Out-of-town Home Buyers and City Welfare

Jack Favilukis and Stijn Van Nieuwerburgh [*]

January 28, 2021

Abstract

Many cities have attracted a flurry of out-of-town (OOT) home buyers. Such capital inflows affect house prices, rents, construction, labor income, wealth, and ultimately welfare. We develop an equilibrium model to quantify the welfare effects of OOT home buyers for the typical U.S. metropolitan area. When OOT investors buy 10% of the housing in the city center and 5% in the suburbs, welfare among residents falls by -0.61% in consumption equivalent units. House prices and rents rise substantially, resulting in welfare gains for owners and losses for renters. Policies that tax OOT buyers or mandate renting out vacant property mitigate welfare losses.

JEL classification: R10, R20, R30, R40, R51, G11, G12, H41, H70, J61

Keywords: housing markets, house prices, foreign investors, property taxes

Residential investment in major urban centers by out-of-town (OOT), including foreign, investors has been on the rise. For example, the U.S. attracted $153 billion in foreign residential real estate investment between April 2016 and March 2017, accounting for 10% of all purchases. These investment flows are controversial since they tend to leave highly desirable real estate under-utilized and are thought to push up the cost of housing for local residents, fueling the affordability issues these cities already struggle with. Public opposition to OOT investor flows has led many large cities to tax residential property purchases by non-residents. But OOT investors bring benefits as well. They spur new construction which requires local labor. This demand for construction services (and for other non-tradables like restaurants) increases wages for all local workers. They generate additional property tax revenue which can pay for education and infrastructure, benefitting local residents. And they increase property values for local home owners. The net effect of these costs and benefits is unknown. This paper asks whether an inflow of OOT real estate buyers is a boon or a bane for the city as a whole, or equivalently, whether taxes on OOT buyers are welfare improving. It also studies whether and how the inflow differentially affects local residents.

We set up and solve an equilibrium model to address these questions. The model is an overlapping generations model with risk averse households that face labor income risk during their life-cycle and make dynamic decisions on consumption, savings, labor supply, and tenure status (own or rent). Home owners also choose how much rental property to own and rent out to local renters. The model generates a cross-sectional distribution over age, labor income, tenure status, housing wealth, and financial wealth. The city produces tradable goods and residential housing. While interest rates and goods prices are taken as given, wages, house prices, and rents are determined in the city's equilibrium. The city has two locations, a city center and the remainder of the metropolitan area; working-age households commute to the city center for work. The model's geographic di-

1

mension allows us to understand how the OOT shock propagates in space. This richness is necessary to identify the winners and losers from the OOT investment and to quantify their gains and losses.

We calibrate the model to the average metropolitan area among the 75 largest MSAs in the United States. It matches the average housing supply elasticity as well as the elasticity of demand of OOT buyers. The model delivers realistic wealth accumulation and home ownership patterns over the life-cycle and across income groups. We shock this city with an inflow of OOT real estate investors. They account for 10% of housing demand in the city center and 5% in the suburbs. Section 2 presents stylized facts on OOT demand suggesting that the 10% share is not uncommon for the urban core of the major cities in the world, while 5% is more representative of the city-wide demand. A key feature of the model, as well as the data, is that OOT investors use the house as a pied-à-terre rather than renting it out, thereby removing some housing otherwise available for locals. From the perspective of the locals, the OOT housing demand shock is a source of aggregate risk. Local residents form beliefs over the expected duration of low- and high-OOT investment spells. We calculate how much each local resident would be willing to pay to avoid a transition from the low-OOT state, with zero OOT demand, to the high-OOT housing demand state.

Given imperfectly elastic housing supply, we find that an inflow of OOT investors is only partially absorbed by new construction. Residential construction increases substantially in the short-run, accommodating 16% of OOT demand. Rents must rise to induce residents to reduce housing demand so that the market for space can clear. Rents go up by 10.9% in the short-run and by 8.5% in the long-run, implying a substantial increase in the cost of housing. House prices increase by 6.3% in the short run and 4.8% in long-run. The price increase is smaller than the rent increase because house prices capitalize a possible future reversal to the low OOT state associated with lower rents. While OOT buyers only affect the ownership market directly, their purchases compete for space and prompt

2

large rent increases in equilibrium. Rent increases in the suburbs are nearly as large as in the urban core, despite an OOT shock that is only half as large. Spatial equilibrium forces bind the fate of housing markets in the metro area together despite the presence of commuting frictions that segment them. City-wide wages rise (+0.6%) due to the boom in the construction sector. The aggregate increase in wages lowers the competitiveness of the city and hours worked fall. Because average labor earnings are essentially unchanged, the rent-income and price-income ratios rise by the same amount as rents and prices, indicating severe reductions in housing affordability.

Renters, whose cost of living rises, suffer welfare losses from the OOT demand shock. The average renter would be willing to forgo -2.02% of annual consumption to avoid the inflow. Younger and older renters, who tend to be poorer, suffer the largest welfare reduction. Owners, on the other hand, benefit from capital gains on housing, resulting in an average welfare gain of 0.43%. Younger owners face higher future housing costs, reducing some of the benefit. Aggregating across all local residents, city welfare falls by -0.61% following the OOT inflow. Since owners are in a numerical majority in the average MSA, a majority of households gain. The aggregate welfare loss reflects large losses for high-marginal utility households.

In an extension, we add a luxury housing market in the city center, and assume that OOT purchases disproportionately take place in that market. This model generates 2.1% point larger price increases in the luxury than in the non-luxury market segment. However, it still produces substantial price appreciation in non-luxury markets, both in the city center and the suburbs, as well as substantial rent growth. The overall welfare effects are similar to the baseline model. These results illustrate that OOT purchases "trickle down" across tenure status, quality segments, and in space to affect a broad swath of society.

We investigate how sensitive the aggregate welfare results are to changes in the model parameters. Results scale with the size of the OOT shock, and are robust to changes in its persistence and in the price elasticity of OOT demand. Welfare costs are larger when

housing supply elasticity is lower, suggesting that the cost from OOT purchases is higher in cities like New York, San Francisco, or Miami.[1] Lower demand elasticities result in larger price and rent increases than in the baseline and a larger welfare cost. A model variant which features too little heterogeneity in wealth substantially understates the welfare cost. One key assumption is that OOT investors do not rent out their properties to locals. A model where they rent out all of their housing results in welfare effects that are close to zero. Put differently, a policy that mandated OOT owners to rent out their property at least some of the time would be welfare increasing. The welfare cost also falls substantially when there is no minimum housing size, (counter-factually) allowing renters to live in very small quarters. Policies that reduce minimum house size restrictions may mitigate the welfare cost of OOT investors. An economy where all households are home owners generates modest welfare gains. These results help understand the key drivers of the welfare effects, and underscore the need for rich heterogeneity on the household side if one is to arrive at a realistic quantification of the welfare effects.

