Productive working-age households have a high opportunity cost of time and prefer to live close to work given the time cost of commuting. Mitigating the high opportunity cost of time is the high cost of living in Manhattan. Indeed, some high-productivity workers may still be early in the life-cycle when earnings are lower and accumulated wealth smaller. Only 17.2% of working-age, top-productivity households live in zone 1.

Figure 21 plots how households of different productivity types sort across space. Zone-1 housing consists mainly of retirees that are home owners and RS renters and top-productivity households that are owners and market renters. There are also some middle-income households in zone 1, mostly market and RS renters. The bottom 25% of households by productivity (yellow) consume a small share of the housing stock.

The model generates a large amount of income inequality at every age. The model's earnings Gini of 0.52 is close to the 0.47 value in the 2015 NY metro data. Earnings inequality is lower within zone 1 (Gini of 0.44) than within zone 2 (Gini of 0.53) in the model.

Home Ownership The model generates a home ownership rate of 59.3%, slightly overstating the 51.5% in the New York data. Row 6 of Table 9 shows that the ratio of the home ownership

Figure 20: House Size Distribution New York, No Migration Model



Note: Left panel: model. Right panel: data. Data source: American Housing Survey for the New York MSA, U.S. Census Bureau, 2015.

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 0.55.

House Prices and Rents The model produces price and rent levels that are close to but somewhat higher than in the data.

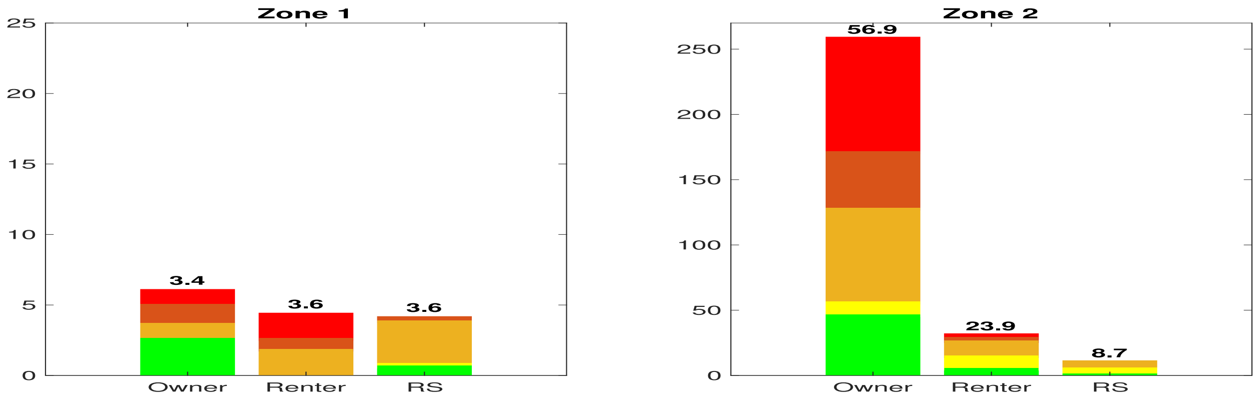
The model generates a ratio of house prices in zone 1 to zone 2 of 2.07, the product of a house size ratio of 0.55 and a price per sf ratio of 3.57. That ratio is 3.11 in the data, and is the product of a ratio of house sizes of 0.59 and a ratio of prices per sf of 5.24. The relative price-rent ratio in zone 1/zone2 is 1.28 compared to 1.89 in the data.

Price-Income and Rent-Income Row 12 of Table 9 reports the ratio of the median value of owner-occupied housing to average earnings in each zone. The model generates a price-income ratio of 4.52, and a ratio across zones of 1.24.

Row 13 reports average rent paid by market renters divided by average income of all residents in a zone; while rows 14 and 15 report two moments related to household-level rent burden. The model generates an average rent-income ratio for renters of 34.9%, which is lower than in the data.The model generates a large "housing affordability crisis," with 58.5% of renters spending more than 30% of their income on rent. The affordability crisis is worse in zone 2 than in zone 1, both in the model and the data.

Rent Stabilization Figure 22 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

Figure 21: Geographic Distribution of Households by Productivity, No Migration Model.



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* in each of the six tenure categories; they sum to 100%.

income distribution at each age. The model is on the left, the data on the right. The no migration model generates less misallocation than in the data.

C.3 Affordability Policies

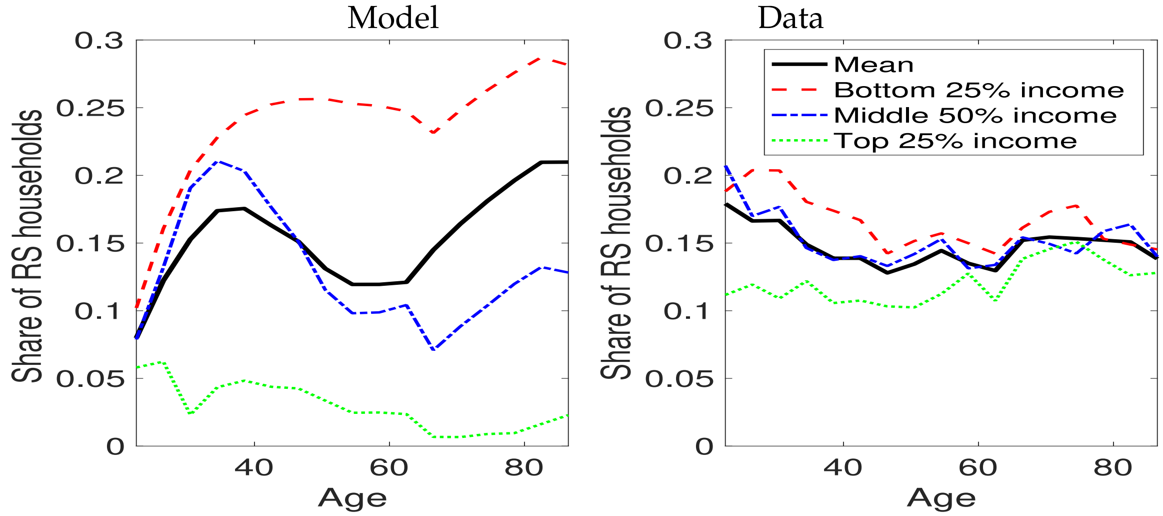
We now consider the same policy experiments as we performed in the main text but in a model without inter-city migration. We report an additional aggregate welfare measure, which is computed the same way as our main welfare measure except that it compares the value function in the new steady state (rather than the value function in the first period of the transition) to the value function in the old steady state. Hence, this measure shows how welfare changes in the long-run after all state variables (e.g., the housing stock and the wealth distribution) have adjusted to their new long-run stochastic steady state. This long-run welfare measure cannot be meaningfully computed for the migration model since the population composition changes after a policy change, making the measure difficult to interpret in that model. This is not the case in the no-migration model since the NY metro population is fixed.