The negative welfare cost of OOT demand prompts us to evaluate policies that tax OOT investors. In one case, the extra tax revenue funds additional public goods over which local residents derive utility. In a second case, the tax revenue is used to offset property taxes for locals. In a third case, it is redistributed to the poorest 25% of the population. In the first exercise, we find that OOT taxes are welfare increasing, and more so the more valuable are public goods. A tax equivalent to a 15% transaction tax offsets one-third of the welfare loss in the baseline model. With higher tax rates and higher public good valuations, the welfare loss can be turned into a gain. The second policy which uses OOT tax revenue to lower locals' property taxes is good for owners, especially when the price elasticity of OOT demand is low, and for renters, especially when the price

---

[1]Recent work by Baum-Snow and Han (2020) suggests slightly lower housing supply elasticities than those estimated in Saiz (2010). They also find lower supply elasticities in the city center, which is a feature of our calibration.

elasticity is high. In the third experiment, poor locals –who are predominantly renters–see no reduction (a substantial increase) in welfare when the OOT tax surcharge (the entire property tax paid by OOT buyers) is redistributed to the bottom quartile of the income distribution. In summary, OOT taxes increase welfare and have the potential to overturn the welfare loss from the OOT inflow. Their distributional effects depend on the details of how the tax revenue is used.

Our paper contributes to three literatures. A large literature in finance solves partial-equilibrium models of portfolio choice between housing (extensive and intensive margin), financial assets, and mortgages. Examples are Campbell and Cocco (2003), Yao and Zhang (2004), Cocco (2005), Berger, Guerrieri, Lorenzoni, and Vavra (2017), and Chen, Michaux, and Roussanov (2020), which contains the richest setup to date in terms of the trade-off between owning and renting and the various ways in which households can access housing collateral. Davis and Van Nieuwerburgh (2015) provides a summary of this literature. Recent work in macro-finance has solved such models in general equilibrium, adding aggregate risk, endogenizing house prices and sometimes also interest rates, (e.g., Favilukis, Ludvigson, and Van Nieuwerburgh, 2017; Kaplan, Mitman, and Violante, 2020; Greenwald and Guren, 2020). Like the former literature, our model features a life-cycle and a rich portfolio choice problem. It 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. Because we model one city, interest rates are naturally taken as given. The model is consistent with data on income and wealth inequality.

Second, our model connects to a growing empirical literature that studies the effect of OOT buyers on local housing markets. Badarinza and Ramadorai (2018) estimate substantial effects of OOT inflows on house prices and home ownership rates in London neighborhoods using as an instrument political shocks in a source country interacted with the pre-existing share of neighborhood residents born in that source country. Cvijanovic

and Spaenjers (2020) use deeds records for Paris and find that non-resident foreigners typically buy in more desirable neighborhoods, pay more for these properties than locals and have lower capital gains upon a sale, and that their purchases are in part driven by local economic conditions in their country of origin. OOT buyers account for about 16.6% of purchases in Paris. They also show that 60% of OOT properties are used as secondary residence rather than being rented out as an investment property. Li, Shen, and Zhang (2020), Barcelona, Converse, and Wong (2020), and Gorback and Keys (2020) focus on the role of Chinese house buyers on U.S. residential property markets, exploiting geographic variation. Badarinza, Ramadorai, and Shimizu (2020) and Agarwal, Sing, and Wang (2019) emphasize the importance of the nationality of the parties in a commercial real estate transaction. We complement this literature by providing a model to confront the empirical evidence on OOT investors with. Such a model can be used for counterfactuals and policy analysis. We also provide new testable implications regarding the effects of OOT purchases on rents, wages, and intra-city migration and inequality. The sensitivity of house prices to an inflow of foreign buyers estimated in the difference-in-difference framework of Gorback and Keys (2020) accords well with the estimate implied by our baseline model.

A related literature highlights the role of investors in the dynamics of housing investment and price formation. Prominent examples are Chinco and Mayer (2016), Bayer, Geissler, Magnum, and Roberts (2020), Gao, Sockin, and Xiong (2020), and DeFusco, Nathanson, and Zwick (2018). Many investors bought houses for speculative purposes, often with debt, amplifying both the boom and bust in American housing markets in the 2000s. Higher default risk of such investors may have contributed to the slow housing market recovery (Piskorski and Seru, 2020). The investors we consider tend to buy properties with cash, for their own use, and are often not primarily motivated by profit. They came to prominence in the 2010s.

Third, our work contributes to the urban economics literature which studies housing

affordability. Models in this literature follow in a long tradition of Alonso-Muth-Mills spatial equilibrium models, as reviewed by Brueckner (1987). Urban models tend to be static and households tend to be risk neutral or have quasi-linear or CARA preferences.[2] The lack of risk, investment demand for housing, and wealth effects makes it hard to study the effect of OOT home investors on house prices in such a setting. Rather than assuming absentee landlords, we close the housing market by explicitly modeling local landlords. Our spatial setup with two housing markets in a metro area can accommodate spatial concentration of OOT demand in one neighborhood and has predictions for house price and rent spillovers to the other neighborhood, as well as for between-neighborhood inequality.

Because it is a heterogeneous-agent, incomplete-markets model, agents choices and equilibrium prices depend on the entire wealth distribution. We use state-of-the-art methods to solve the model, extending the approach of Favilukis, Ludvigson, and Van Nieuwerburgh (2017), which itself extends Gomes and Michaelides (2008) and Krusell and Smith (1998) before that. In follow-up work, Favilukis, Mabille, and stijn Van Nieuwerburgh (2021) study policy reforms to the rent stabilization system in New York City.

The rest of the paper is organized as follows. Section I provides stylized facts on the importance of OOT home buyers and recent OOT tax policies. Section II sets up the baseline model and Section III calibrates it. Section IV discusses its main results. Section V

---

[2]Hizmo (2015) and Ortalo-Magné and Prat (2016) study a portfolio choice problem where households make a once-and-for-all location choice between cities. Conditional on the location choice, they are exposed to local labor income risk and make an optimal portfolio choice. They have constant absolute risk aversion preferences and consume at the end of life. The model features absentee landlords. Van Nieuwerburgh and Weill (2010) solve a dynamic spatial equilibrium model with many cities and many household types. However, households still have quasi-linear preferences. Recent work on spatial sorting across cities includes Behrens, Duranton, and Robert-Nicoud (2014) and Eeckhout, Pinheiro, and Schmidheiny (2014). 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). Parkhomenko (2020) adds a voting decision to a spatial equilibrium model.

discusses how the welfare results depend on parameter assumptions. Section VI studies the effects of a tax on OOT investors. Section VII discusses a model extension with luxury housing. Section VIII concludes. The appendix contains further details on the model and on the data.

I   Motivating Evidence

Comprehensive data for OOT home buyer demand across time and space is not available, despite recent improvements in data collection. However, there is mounting evidence for the quantitative importance of OOT investors on both quantities and prices in the housing market of many major cities around the world. This section collects some stylized facts as motivation for (i) the theoretical model that is the focus of this paper, (ii) the calibration to a 10% OOT investor share, and (iii) the OOT tax policy exercise in Section 6.

New York   We obtain data from *CoreLogic* on the fraction of OOT housing purchases for Manhattan and for the rest of the New York MSA between January 2004 and September 2016. Housing purchases are defined as purchases of single-family, 2-4 family, condominiums, and co-ops. OOT purchases are identified using the reported mailing addresses on payment/tax forms. Specifically, if the address of a buyer is either abroad or not contained in the list of 1,304 ZIP codes inside NYC MSA, then the transaction is classified as an OOT purchase. Appendix E.B describes in detail how we deal with purchases made by LLCs and other corporate entities. Figure 1 plots the OOT purchase share at quarterly frequency, averaging the months in the quarter. Four facts stand out. First, OOT purchases are a non-trivial part of the market throughout the sample period. Second, the OOT share is much larger for Manhattan than for the rest of the metro area. Over the period of measurement, the data suggest an OOT share of 10% for Manhattan and 5% for the entire NYC metro area. Third, there is a steady increase in the OOT share in both

8

Manhattan and the rest of the metro area over the last thirteen years. Fourth, Figure 1 shows that the OOT demand is quite persistent.

Figure 1. OOT Purchase Share New York
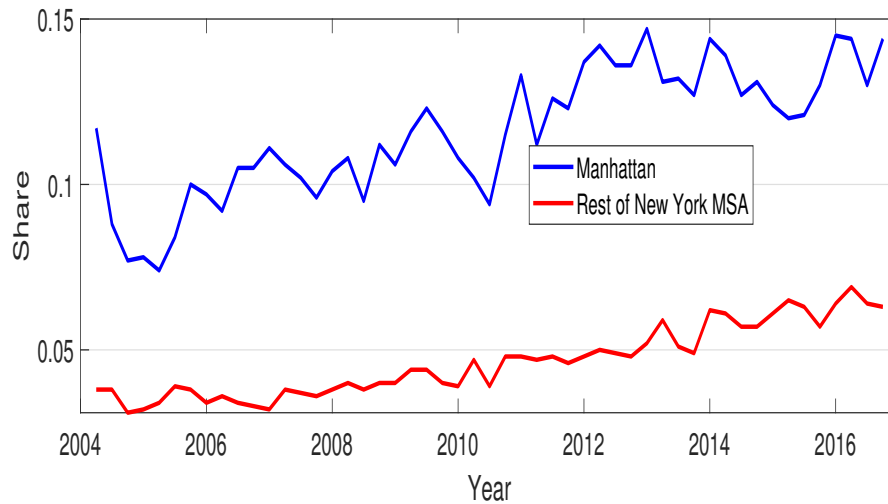
Suher (2016) provides corroborating evidence from New York tax records suggesting that, out of a sample of 84,000 condo units in the core of Manhattan in 2012, 25% are owned by non-residents.[3]

Evidence for the prevalence of vacant properties owned by non-residents comes from the American Community Survey data. It reports homes that are vacant for seasonal, recreational or other occasional use. Data for Manhattan show that the number of such vacant units has risen from 30.9% of vacant units and 4.5% of occupied units in 2010 to 39.3% of vacant and 5.9% of occupied units in 2015. This category of vacancies under-counts non-resident ownership because the category can only be assigned if no one responds to multiple contact requests by the surveyor. At that point, the surveyor will speak to neighbors, brokers, or property managers to try to figure out whether the unit is in fact occupied

---

[3]An April 2019 investigation by *The Real Deal* corroborates these numbers. Out of 92,000 Manhattan condo units investigated, 16% were bought by anonymous LLCs. One-third of units did not apply for the annual condo tax abatement available only to primary owners; those are pied-á-terre units. Stripping out units that are ineligible for the tax break raises the fraction of pieds-á-terre to 43%.

but only used occasionally. Wheaton (2017) studies the ACS seasonal/occasional vacancy data and shows that they are related to regional variation in the amplitude of the house price boom and bust.

While non-resident buyers face no additional taxes to buy an apartment in NYC, despite public outcry for the introduction of such a tax, they face higher taxes than residents when selling. This includes Federal (20%) and New York State (8.8%) capital gains taxes as well as Federal estate taxes (no exemptions for foreigners). The Regional Plan Association backed a pied-à-terre tax for New York City in its 2018 Fourth Regional Plan, noting 60,000 NYC apartments are vacant but not on the housing market.

Rest of U.S. The National Association of Realtors (NAR) has been conducting a survey among its members on foreign home purchases in the United States since 2010. The share of foreign purchases was 10% during the 12-month period that ended March 2017 ($153bn). It was about 8% in the March 2015 ($103.9bn), March 2016 ($102.6bn), and the March 2018 ($121bn) surveys. The 2018 foreign investment is approximately double the 2010 investment ($65.9bn) when data collection started. Florida attracted most of the foreign investment in 2018 (22%). Foreigners accounted for 50% of purchases in Miami-Dade county. About 40% of foreign purchases are by non-resident foreigners. OOT purchases would exclude purchases by foreigners that are local residents but include all purchases by non-resident (out-of-MSA) U.S. citizens. Such data are not readily available for the entire U.S.