C.3.1 Improving the Targeting of RS

The first set of policies aims to improve the targeting of the RS system. Table 10 contains the results.

Introducing Income Qualification Requirement Column (1) introduces income qualification for RS at 60% of AMI in zone 1 and at 50% of AMI in zone 2. The requirement is enforced only at the time of entry; existing RS tenants are exempt. This experiment creates essentially no change in aggregate welfare (0.04% in row 31) in the transition and a modest welfare gain in the long-run (0.32%, row 32). The policy is successful at allocating more affordable housing units to low-income households. There is a 26.08% increase in the fraction of Q1-income households in

Figure 22: Prevalence of Rent Stabilization, No Migration Model



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.

RS (row 4), which exceeds the overall increase in the fraction of households in RS of 1.59% (row 3). Because the households in RS choose smaller apartment units (rows 6 & 7), the RS system accommodates more households in the same square feet of affordable housing space. RS becomes a better insurance device. Income qualification improves *access to insurance* for lower-income households who have fallen on hard times (27.16%, row 27). Row 28 reports that the *stability of insurance* is nearly unaffected (0.46%) since income testing is only at the point of first entry and existing tenants can stay with high probability $p^{RS,exog}$. Row 30 reports that the policy lowers the volatility of the marginal utility growth of housing consumption (-1.94%), offering the average household more housing stability.

It may be surprising that income qualification is not more beneficial in this model. The first reason is that the maximum size of RS units–such that the average RS unit has the same size as the average market rental—already discourages many higher-income and higher-wealth households from choosing a RS unit. The second reason is that the income qualification does not create much change in the RS system since existing tenants are exempt. The third reason is that, since the benefit of staying in RS grows with tenure, long-tenure RS tenants have a growing incentive to stay even if their income levels would suffice to rent a (potentially larger) market rental. Some of the long-time tenants do lose access (with probability 1-$p^{RS,exog}$). When they do, they lose a large RS discount. They are replaced by a more needy tenant but one who receives a smaller discount due to the reset of the tenure clock. The welfare losses from the former group offset the welfare benefits from the latter group.

Figure 23 shows that the oldest retirees, and the bottom productivity, income, and wealth groups benefit, while all others lose.

This policy does not change developer distortions relative to the baseline model, and there-

Table 10: Policies That Better Target RS—No Migration Model

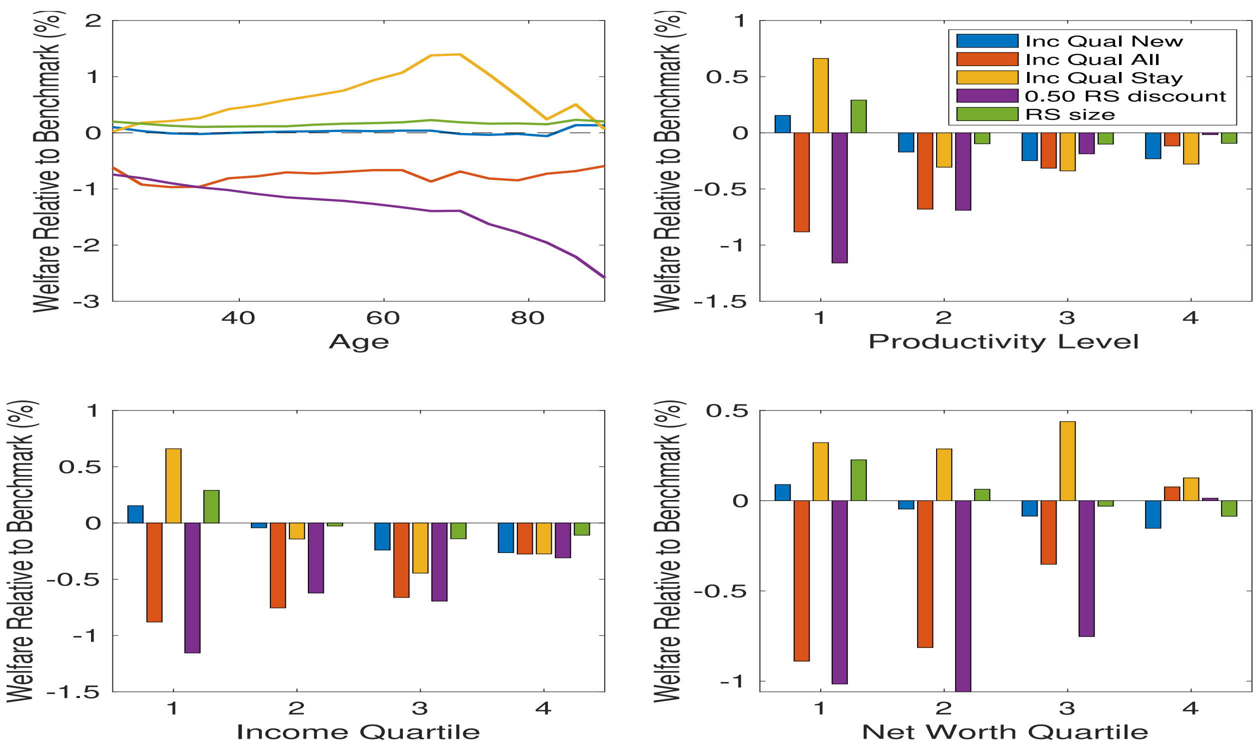
		Benchm.	(1) Inc Qual New	(2) Inc Qual All	(3) Inc Qual Stay	(4) 0.50 RS discount	(5) RS size
1	Avg(rent/inc.) renters in Z1 (%)	32.0	3.29%	31.01%	33.03%	-0.24%	-1.83%
2	Avg(rent/inc.) renters in Z2 (%)	35.5	3.13%	9.25%	6.49%	6.28%	1.37%
3	Fraction of hhs in RS (%)	14.60	1.59%	6.51%	9.77%	1.58%	4.56%
4	Frac. in RS of those in inc. Q1 (%)	22.97	26.08%	31.23%	61.28%	18.78%	21.09%
5	Frac. rent-burdened (%)	58.5	4.45%	10.07%	10.63%	2.67%	-1.92%
6	Avg. size of RS unit in Z1 (sf)	719	-8.05%	-21.50%	-21.50%	-3.40%	-7.23%
7	Avg. size of RS unit in Z2 (sf)	719	-6.19%	-11.47%	-15.16%	-8.27%	-9.06%
8	Avg. size of a Z1 mkt unit (sf)	1079	-0.81%	-2.28%	-0.43%	0.34%	0.10%
9	Avg. size of a Z2 mkt unit (sf)	1861	1.08%	2.89%	3.36%	1.23%	1.26%
10	Frac. of pop. living in Z1 (%)	10.5	3.66%	9.37%	8.54%	0.75%	2.39%
11	Frac. of retirees living in Z1 (%)	19.6	-6.22%	83.87%	81.75%	3.38%	1.70%
12	Housing stock in Z1	–	0.11%	0.41%	0.36%	0.32%	-0.14%
13	Housing stock in Z2	–	0.34%	0.75%	0.78%	0.47%	0.13%
14	Rent/sf Z1 ($)	3.98	0.37%	0.07%	0.46%	-0.39%	-0.05%
15	Rent/sf Z2 ($)	1.43	0.45%	0.04%	0.58%	-0.45%	-0.03%
16	Price/sf Z1 ($)	993	0.38%	0.05%	0.45%	-0.41%	-0.05%
17	Price/sf Z2 ($)	278	0.46%	0.03%	0.64%	-0.46%	-0.03%
18	Homeownership rate in Z1 (%)	33.9	-1.57%	0.66%	-0.93%	4.47%	-1.78%
19	Homeownership rate in Z2 (%)	62.2	3.24%	3.61%	3.84%	2.28%	1.59%
20	Avg. inc. Z1 working-age HHs ($)	163506	-3.57%	-15.64%	-16.18%	0.68%	-1.85%
21	Avg. inc. Z2 working-age HHs ($)	99463	0.42%	2.31%	2.45%	-0.21%	0.18%
22	Frac. of top-prod. HHs in Z1 (%)	17.2	-1.18%	-2.17%	-2.29%	0.07%	-0.02%
23	Total hours worked	–	-0.15%	0.30%	0.10%	0.31%	-0.03%
24	Total hours worked in effic. units	–	0.02%	0.27%	0.20%	0.31%	0.08%
25	Total output	–	-0.00%	0.11%	0.06%	0.16%	0.03%
26	Total commuting time	–	-0.55%	1.41%	1.41%	-0.02%	-0.25%
26	Developer profits	–	0.75%	1.97%	2.07%	1.49%	0.25%
27	Access to RS insurance (%)	5.9	27.16%	112.23%	65.89%	18.70%	23.07%
28	Stability of RS insurance (%)	80.8	0.46%	-82.57%	0.87%	0.17%	0.32%
29	Std. MU growth, nondurables	0.60	0.23%	-0.94%	-0.66%	-0.37%	-0.01%
30	Std. MU growth, housing	0.59	-1.94%	2.38%	0.86%	0.83%	0.75%
31	**Aggr. welfare change (NY pop)**	–	**0.04%**	**-0.78%**	**0.32%**	**-0.96%**	**0.16%**
32	*Aggr. welfare change (Long-run)*	–	*0.32%*	*-0.55%*	*0.73%*	*-0.57%*	*0.37%*