Chinco and Mayer (2016) use housing transactions merged with tax assessor data to identify OOT buyers, using the property tax billing address. They find that the OOT share rises as high as 17% in some boom markets like Las Vegas. Bayer, Geissler, Magnum, and Roberts (2020) use transaction data for the period 1988-2009 for Los Angeles county. They focus on the role of all investors, without distinguishing between local and out-of-town investors. Using three different measures, the investor share triples between the early

10

1990 to the peak of the boom in 2003-06.[4]

London   A study by the Mayoral office shows that 13% of properties sold in 2014-16 were bought by foreigners. Half of these homes were below £500,000, homes that could be bought by typical first-time home buyers. Separately, Knight Frank estimates that 49% of Central London homes above £1 million were sold to foreigners in the year to June 2013. More than half of these sales (28% of total sales) were to non-resident foreigners.

In April 2016, the U.K. began to levy a 3% stamp duty surcharge on second property purchases. Given the progressive schedule of stamp duty and the fact that OOT purchases are usually higher-end properties and always second homes, the incidence of this surcharge disproportionately falls on OOT buyers.

Paris   Data from Cvijanovic and Spaenjers (2020) allow us to compute the share of OOT buyers in Paris. We define OOT buyers as either foreign or French residents who do not live in Paris or in Ile-de-France at the time of their housing purchase in Paris. These buyers account for 16.6% of transactions (and a somewhat larger share of value) over the 1992-2016 sample. The OOT purchase share in Paris is fairly constant over time.

The Paris data also contain information on the use of the apartment, distinguishing between primary residence, investment property for rent, and secondary home (pied-à-terre). This information is available for all sales, and sellers can be grouped by residence at the time of sale. This data shows that 61% of Parisian dwellings sold by OOT owners are secondary residences, with the remaining 39% for rent.

---

[4]Their measures of investors are (i) whether an individual owns two homes at the same time –this measure rises to a nearly 30% share in 2006,– (ii) purchases that were resold within two years –15% of all homes bought in 2003-05 were resold within a two year period,– and (iii) flippers defined as the fraction of purchasers who buy at least two houses while holding them for less than two years –this measure peaks at 5% in 2006.

Vancouver and Toronto Foreigners owned 7.9% of Vancouver's and 7.2% of Toronto's condominium apartments in mid-2017 according to Statistics Canada. Non-residents owned 5.1% of all residential properties by value in Vancouver and 3.0% in Toronto. Statistics Canada suspects that these numbers understate foreign ownership because they fail to account for purchases made by corporations incorporated in Canada but controlled by foreign residents, as well as for properties bought by foreigners but in the name of a Canadian resident relative.[5]

Soaring prices prompted the government of British Columbia to introduce a 15% transaction tax on foreign buyers in August 2016. Foreigner buyers exclude foreign nationals who work and pay income taxes in British Columbia. This is consistent with the treatment of OOT buyers in our model: OOT investors do not work in the city either. The Government of Ontario followed suit with its own 15% transaction tax in April 2017. The levy in British Columbia was increased to 20% in mid-2018, and now applies to a larger geographical area. In the five weeks leading up to the introduction of the tax, foreign buyers accounted for 10% of purchase value in the Vancouver metro area and 11% in the City of Vancouver.

In April 2018, the City of Vancouver instated an "empty home tax" of 1% of the taxable assessed value of the home for properties that are left vacant, i.e., that do not serve as primary residence or are not rented out at least six months per year. The province of British Columbia passed its own "speculator" tax, which went into effect in 2019, targeting both foreign and domestic OOT home buyers who don't live in or rent out their properties for at least six months per year. The BC vacancy tax rate is 2% of the home value for foreigners, 1% for OOT residents, and 0.5% for residents.

Australia and New Zealand Foreigners must apply with the government to purchase residential real estate in Australia. Data from Australia's Foreign Investment Review

---

[5]See https://vancouversun.com/news/local-news/foreign-ownership-data-released-so-far-just-the-tip-of-the-iceberg-statscan-director.

Board show a quadrupling of residential real estate approvals from 10,000 per year in the 2010-2012 period to 40,000 a year in 2015-2016. The 40,000 approvals correspond to $72 billion in investment. The foreign buyer share hovered between 10 and 15% between 2014.Q4 and 2017.Q1 according to the NAB.

Approvals dropped to 13,000 in 2016-2017, totalling $25 billion after the passage of stricter controls and higher application fees on foreign ownership. The province of New South Wales, where Sydney is located, introduced a stamp duty surcharge of 4% on the purchase of residential real estate by foreign persons from June 2016 onwards. For purchases after July 2017, the surcharge was increased to 8%. Victoria with capital Melbourne introduced its own stamp duty surcharge of 3% on July 1, 2015, and increased it to 7% for purchases after July 1, 2016. Foreigners who live and work in Australia are exempt. The introduction of a "ghost" tax on properties that are not available for rent or occupied more than half of the year and tighter Chinese capital controls may also have contributed to the decline in the foreign buyer share. By 2017.Q4, it had fallen to 8.4%.

New Zealand similarly passed severe limitations on foreign home buyers in August 2018, after house prices surged. The non-resident share of home purchases peaked in April 2018 at 3.3% in New Zealand, but at nearly 10% in Queenstown and 7.3% in Auckland.

Singapore and Hong Kong   The non-resident foreign purchase share in Singapore was 7.4% in 2016.H1 and 6.8% in 2017.H2. Singapore imposed a special tax of 15% on foreign property buyers in 2013, and increased its tax to 20% in August 2018.

Hong Kong introduced a 15% non-resident stamp duty in 2012. Non-residents currently pay 30% stamp duty in Hong Kong.

Israel   The share of residential properties owned by non-residents rose sharply from about 1% prior to 2000 to 6% in 2005-06 before falling back to 3% by 2009, according to the Israeli Ministry of Finance. The share is much higher in Tel Aviv (about 8-10%) and in

Jerusalem (about 12-16%). Starting January 2017, the purchase tax for non-residents was substantially increased, relative to that for residents.

II Model

We model a housing market corresponding to a metropolitan statistical area (MSA). The MSA has a fixed population normalized to one.[6] It consists of two geographies, the "urban core" and the "periphery." The urban core, which we refer to as zone 1, is the central business district where all employment takes place. The periphery, or zone 2, contains the outer boroughs of the city as well as the suburban areas that belong to the metropolitan area.

II.A Households

Preferences The economy consists of overlapping generations of households. There is a continuum of households of a given age. Each household maximizes utility U over consumption goods c, housing h, and leisure l (labor supply is n). Utility depends on location ℓ, age a, and local public goods spending G_t:

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

$$C(c_t, h_t, l_t) = \left[(1-\alpha_n)\left((1-\alpha_h)c_t^\epsilon + \alpha_h h_t^\epsilon\right)^{\frac{\eta}{\epsilon}} + \alpha_n l_t^\eta\right]^{\frac{1}{\eta}} \tag{2}$$

---

[6]Future work could consider an open-city model extension and study interactions between OOT investor flows and resident net migration patterns. Such a model would need to take a stance on a reservation utility of moving to other locations and on the moving costs. These would naturally differ by age, productivity, and wealth. A proliferation of parameters would ensue with little guidance from the literature on how to set these parameters. Evidence from the New York metropolitan area, discussed in Appendix E.C, suggests that net migration rates during the period of OOT inflows were small, and positively rather than negatively correlated with OOT purchase activity across time and space.

$$h_t \geq \underline{h} \tag{3}$$

$$n_t^a = \begin{cases} 1 - \phi_T^\ell - l_t \geq \underline{n} & \text{if } a < 65 \\ 0 & \text{if } a \geq 65 \end{cases} \tag{4}$$

$$\chi_t^{\ell,a} = \begin{cases} \chi^1 & \text{if } \ell = 1 \text{ and } a < 65 \text{ and } c_t < \underline{c} \\ \chi^1 \chi^W & \text{if } \ell = 1 \text{ and } a < 65 \text{ and } c_t \geq \underline{c} \\ \chi^1 \chi^R & \text{if } \ell = 1 \text{ and } a \geq 65 \\ 1 & \text{if } \ell = 2 \end{cases} \tag{5}$$

The coefficient of relative risk aversion is γ. The parameter $\theta \geq 0$ modulates the importance of the public good. The function $\mathcal{C}$ is a CES aggregator of non-housing consumption c, housing consumption h, and leisure l. The Frisch elasticity of labor supply is affected by all utility parameters, but dominated by η. The parameter ϵ controls the intra-temporal elasticity of substitution between housing and non-housing consumption.

Housing is divisible and there are no moving costs. Equation (3) imposes a minimum house size requirement ($\underline{h}$). Cities' building codes often contain such minimum size restrictions on dwellings.

Total non-sleeping time in equation (4) is normalized to 1 and allocated to work (n_t), leisure (l_t), and commuting time ϕ_T^ℓ. We normalize commuting time for zone 1 residents to zero: $\phi_T^2 > \phi_T^1 = 0$. 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 age- and location-specific taste-shifter $\chi^{\ell,a}(c_t)$ is normalized to one for all zone 2 residents. The shifter χ^1 captures the amenity value of zone 1 relative to zone 2. It captures relative school and air quality, crime, noise, and congestion, but also restaurants and cultural spaces. Whether χ^1 is smaller or greater than 1 is an empirical matter. The parameter χ^W (χ^R) shifts the utility for working-age (retired) households that live in zone

15

1 and consume above a threshold $\underline{c}$. Values for χ^W and χ^R above 1 capture a complementarity between living in zone 1 and high consumption levels, possibly reflecting luxury amenities located in the urban core. Such a luxury amenity effect provides an extra pull for rich households to live in the city center beyond the pull provided by the opportunity cost of commuting. Guerrieri, Hartley, and Hurst (2013) achieve a similar outcome through a neighborhood consumption externality.

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. A special case of the model with $\beta^H = \beta^L$ is discussed below.

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, persistent, stochastic labor productivity state z. Idiosyncratic productivity risk is the main source of risk in the model, giving rise to market incompleteness.

There is an exogenous retirement age. After retirement, households earn a pension which is the product of an aggregate component $\overline{\Psi}$ and an idiosyncratic component ψ^z which has a cross-sectional mean of one. The idiosyncratic component reflects productivity during the last period of the working stage. Labor income is taxed at rate τ^{SS} to finance the pension system.

Households face mortality risk which depends on age, p^a. Although there is no intentional bequest motive, agents who die leave accidental bequests. We assume that the number of people who die with positive wealth leave a bequest to the same number of agents alive of ages 21 to 65. The recipients are randomly chosen, with one restriction. Patient agents (β^H) only leave bequests to other patient agents and impatient agents (β^L)

only leave bequests to other impatient agents. One interpretation is that attitudes towards saving are passed on from parents to children. Conditional on receiving a bequest, the size of the bequest $\widehat{b}_{t+1}$ is a draw from the relevant distribution (different for β^H and β^L types). Because housing wealth is part of the bequest and the house price depends on the aggregate state of the economy, the size of the bequest is stochastic. Agents know the distribution of bequests, conditional on β type. This captures several stylized facts: many households receive no bequest, there is substantial heterogeneity among bequest sizes and ages at time of receipt for those who receive a bequest.

Location and Tenure Choice Let S_t be the aggregate state of the world, 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 location ℓ. The household's individual state variables are its net worth at the start of the period x_t, its idiosyncratic productivity level z_t, and its age a. We suppress the dependence on β-type in the problem formulation below, but note that there is one set of Bellman equations for each β-type. The household chooses each period in which location $\ell \in \{1, 2\}$ to live and whether to be an owner or a renter. Denote by V the value functions over these choices, with subscript R denoting the choice of renting and O that of owning:

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

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

Renter Problem A renter household in location ℓ chooses non-durable consumption c_t, housing consumption h_t, and working hours n_t to solve:

$$V_{R,\ell}(x_t, z_t, a, S_t) = \max_{c_t, h_t, n_t} U(c_t, h_t, n_t; \ell_t, a, G_t) + (1 - p^a)\beta E_t[V(x_{t+1}, z_{t+1}, a + 1, S_{t+1})]$$

s.t.

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

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

$$y_t^{lab} = W_t n_t G^a z_t$$

and equations (1), (3), (4), (5).

In addition to a time cost, residents of zone 2 face a financial cost of commuting ϕ_F^2. As we did for the time cost, we normalize the financial cost of commuting within zone 1: $\phi_F^1 = 0$. The renter's savings in the risk-free bond, $Q b_{t+1}$, where Q is the bond price, are obtained from the budget constraint. Next period's financial wealth consists of these savings plus any bequest received, $\widehat{b}$. Retirement income $\overline{\Psi}\psi^z$ is zero prior to age 65 and labor income is zero after age 65.