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

fore has only minor implications for the housing stock, market rents, house prices, and home ownership rates in both zones (rows 12-19). Because there are fewer middle- and high-income households in RS units after the introduction of income qualification, there are fewer households who are choosing sub-optimally small apartments.

Rent-income ratios among renters increase in zone 1 (3.29%, row 1) and in zone 2 (3.13%, row 2). These changes reflect the new socio-economic make-up of the two zones. There are more low-income households in zone 1 because of the policy change, so that the average income of zone 1 falls (-3.57%, row 20). The opposite is true in zone 2 (0.42%, row 21). This suggests that rent-income ratios, the most common metric of housing affordability, must be interpreted carefully as they reflect both equilibrium rents and the income of the people who have sorted into each zone in spatial equilibrium. Even the fraction of rent-burdened households rises (4.45%, row 5); it does not accurately reflect the improved access to affordable housing for lower-income households.

Figure 23: Policies That Better Target RS—No Migration Model



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.

Re-applying Each Period In the second policy experiment, we force every household to go through the RS lottery each period (four years). We enforce an income limit of 60% of AMI in both zones on every RS tenant each period. (The RS market in zone 2 does not clear if we set the income cutoff at 50% of AMI in zone 2 in this experiment.) By setting the parameter $p^{RS,exog} = p^{RS}$, the endogenously determined probability of winning the RS lottery increases substantially. Relative to the baseline model, this policy removes the preference for insiders and introduces income qualification. The results in column (2) show that access to insurance improves dramatically (112.23%). The fraction of low-income households in RS grows strongly (31.23%), showing the improved targeting of the RS system. The overall fraction of households in RS also increases (6.51%), as poorer households choose smaller RS unit size.

However, the policy experiment results in a substantial welfare loss of -0.78% per New Yorker (and -0.55% in the long-run). The reason is twofold. First, the policy dramatically lowers the stability of this insurance (-82.57%, row 28). Housing consumption becomes more unstable over time (2.38%, row 30). Second, the higher churn of RS residents lowers the average tenure and thereby the average rent discount that RS tenants enjoy, since the rent discount $\kappa_1(d)$ is rising in tenure d. The policy effectively makes the average RS housing unit less affordable. In sum, the welfare gains from better targeting are more than offset by the welfare losses from excessive housing churn.

The (endogenously) lower average rent discount in the RS system reduces distortions for developers. It results in higher developer profits (row 26) and a larger equilibrium housing supply in both zones (rows 12 and 13). With more RS tenants living in smaller housing units, the fraction of the population that lives in the urban core grows (9.37%). Again, rent-income ratios and rent burden suggest worsened housing affordability, but actually pick up composition effects due to spatial resorting.

Restoring the Preference For Insiders In the third experiment, we introduce income qualification for RS at 60% of AMI in zone 1 and at 50% of AMI in zone 2 but restore the preference for RS insiders: $p^{RS,exog}$ is set to its baseline value. Compared to the baseline model, the experiment in Column (3) of Table 10 imposes an income cutoff on all RS residents in every period. Compared to the experiment in Column (1), the income cutoff applies also to existing RS residents, not only to new entrants. This experiment strikes us as the most realistic way of introducing income qualification.

This experiment generates a welfare gain of 0.32% (and 0.73% in the long run). It combines the fairness of income qualification while avoiding excessive churn in the RS system by giving preference to income-qualifying insiders. The targeting of RS units to low income households increases substantially (61.28%) as does the access to insurance metric (65.89%). These gains are much larger than in column (1) since now income qualification is applied to existing tenants, reducing the misallocation that builds up over time as tenant income grows. Making RS less persistent helps to reduce the misallocation since it replaces high-income insiders with low-income outsiders. Like in the previous experiment, the fraction of all households in RS increases (9.77%). In sum, the combination policy with strict income targeting for all RS tenants and stability for insiders produces non-trivial welfare gains, yet requires no expansion of the scope of the RS program nor additional taxes.

The policy results in a larger share of retirees living in zone 1, lowering zone-1 average income, thereby creating more income mixing. There is more commuting, even though a larger share of the population lies in the urban core. A smaller share of top-productivity households live in zone 1. Figure 23 shows that the benefits from this experiment flow to the middle-aged and retirees. There are substantial welfare gains for low-income households and welfare losses for all other income quartiles.