Owner's Problem 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:

$$V_{O,\ell}(x_t, z_t, a, S_t) = \max_{c_t, h_t, \widehat{h}_t, n_t} U(c_t, h_t, n_t; \ell_t, a, G_t) + (1 - p^a)\beta E_t[V(x_{t+1}, z_{t+1}, a + 1, S_{t+1})]$$

s.t.

$$c_t + P_t^\ell h_t + Q b_{t+1} + P_t^\ell \widehat{h}_t + \phi_F^\ell = (1 - \tau^{SS}) y_t^{lab} + \overline{\Psi}_t \psi^z + x_t + R_t^\ell \widehat{h}_{,t}$$

$$x_{t+1} = b_{t+1} + \widehat{b}_{t+1} + P_{t+1}^\ell (h_t + \widehat{h}_t)(1 - \delta^\ell - \tau^{P,\ell}),$$

$$-Q_t b_{t+1} \leq \kappa P_t^\ell (h_t + \widehat{h}_t) - R_t \widehat{h}_t - ((1 - \tau^{SS}) y_t^{lab} - c_t) + \phi_{F,t}^\ell,$$

$$\widehat{h}_t \geq 0,$$

and equations (1), (3), (4), (5).

18

Home owners in a zone are the landlords to the renters in that zone.[7] 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 $R_t \widehat{h}_t$ on their investment units $\widehat{h}_t$.

The physical rate of depreciation for housing units is δ^ℓ. The term $Ph\delta^\ell$ is a financial cost, i.e., a maintenance cost. As shown in equation (11) below, physical depreciation is offset by residential investment undertaken by the construction sector. 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 is used for local government spending that enters the local residents' utility function.

Housing serves as a collateral asset for debt. For simplicity, mortgages are negative short-term safe assets.[8] Households can borrow a fraction κ of the market value of their primary residence and investment property.[9] Rental income and savings $((1 - \tau^{SS})y^{lab} - c)$ in the first period (four years in the calibration) after the purchase of a rental property are excluded from household net worth when computing the LTV ratio.

II.B Firms

Goods Producers   There are a large number n_f of identical, competitive firms all of which produce the numéraire consumption good.[10] This good is traded nationally; its

---

[7]This assumption is not important for our results. The opposite extreme that all rentals are owned by non-locals would give rise to nearly identical quantitative results. The reason is that the equilibrium return on rental housing is close to the risk-free rate because risk aversion is low and the only source of aggregate risk, fluctuations in the OOT demand, displays only modest volatility.

[8]It would be easy to introduce an exogenous mortgage spread. We could also add tax deductibility of mortgage interest rates. The implicit assumption here is that these two effects, one raising the mortgage rate and the other one lowering it, cancel out.

[9]It is easy to introduce a different LTV limit for investment and primary housing.

[10]We assume that the number of firms is proportional to the number of households in the city when solving the model. With this assumption, our numerical solution is invariant to the number of households.

price is unaffected by events in the city and normalized to 1. The firms have decreasing returns to scale ($\rho < 1$) and choose labor inputs to maximize profit each period:

$$\Pi_{c,t} = \max_{N_{c,t}} N_{c,t}^{\rho} - W_t N_{c,t} \tag{6}$$

Developers 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 at a price P_t^{ℓ} per unit. All developers are headquartered in the urban core, regardless of where their construction activity takes place. Let H_{t-1}^{ℓ} be the existing housing stock in zone ℓ. The construction firms have decreasing returns to scale and choose labor to maximize profit each period:

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

The production function of housing has two nonlinearities. First, as for consumption goods firms, there are decreasing returns to scale because $\rho < 1$. Second, construction is limited by zoning laws. The maximal amount of square footage zoned for residential use in zone ℓ is $\overline{H}^{\ell}$. We interpret $\overline{H}^{\ell}$ as the total land area zoned for residential use multiplied by the floor area ratio (FAR), the maximum permitted 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.

When $\overline{H}^{\ell}$ is sufficiently high, the model's solution becomes independent of $\overline{H}^{\ell}$, and the housing supply elasticity is governed solely by ρ. When $\overline{H}^{\ell}$ is sufficiently low, the

---

Due to decreasing return to scale, the numerical solution would depend on the number of households otherwise.

housing supply elasticity is lower and depends on both $\overline{H}^{\ell}$ and ρ.[11]

Profits Per capita profits from tradeable and construction sectors are:

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

We assume that goods and construction firms are owned by equity holders outside the city. Below, we explore sensitivity to this assumption.

II.C Out-of-town Buyers

OOT demand for housing is price elastic, stochastic, and persistent. OOT shocks are the only source of aggregate risk in the model. Shocks to the oil price, to the exchange rate (Ruf and Levi, 2011), political shocks in the country of origin (Badarinza and Ramadorai, 2018) or in the destination country (e.g., Brexit) are all examples of the underlying drivers of this stochastic OOT process. The persistence captures the notion that an OOT inflow is likely to last for a while, but could reverse in the future.[12] OOT buyers do not rent out their properties. Section I, and in particular Cvijanovic and Spaenjers (2020) provide empirical support for this assumption. Below, we solve a version of the model that assumes OOT housing is rented out, with substantially different results. OOT buyers do not work in the local labor market, do not consume local public goods, and are not counted as part of city welfare.

---

[11]In this sense, the model captures that construction firms must pay more for land when land is scarce. This scarcity is reflected in equilibrium house prices. In the background, the government makes available permits to build on land each period, in an amount normalized to 1 (Favilukis, Ludvigson, and Van Nieuwerburgh, 2017).

[12]An alternative modeling approach would be to model the arrival of OOT buyers as an MIT shock. In that case, households would expect the OOT buyers to remain forever after. a MArkov process allows for the possibility of a reversal. With the benefit of hindsight, the data suggest at least a partial reversal in foreign purchases of U.S. real estate starting in 2018.

Specifically, OOT purchases follow a two-state Markov process with a high state and a low state. In the low state, $OOT^L = 0$ in both zones. In the high state, OOT purchases in zone ℓ are strictly positive and depend on the equilibrium house price with elasticity coefficient b:

$$\log\left(OOT_t^{H,\ell}\right) = a_\ell - b \log\left(P_t^\ell\right) \tag{8}$$

Appendix A provides two micro-foundations for this demand function based on either preference or wealth shocks to OOT investors. By virtue of the calibration, the model will match the observed price elasticity of housing demand by OOT investors.

We assume a symmetric transition probability matrix between the two OOT states, with one parameter π governing the transition probability between regimes and therefore the expected duration of each regime. Locals observe the aggregate OOT state, understand its law of motion, and consider it when making their optimal decisions.

II.D Equilibrium

Given parameters and a stochastic process $\{OOT_t\}$, a competitive equilibrium is a price vector $(W_t, P_t^\ell, R_t^\ell)$ and an allocation, namely aggregate residential demand by market renters $H_t^{R,\ell}$ and owners $H_t^{O,\ell}$, aggregate investment demand by owners $\widehat{H}_t^\ell$, aggregate housing supply, aggregate labor demand by goods and housing producing firms $(N_{c,t}, N_{h,t}^\ell)$, and aggregate labor supply N_t such that households and firms optimize and markets clear.

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

$$N_{c,t} = \left(\frac{\rho}{W_t}\right)^{\frac{1}{1-\rho_c}} \quad \text{and} \quad N_{h,t} = \left(\frac{\left(1 - \frac{H_{t-1}^\ell}{\overline{H}^\ell}\right) P_t^\ell \rho}{W_t}\right)^{\frac{1}{1-\rho_h}}. \tag{9}$$

Second, labor markets clear:

$$n_f \left(N_{c,t} + N_{h,t}^1 + N_{h,t}^2 \right) = N_t. \tag{10}$$

Third, the housing market clears in each zone ℓ:

$$(1 - \delta^\ell) H_{t-1}^\ell + \underbrace{n_f \left(1 - \frac{H_{t-1}^\ell}{\overline{H}^\ell} \right) \left(N_{h,t}^\ell \right)^\rho}_{INV} = H_t^{O,\ell} + \widehat{H}_t^\ell + OOT_t^\ell. \tag{11}$$

The left-hand-side is the supply of housing which consists of the non-depreciated housing stock plus residential investment INV. The right-hand-side is the demand for those housing units by owner-occupiers, landlords, and out-of-towners.

Fourth, the rental market clears:

$$\widehat{H}_t^\ell = H_t^{R,\ell} \tag{12}$$

Fifth, average pension payments equal to average labor income taxes collected:

$$\overline{\Psi} N_{ret} = \tau^{SS} E\left[N_t W_t\right], \tag{13}$$

where we used the fact that G_a and z average to 1 in the cross-section, and N_{ret} is the total number of retirees, which is a constant.[13] Sixth, the aggregate state S_t evolves according to rational expectations. Seventh, the value of all bequests received is equal to the wealth of all agents who die. Eighth, local public goods spending equals property tax revenue.

---

[13]For simplicity, we assume that the total pension payments are equal to the average of all social security tax revenues, where the expectation is across high and low OOT demand states. OOT demand affect wages and therefore the total social security tax collected in a city. We do not think that letting the pension fluctuate with OOT demand of local real estate would be desirable. In the U.S., Social Security is maintained at the national level, and pension payments do not depend on local-area variation in wages.

Appendix B presents first order conditions.

II.E Welfare effects on Locals from OOT Buyers

We compute the welfare effect of an OOT inflow as follows. Suppose that OOT demand in period t is low and that it stays low in period $t + 1$. Denote agent i's welfare at $t + 1$ as $V_{t+1,i}(LL)$. Suppose instead that OOT demand at $t + 1$ switches to high and denote agent i's welfare in this situation as $V_{t+1,i}(LH)$. Agent $i's$ change in welfare from the OOT inflow in consumption equivalent units is (recall γ denotes risk aversion):

$$\mathcal{W}_{t,i} = -1 + \left(\frac{V_{t+1,i}(LH)}{V_{t+1,i}(LL)} \right)^{\frac{1}{(1-\gamma)(1-\alpha_n)}}.$$

It measures how much the household's value function, which reflects the entire expected present discounted value of future utility flows, changes upon a transition from the low to the high OOT state, expressed in consumption equivalent unit (in percentage points). It fully accounts for the persistent and stochastic nature of the OOT process. A positive number reflects a gain from the inflow, while a negative number reflects a loss. We compute aggregate welfare effects from "inflows" by summing $\mathcal{W}_{t,i}$ across all agents, calling the resulting aggregate welfare measure $\mathcal{W}$. We also sum separately among owners ($\mathcal{W}_o$) and renters ($\mathcal{W}_r$), for different age groups, income groups, and wealth groups.

III Calibration

The baseline model is calibrated to the average U.S. metropolitan area. Appendix E contains data sources and more detail. Table I summarizes the chosen model parameters. Externally calibrated parameters are indicated with a star.

Table I. Calibration

Description	Parameter	Values	Target
Panel A: Labor Income and Pension			
Income states	z	[0.258 0.775 2.192]	Income distribution SCF
Pension income*	ψ^z	[0.461 1.063 1.413]	Pension distr. rules
Pension tax rate*	τ^{SS}	0.10	Contribution rates
Panel B: Preferences			
Time Preference (4yr)	(β^L, β^H)	(0.793,1.020)	Wealth/income and wealth gini
Risk aversion*	γ	5.0	Standard value
Leisure weight*	α_n	0.68	Average workweek
Housing consumption weight*	α_h	0.26	Housing share in consumption of 21.6%
CES parameter consumption/housing*	ϵ	-0.50	Intra-temp elasticity c & h of 2/3
CES parameter consumption/leisure	η	0.00	Frish elasticity of labor supply of 1
Minimum hours	$\underline{n}$	0.15 E[n]	Capture part-time and full-time work
Local Public Goods Preference	θ	1.15	
Panel C: Finance and Regulatory			
Bond Price (4yr)*	Q	0.825	Avg return stock-bond portfolio 1987-2018
Maximum residential/investment LTV*	κ	0.90	Max LTV on primary residence/investment property
Property tax (4yr)*	τ^P	6.30%	Property tax rates
Housing depreciation (4yr)*	δ	0.0946	BEA housing depr 1987-2018
Minimum dwelling size*	$\underline{h}$	0.45 E[h]	Annual Housing Survey
Panel D: Production and OOT Demand			
Return to scale*	$\rho_c = \rho_h^1 = \rho_h^2$	0.66	Labor share of income
Available space	$(\overline{H}_1, \overline{H}_2)$	(0.21, 3.30)	Housing supply elasticity of 1.0
Time-commuting cost*	ϕ_T^2	0.036	Avg. commuting time
Financial-commuting cost*	ϕ_F^2	0.033	Transportation spending BEA
OOT demand elasticity	b	0.6	Section 2
OOT demand level	(a_1^H, a_2^H)	(-5.027 -4.250)	Section 2
OOT demand transition prob.*	π	0.90	Section 2
Cons. externality threshold	$\underline{c}$	0.25	Ratio of income zone 1/zone 2 avg. msa
Utility multiplier zone 1 all residents	χ^1	0.93	Ratio of home ownership rate zone 1/zone 2 avg. msa
Utility multiplier zone 1 workers	χ^W	1.03	Ratio of rent zone 1/zone 2 avg. msa
Utility multiplier zone 1 retirees	χ^R	1.05	Fraction of retirees in zone 1

Notes: The table reports the parameters of the model, their values in the baseline model and the the Vancouver model, as well as the target. Moments denoted with a * are externally calibrated. The other parameters are chosen to target a moment that is endogenous to the model.