Varying the RS Discount Column (4) of Table 10 reports on an experiment that changes the size of the rent discount for RS units relative to the market rent. We multiply the entire discount schedule, which is a function of tenure, by 0.5. Reducing the discount by half results in a large welfare loss (-0.96%).

There are interesting equilibrium effects on access to insurance. Making RS *less* generous makes it less attractive, which reduces competition for it in the absence of income qualification, and results in *more* bottom-quartile households ending up in it (18.78%). By this metric, the targeting is almost as good as it is in the income qualification experiment of column (1). Access to insurance improves, while the stability of that insurance does not deteriorate. The policy reduces distortions to development, resulting in a higher equilibrium developer profits, a larger housing stock, and lower rents. Finally, labor supply and output rise. All of these factors offset the negative welfare effects from lower rent discounts which hurt low-income households the most.

Indeed, Figure 23 shows that a smaller discount hurts older and low-productivity households the most. The age effect arises because the discounts are increasing in tenure and the effects on rent are therefore largest in absolute magnitude for the old.

Maximum Size of RS Unit Column (5) of Table 10 studies a reduction in the maximum size of a Rent Stabilized housing unit by 10% compared to the baseline. The actual average size of

RS units falls by slightly less than 10%. The aggregate welfare effect is a gain of 0.16% (0.37% in the long-run). Making RS units smaller is an effective way of targeting RS units to low-income households. Higher-income households do not want to live in small RS units. Because units are now smaller but the same total square feet are devoted to RS, more households qualify. For both reasons, access to insurance improves. The policy benefits low-income households. Overall, the policy in column (5) is quite similar to the income qualification policy in column (1).

C.3.2 Expanding the Affordable Housing Mandate

The second set of policy experiments we study change the scope of the affordable housing mandate. We symmetrically vary η^{ℓ} in each zone, the share of all rental square footage that must be set aside for affordable units. Table 11 shows the results, varying the share of RS housing from 0.25 to 1.75 times the value in the benchmark economy. In the migration model, we only computed up to 1.5x the benchmark RS share. In the no-migration model, we can compute the 1.75x case as well before running into the issue of excess supply of RS housing in equilibrium (and hence lack of market clearing in the RS market).

As we increase the share of square feet of affordable housing η^{ℓ}, the fraction of *households* in RS also increases (row 3), as does the share of low-income households in RS (row 4). Access to insurance and the stability of that insurance rise monotonically with the share of RS rentals. Housing stability improves (row 30). Row 31 shows large welfare losses from strong cuts in the scope of the RS system and large welfare gains from strong expansions of the RS mandate.

Expanding the RS mandate increases distortions. First and foremost, these distortions affect developers. Developer profits fall, which in turn affects household wealth adversely. A larger share of rental housing that is RS lowers the size of the equilibrium housing stock and increases equilibrium rents and prices. It increases the fraction of households that are rent burdened. With higher house prices and more RS rental households, the home ownership rate naturally falls in the RS share. A second distortion comes in the form of labor market distortions. Labor supply and effective labor supply both decrease in the scope of the RS mandate. As a result output falls. The spatial allocation of labor worsens as the RS share grows, with a smaller fraction of top-productivity households and a larger fraction of retirees that live in zone 1. These are the distortions from RS emphasized by economists. We find that they are quantitatively modest, even though RS engenders much misallocation (no income qualification, preference for insiders).

How does welfare change with the scope of RS? Figure 24 shows that aggregate welfare, expressed as a percentage change relative to the benchmark, increases with the scope of the affordable housing mandate. The insurance benefits from expanding the RS system continue to outweigh the costs until all households that want RS obtain such a unit (large circle).

Figure 25 illustrates the redistributive effects of a more expansive RS system. A more ubiquitous RS system benefits the young and the low-productivity/low-income households more. However, for large increases in RS, even the Q4-income and Q4-wealth households benefit. This is because an increasing fraction of them now also access RS; recall that there is no income qualification for RS in this experiment. For example, the share of top income-quartile households in RS is three times higher in the "1.75x" case as in the benchmark, and two times higher for the other income groups. This highlights the value of RS insurance; the option value of needing RS in the event of a future adverse income shock is valuable even to fairly rich households.

It is worth noting that our welfare criterion is calculated in the first period of the transition. In the long-run, the average welfare gains are very similar (row 32 of Table 11). However, we have confirmed that the first-period gains for high-income and high-wealth households are larger than the long-run gains. The reason is that the housing stock has not adjusted much yet in the

Table 11: Varying the Scope of the RS Mandate—No Migration Model

			(1)	(2)	(3)	(4)	(5)	(6)
		Benchm.	0.25x	0.50x	0.75x	1.25x	1.50x	1.75x
1	Avg(rent/inc.) renters in Z1 (%)	32.0	-19.12%	-11.81%	-5.41%	4.85%	10.54%	17.54%
2	Avg(rent/inc.) renters in Z2 (%)	35.5	7.27%	5.30%	2.97%	-2.97%	-5.25%	-7.11%
3	Fraction of hhs in RS (%)	14.60	-160.66%	-85.72%	-37.55%	30.33%	56.20%	84.41%
4	Frac. in RS of those in inc. Q1 (%)	22.97	-162.10%	-87.97%	-39.62%	33.14%	58.88%	82.01%
5	Frac. rent-burdened (%)	58.5	-5.40%	-3.50%	-1.65%	1.79%	4.04%	9.08%
6	Avg. size of RS unit in Z1 (sf)	719	-0.22%	-0.01%	0.04%	0.05%	0.04%	-0.30%
7	Avg. size of RS unit in Z2 (sf)	719	0.77%	0.68%	0.31%	-0.48%	-0.64%	-1.09%
8	Avg. size of a Z1 mkt unit (sf)	1079	-9.12%	-7.51%	-6.06%	10.60%	17.73%	70.80%
9	Avg. size of a Z2 mkt unit (sf)	1861	-5.64%	-4.13%	-2.20%	2.70%	6.54%	12.08%
10	Frac. of pop. living in Z1 (%)	10.5	-1.90%	-0.98%	0.80%	-2.16%	0.51%	9.46%
11	Frac. of retirees living in Z1 (%)	19.6	-44.50%	-29.34%	-15.68%	14.17%	23.91%	48.62%
12	Housing stock in Z1	–	0.38%	0.32%	0.24%	-0.22%	-0.45%	-1.08%
13	Housing stock in Z2	–	0.76%	0.55%	0.28%	-0.27%	-0.60%	-0.84%
14	Rent/sf Z1 ($)	3.98	-1.37%	-1.01%	-0.44%	0.34%	1.31%	4.49%
15	Rent/sf Z2 ($)	1.43	-0.64%	-0.44%	-0.22%	0.33%	0.71%	1.49%
16	Price/sf Z1 ($)	993	-1.33%	-0.98%	-0.43%	0.33%	1.28%	4.24%
17	Price/sf Z2 ($)	278	-0.65%	-0.44%	-0.23%	0.33%	0.70%	1.48%
18	Homeownership rate in Z1 (%)	33.9	28.54%	19.21%	7.07%	-2.01%	-17.33%	-133.25%
19	Homeownership rate in Z2 (%)	62.2	9.16%	7.04%	4.23%	-4.71%	-9.17%	-13.13%
20	Avg. inc. Z1 working-age HHs ($)	163506	14.21%	9.70%	2.73%	0.12%	-8.75%	-55.94%
21	Avg. inc. Z2 working-age HHs ($)	99463	-2.82%	-1.92%	-0.62%	0.15%	1.60%	8.15%
22	Frac. of top-prod. HHs in Z1 (%)	17.2	21.56%	13.45%	3.64%	-0.72%	-17.21%	-169.76%
23	Total hours worked	–	0.60%	0.43%	0.24%	-0.29%	-0.58%	-0.95%
24	Total hours worked in effic. units	–	0.58%	0.44%	0.24%	-0.11%	-0.36%	-0.87%
25	Total output	–	0.30%	0.21%	0.10%	-0.11%	-0.26%	-0.54%
26	Total commuting time	–	-0.41%	-0.33%	-0.36%	0.52%	0.43%	0.06%
26	Developer profits	–	2.15%	1.60%	0.89%	-0.76%	-1.67%	-2.88%
27	Access to RS insurance (%)	5.9	-179.47%	-97.41%	-45.72%	41.25%	77.31%	114.48%
28	Stability of RS insurance (%)	80.8	-1.05%	-0.85%	-0.39%	0.49%	0.91%	1.36%
29	Std. MU growth, nondurables	0.60	-0.30%	-0.27%	-0.16%	0.12%	0.23%	0.41%
30	Std. MU growth, housing	0.59	1.52%	1.38%	1.21%	-2.42%	-1.81%	-2.43%
31	**Aggr. welfare change (NY pop)**	–	**-0.98%**	**-0.90%**	**-0.68%**	**0.53%**	**1.36%**	**2.20%**
32	*Aggr. welfare change (Long-run)*	–	*-1.39%*	*-1.06%*	*-0.59%*	*0.63%*	*1.42%*	*2.44%*

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

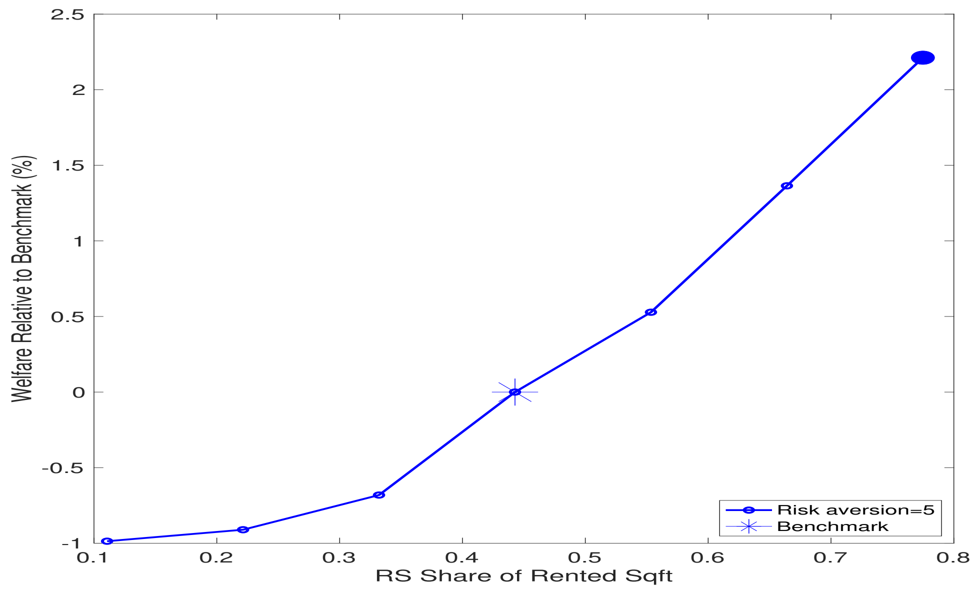
first period of the transition and neither have rents risen much yet. As a results, profits from development, which go disproportionately to the rich, have not suffered much yet.

C.3.3 Geographic Location of Affordable Housing

Columns (1) and (2) of Table 12 conduct two policy experiments that shift all RS housing from zone 1 to zone 2. In the experiment of Column (2), the experiment is coupled with subsidized transportation for RS tenants. The total transit subsidy amount is $800 million (about 0.05% of metro-area GDP) and the subsidy is the same for all recipients. The subsidy is paid for by higher income taxes, engineered through a lower λ. By construction, the experiment keeps the number of households in RS constant (row 3 shows that this is essentially the case).

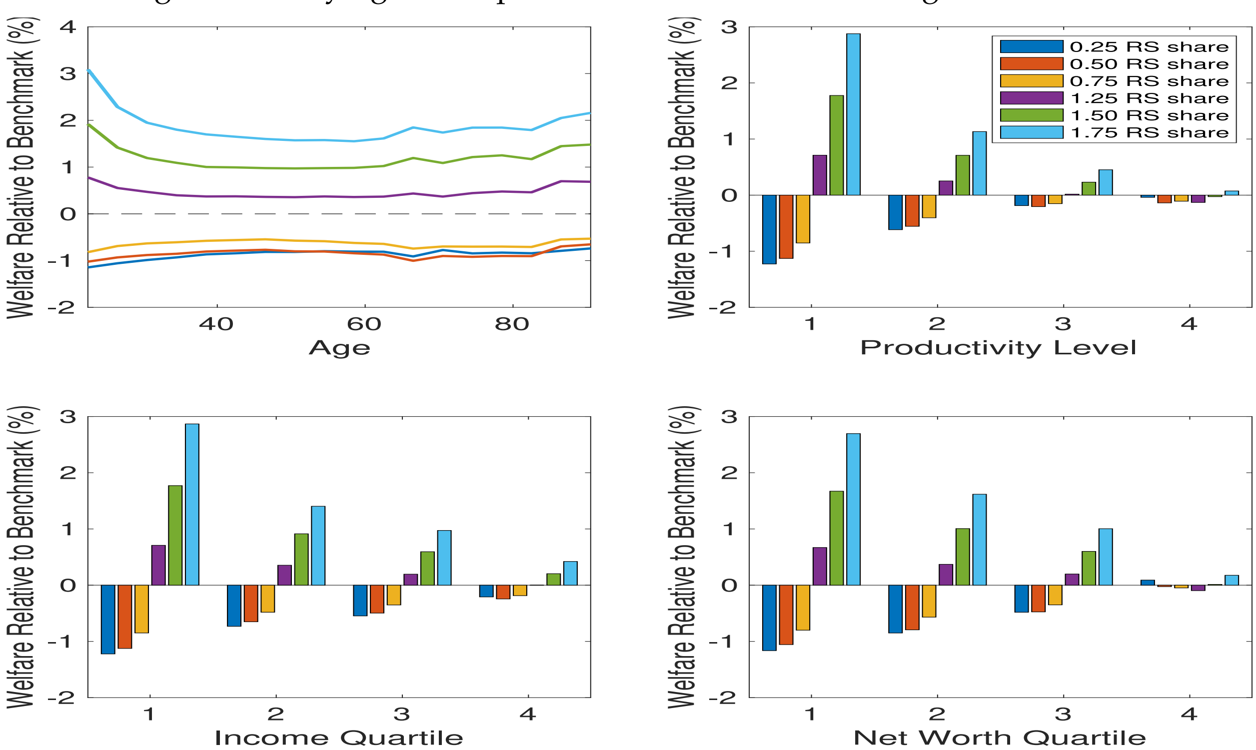
There is an aggregate welfare gain of 0.37% in Column (1) and 0.96% in the experiment with subsidized transit. The reason for the larger gain is that financial transportation costs are important for low-income households. Subsidizing this cost makes RS housing substantially more

Figure 24: Aggregate Welfare for Varying RS Share—No Migration Model.



Notes: The baseline model has the following parameters: $\eta^1 = 56.92$, $\eta^2 = 31.63$, $\kappa_1 = 7\%$, $\kappa_2 = 1000.00$, $\kappa_3 = 0.50$. The share of RS rented sf is calculated as a (total sf-)weighted average of η^1, η^2. The larger dots on the right-hand side of the graph represent the maximum RS share above which markets do not clear. The welfare changes are measured as consumption equivalent variations for an average household.

Figure 25: Varying the Scope of the RS Mandate—No Migration Model.



Notes: The baseline model has the following parameters: $\eta^1 = 56.92$, $\eta^2 = 31.63$, $\kappa_1 = 7\%$, $\kappa_2 = 1000.00$, $\kappa_3 = 0.50$. 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.

attractive to those low-income households. The policies result in greater share of low-income households in RS, better access to RS insurance, more housing stability, and slightly lower volatility of marginal utility growth of non-housing consumption.

In both experiments, the urban core gentrifies with more high-income and top-productivity households and a much higher home ownership rate in zone 1. There are also a lot fewer retirees in zone 1. As anticipated, moving affordable housing to the suburbs improves the spatial allocation of labor. This can be seen in the growing wedge between labor supply and labor supply in efficiency units. It shows that high-productivity households supply relatively more labor compared to the average worker, relative to the benchmark model. The increases in aggregate labor supply is smaller in the case with subsidized transit since the subsidy dissuades labor supply among the recipients and because the transit is paid for with distortionary income taxation. Aggregate output actually falls in column (2); the distortionary labor income effects dominate the productivity gains from a better 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. Developer distortions increase in zone 2, lowering the housing stock in zone 2. Market rents also fall in zone 2 which is due to the lower aggregate demand for rentals in zone 2 after higher-income renters leave for zone 1. Rent-income ratios fall in both zones, and the share of rent-burdened households fall by the most in any of our experiments.

Figure 26 shows that this policy benefits households across the age distribution, but more so young and old households. It benefits low-productivity, low-income, and low-wealth households the most. This is consistent with more of the RS going to low-income households in this experiment.

C.3.4 Upzoning the Urban Core

The next experiment studies a zoning change that allows for more housing in the urban core. We increase $\overline{H}^1$ by 10%. The equilibrium housing stock in Manhattan increases by 9.13%, as shown in Column 3 of Table 12. Since a fixed fraction of rental 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 mandatory inclusionary housing policies. This policy is welfare increasing with an aggregate benefit of 0.40% (and 0.33% in the long-run). Rents and prices in zone 1 fall (-0.74% for rents). The population share of Manhattan rises by 9.89%. Because of the population reallocation, average income in Manhattan decreases (-3.73%). Average rent-to-income among renters increases by 0.11% in zone 1, despite the rent decline. More middle-income households can now afford Manhattan and the additional affordable housing that is associated with the new construction also brings in lower-income households. Hence upzoning increases the socio-economic diversity of the urban core. With more working-age households in zone 1, aggregate commuting time falls substantially (-1.22%). In equilibrium, most of the aggregate time saved commuting goes towards leisure, boosting utility. Output is nearly unaffected.

The housing stock in zone 2 falls in the long-run (-0.53%) as developers shift their resources towards zone 1 where the population has swelled. Rents in zone 2 also fall (-0.78%) because of the weaker demand for housing in zone 2 due to the population pivot to Manhattan. Average rent-to-income among renters increases by 0.67% in zone 2. The rising rent-income ratios in both zones obscure the fact that more households can now afford to live close to work. Again, it mostly reflects compositional changes in the income profile of each neighborhood.

In contrast to the preceding policies, upzoning is much less redistributive in nature. As can be seen in Figure 26, the upzoning policy brings modest but similar benefits to all age, productivity,

Table 12: Spatial Housing Policies—No Migration Model

		Benchm.	(1) All RS in Z2	(2) All RS in Z2 + transit	(3) Zoning	(4) Vouchers	(5) LIHTC	(6) Cash transfer V	(7) Cash transfer P
1	Avg(rent/inc.) renters in Z1 (%)	32.0	-29.50%	-29.26%	0.11%	0.24%	-0.18%	0.30%	0.02%
2	Avg(rent/inc.) renters in Z2 (%)	35.5	-1.90%	-2.38%	0.67%	0.27%	-0.15%	0.42%	2.43%
3	Fraction of hhs in RS (%)	14.60	-0.10%	0.76%	0.76%	0.28%	0.19%	-1.52%	0.79%
4	Frac. in RS of those in inc. Q1 (%)	22.97	21.40%	16.76%	0.51%	-0.64%	1.07%	-2.52%	0.98%
5	Frac. rent-burdened (%)	58.5	-7.51%	-8.64%	0.96%	-0.06%	0.20%	-0.10%	0.70%
6	Avg. size of RS unit in Z1 (sf)	719	–	–	0.11%	-0.03%	0.06%	-0.02%	-0.00%
7	Avg. size of RS unit in Z2 (sf)	719	0.70%	2.09%	-0.40%	0.21%	-0.11%	0.32%	0.08%
8	Avg. size of a Z1 mkt unit (sf)	1079	-11.78%	-11.62%	-1.19%	0.14%	0.01%	-0.25%	-1.13%
9	Avg. size of a Z2 mkt unit (sf)	1861	2.40%	2.17%	0.62%	-0.35%	0.30%	-0.40%	0.15%
10	Frac. of pop. living in Z1 (%)	10.5	-1.29%	-1.40%	9.89%	0.09%	0.14%	0.35%	0.74%
11	Frac. of retirees living in Z1 (%)	19.6	-68.09%	-68.01%	1.31%	-0.87%	0.20%	-1.12%	-0.78%
12	Housing stock in Z1	–	0.37%	0.41%	9.13%	0.15%	0.21%	0.23%	0.00%
13	Housing stock in Z2	–	-0.49%	-0.69%	-0.53%	-0.28%	0.24%	-0.16%	-0.02%
14	Rent/sf Z1 ($)	3.98	-1.41%	-1.47%	-0.74%	0.39%	-0.34%	0.30%	0.04%
15	Rent/sf Z2 ($)	1.43	-0.26%	-0.36%	-0.78%	0.47%	-0.42%	0.36%	-0.02%
16	Price/sf Z1 ($)	993	-1.36%	-1.36%	-0.73%	0.33%	-0.31%	0.24%	0.08%
17	Price/sf Z2 ($)	278	-0.28%	-0.32%	-0.78%	0.41%	-0.38%	0.29%	0.03%
18	Homeownership rate in Z1 (%)	33.9	51.95%	51.16%	-3.52%	0.40%	-0.20%	0.74%	-1.78%
19	Homeownership rate in Z2 (%)	62.2	-3.43%	-4.55%	0.95%	0.26%	0.03%	1.79%	-0.59%
20	Avg. inc. Z1 working-age HHs ($)	163506	18.71%	18.69%	-3.73%	0.55%	-0.23%	0.32%	-1.21%
21	Avg. inc. Z2 working-age HHs ($)	99463	-3.89%	-3.87%	-0.02%	-0.03%	0.03%	-0.01%	0.18%
22	Frac. of top-prod. HHs in Z1 (%)	17.2	28.01%	27.94%	2.01%	1.18%	-0.13%	1.03%	-2.59%
23	Total hours worked	–	-0.18%	-0.48%	-0.02%	-0.23%	-0.01%	-0.36%	-0.79%
24	Total hours worked in effic. units	–	0.22%	0.09%	0.11%	0.05%	0.01%	0.03%	-0.03%
25	Total output	–	0.04%	-0.04%	0.03%	0.03%	-0.01%	0.01%	-0.02%
26	Total commuting time	–	-0.73%	-0.71%	-1.22%	-0.00%	-0.01%	-0.04%	-0.10%
26	Developer profits	–	-0.12%	-0.50%	-0.04%	0.27%	0.97%	0.11%	-0.03%
27	Access to RS insurance (%)	5.9	13.12%	8.07%	2.28%	-0.22%	1.67%	-2.62%	1.19%
28	Stability of RS insurance (%)	80.8	0.43%	0.31%	0.04%	0.06%	0.02%	0.01%	0.03%
29	Std. MU growth, nondurables	0.60	-0.00%	-0.15%	-0.19%	0.87%	-0.09%	0.86%	-5.43%
30	Std. MU growth, housing	0.59	-0.57%	-0.57%	1.46%	0.35%	0.24%	0.51%	-2.24%
31	**Aggr. welfare change (NY pop)**	–	**0.37%**	**0.96%**	**0.40%**	**0.53%**	**0.05%**	**0.56%**	**4.66%**
32	*Aggr. welfare change (long-run)*	–	*0.33%*	*0.90%*	*0.33%*	*0.48%*	*0.19%*	*0.66%*	*5.25%*

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

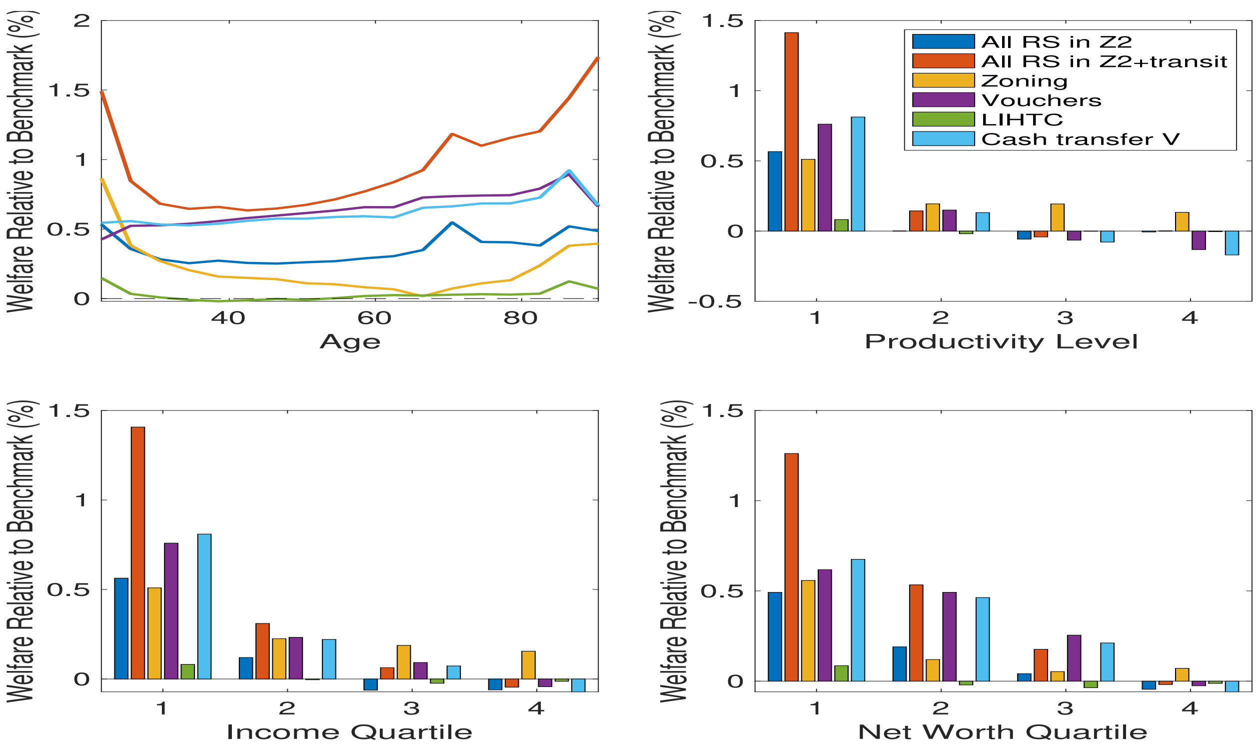
income, and wealth groups. The real-world resistance to upzoning, usually driven by home owners, can be understood from the lower equilibrium house prices which represent capital losses to existing home owners (rows 16 and 17).

C.3.5 Housing Vouchers

We now study the effects of increasing the size of the housing voucher program. Voucher recipients must earn less than 50% of AMI, receive $8300 per year in in-kind housing subsidies, and must spend at least the voucher amount plus 20% of household income on housing expenditures. There is a voucher lottery to allocate the vouchers. The $800 million voucher program is paid for by higher income taxes, engineered through a lower λ.

Column (4) of Table 12 shows that aggregate welfare increases substantially when the housing voucher program is expanded (0.53% in the transition and 0.48% in the long-run). Figure 26

Figure 26: Spatial Housing Policies—No Migration Model



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.

shows that low-productivity, low-income, and low-wealth households gain much from the policy, while the wealthy and high-income households lose.

The welfare gain in the voucher experiment occurs despite severe distortions. Chief among them is tax-induced labor supply distortions. In the model, as in the real world, vouchers must be paid for with distortionary labor income taxes. Total hours worked fall (-0.23%). However, hours in efficiency units (0.05%) and total output (0.03%) rise slightly by virtue of a more efficient spatial allocation of labor. These distortions are much smaller than in the migration model since high-productivity households who are hurt by the reform cannot leave for the outside MSA. As a result, the tax increase that is needed to raise the $800 million in equilibrium to pay for the vouchers is lower in the no-migration model.

C.3.6 LIHTC

Column (5) of Table 12 studies a policy that subsidizes construction costs associated with affordable housing development, modeled after the federal Low Income Housing Tax Credit (LIHTC) program. The tax credit increases the average price $\overline{P}^{\ell}$ developers earn, thereby stimulating new construction. The policy is sized to have the same cost of the voucher expansion and subsidized transportation experiments in columns (2) and (4), namely $800 million. It generates a trivial welfare gain of 0.05% in transition and a small welfare gain 0.19% in the long-run. The envisioned increase in the housing stock materializes in equilibrium, but is blunted by a reduction in housing demand. The latter arises from the distortionary taxation required to pay for the tax credits. Tax credits in difficult-to-develop gateway cities, like New York, create too few additional affordable housing units to make a meaningful dent in the welfare of low-income households. This experiment underscores the importance of general equilibrium effects, of targeted policies, and of how affordability programs are financed. The welfare benefit per dollar of taxpayer money spent is much lower for developer tax credits as for a voucher expansion.

C.3.7 Cash Transfers

Columns (6) and (7) of Table 12 study two policies that raise taxes by lowering λ, collecting an additional \$800 million in tax revenues, and then redistributes that extra revenue to households earning less than 50% of AMI. For the policy in column (6), labeled cash transfer V, the benefit allocation is the same as it was for the housing voucher program in column (4). For the policy in column (7), labeled cash transfer P, recipients receive a recurring "check" for the maximum of zero and X-30% of pre-tax household income. The parameter $X = \$5,980$ per household is set such that the program costs exactly \$800 million in the aggregate. About 7% of households receive a positive cash transfer. The average transfer is \$900.

Cash transfer V creates an aggregate welfare gain of 0.56%, only slightly higher than the housing voucher program with the extra housing expenditure restriction. The policy is highly redistributive, as can be seen from Figure 26.

Cash transfer P creates an aggregate welfare gain of 4.66%. This policy does not affect rents or prices much nor does it have spatial effects. It mostly lowers the volatility of marginal utility growth of non-housing and housing consumption, resulting in a large welfare gain. It serves as a useful benchmark for gauging the welfare benefits of the housing policies. This policy is perfectly targeted on the low-income households, and the size of the transfers grows the poorer the household is. Like the other policies that increase taxes, the policy has adverse effects on aggregate labor supply, but only modest effects on effective labor supply and output. This policy does not create more housing nor does it alleviate rent burden. It has some interaction with RS policy in that it results in a small increase in low-income households in RS units.

D Higher Depreciation of Rent-Stabilized Housing Units

Table 13 studies how sensitive the welfare changes from the RS expansion policy (50% increase in the sf share devoted to RS) are to the depreciation rate on RS housing. In the benchmark policy exercise, we assumed that the depreciation rate of market and RS rental housing was the same. In this robustness check, we assume instead that the depreciation rate on RS housing is 0.5% per year higher. The welfare gain is 0.52%, which compares to 0.91% in the main text. We repeat this exercise for the no migration model. The welfare gain from RS expansion with higher RS depreciation is 0.57%, compared to the baseline gain of 1.36%. In both cases, higher RS depreciation moderates the welfare benefits from an expansion of rent regulation but does not eliminate them.

Table 13: Varying the Scope of the RS Mandate with Higher RS Depreciation–Migration Model

		Benchm.	(1) 1.50×
1	Avg(rent/inc.) renters in Z1 (%)	42.9	-7.28%
2	Avg(rent/inc.) renters in Z2 (%)	33.0	-0.49%
3	Frac. of HHs in RS (%)	12.70	72.01%
4	Frac. in RC of those in inc. Q1 (%)	15.56	58.00%
5	Frac. rent-burdened (%)	54.6	6.28%
6	Avg. size of RC unit in Z1 (sf)	847	-6.88%
7	Avg. size of RC unit in Z2 (sf)	851	-1.25%
8	Avg. size of a Z1 mkt unit (sf)	1142	-11.54%
9	Avg. size of a Z2 mkt unit (sf)	1816	9.92%
10	Frac. of pop. living in Z1 (%)	10.5	22.71%
11	Frac. of retirees living in Z1 (%)	15.0	25.31%
12	Housing stock in Z1	–	-0.98%
13	Housing stock in Z2	–	0.18%
14	Rent/sf Z1 ($)	3.66	16.25%
15	Rent/sf Z2 ($)	1.30	3.21%
16	Price/sf Z1 ($)	863	4.47%
17	Price/sf Z2 ($)	248	0.46%
18	Homeownership rate Z1 (%)	49.8	-159.15%
19	Homeownership rate Z2 (%)	63.3	-7.07%
20	Avg. inc. Z1 working-age HHs ($)	186249	-53.29%
21	Avg. inc. Z2 working-age HHs ($)	98078	9.17%
22	Frac. of top-prod HHs in Z1 (%)	24.2	-88.08%
23	Total hours worked	–	-1.29%
24	Total hours worked in effic. units	–	-0.91%
25	Total output	–	-0.51%
26	Total commuting time	–	-3.40%
26	Developer profits	–	1.84%
27	Access to RC insurance (%)	3.6	73.92%
28	Stability of RC insurance (%)	80.0	-0.31%
29	Std. MU growth, nondurables	0.60	-2.36%
30	Std. MU growth, housing	0.60	-5.36%
31	**Aggr. welfare change (NY pop)**	–	**0.52%**
32	NY population	–	-1.32%
33	Aggr. welfare change (no migr.)	–	0.57%

Notes: Column "Benchmark" reports values of the moments for the baseline model with higher depreciation of RS units.