III.A 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 65, and retire with a pension after age 65. Survival probabilities $p(a)$ are calibrated to mortality data from the Census Bureau. People age 65 and over comprise 18.3% of the MSA population age 21 and over in the data and 21.9% in the model.[14]

III.B Labor Income

Pre-tax labor earnings for agent i of age $a < 65$ is $y_t^{lab} = W_t n_t^i G^a z_t^i$, 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 0.15 times average hours worked.[15] This constraint binds for 21.90% of workers in equilibrium.

Efficiency units of labor $G^a z_t^i$ consist of a deterministic component that depends on age (G^a) and a stochastic component z^i that captures idiosyncratic income risk. The G^a function is chosen to enable the model to match the mean of labor earnings by age. We use data from ten waves of the Survey of Consumer Finance (SCF) from 1983-2010 to estimate G^a.

The idiosyncratic productivity process z^i is chosen to match earnings inequality and to generate realistic persistence in individual earnings. We discretize productivity z as a 3-state Markov chain. The values for the three states are chosen so that the average

---

[14]To speed up computation, we assume that the probability of dying is zero before age 36. The observed probability is below 1% for each 4-year period before age 36. We use mortality tables from 1960 rather than the latest available ones so as to better match the observed share of agents above age 65 in the current population.

[15]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 the earnings data is for the (part-time and full-time) employed. The presence of the constraint enables the model to better match the observed correlation between wealth and income.

earnings of households in the bottom 25%, middle 50%, and top 25% of the earnings distribution in the model matches those same objects in the 1983-2010 SCF. We assume a parsimonious transition probability matrix for z, where the probability of staying in the same productivity state is 90% for the average worker and 100% for retirees. The implied standard deviation and autocorrelation of the idiosyncratic component of labor income are 0.7 and 0.9, respectively, matching the micro evidence in Storesletten, Telmer, and Yaron (2006). We refer the reader to appendix C for details.

The Social Security tax rate, τ^{SS}, is set to 10%. In the data, employees contribute 6% and employers contribute an additional 6%, but only on income below $118,500. 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 $\psi^z = [0.46, 1.06, 1.41]$, where z reflects the last productivity level prior to retirement. Average budget balancing retirement income $\overline{\Psi}$ is $26,914, which corresponds to 35.84% of average earnings.

III.C Preferences

The functional form for the utility function is given in equations (1) and (2). We set risk aversion $\gamma = 5.0$, a standard value in the macro-finance literature.

We set α_n to match the average workweek of 34.5 hours per week in the U.S., which is 30.8% of non-sleeping time (112 hours per week). The model generates 30.6 %.

We set α_h to match the ratio of housing consumption to total consumption. The average in U.S. data for 1987-2018 (BEA real housing services consumption to real non-durable plus real services consumption) is 22.1%; the model generates 25.2%.

The parameter ϵ governs the intra-temporal marginal rate of substitution between housing and non-housing consumption. While the literature contains a range of estimates, the median elasticity across studies is 2/3, resulting in $\epsilon = -0.5$. We provide

sensitivity analysis below.

The parameter η governs the Frisch elasticity of labor supply, alongside the other utility parameters. Here too, there is a wide range of estimates from 0 to 1.5 based on micro data and from 2 to 4 based on macro data. We target a value of 1, resulting in $\eta = 0$. We obtain a Frisch elasticity in the model of 1.03 using aggregate quantities and 1.16 when using individual quantities.

We set $\beta^H = 1.020$ (1.005 per year) and $\beta^L = 0.793$ (0.944 per year).[16] A 25% share of agents has β^H, the rest has β^L. This delivers an average β of 0.85, chosen to match the average wealth-income ratio which is 5.69 in the 1998-2010 SCF data. The model generates 5.87. The dispersion in betas delivers a wealth Gini coefficient of 0.78, close to the observed wealth Gini coefficient of 0.80 for the U.S.

The probability of receiving a bequest equals the number of dead households divided by the number of households between ages 21 and 65. It is equal to 9.5% over each 4-year period, and identical for β^H and β^L household types. Under our calibration, 1.8% of wealth is bequeathed each year, close to the 1.2% in the data.

The parameter $\theta \geq 0$ modulates the importance of the public good in the utility function. It captures the government's efficacy at converting a given amount of tax revenue into valuable public goods. When $\theta = 0$, government spending is wasteful. Values of θ below 1 imply that the average household is unwilling to forgo private consumption for more public goods. Values of θ above 2 imply that households want to forgo so much private consumption that optimal government tax revenue would exceed 50% of private consumption. The public finance literature provides little guidance on how to set θ. We set $\theta = 1.15$ in our benchmark model and provide sensitivity analysis.

The taste-shifter for zone 1 is parameterized as: $\chi^1 = 0.93$, $\chi^W = 1.03$, $\chi^R = 1.05$, $\underline{c} = 0.25$. We chose these four parameters to get our model to better match the following

---

[16]Note that because of the probability of death, the effective time discount rate is $(1 - p(a))\beta$, which is less than one.

four ratios of zone 1 relative to zone 2 variables, given all other parameters: the relative fraction of retirees of 0.84, a relative household income ratio of 1.12, the relative ratio of market rents per unit of 1.03, and the relative home ownership rate of 0.65. In the model, these ratios are 0.84, 1.12, 1.03, and 0.45, respectively. The parameters imply that the amenities of zone 1 are 7% below those of zone 2 for households who consume below the threshold. The financial commuting cost compels these lower-income households to live in zone 1. Matching the relative income and rent ratios requires net disamenities for the city center. About 30.7% of the agents in the model consume above the threshold $\underline{c}$. They like zone 1 better than poorer agents, especially the retirees ($\chi^1 \chi^R = 0.98$).

III.D Production and Housing

The return to scale parameter in the both sectors is set to $\rho = 0.66$ to match the observed labor share of output of 66%.

The two zones in the MSA differ in the maximum buildable residential square footage permitted by existing zoning rules, $\overline{H}^1$ and $\overline{H}^2$. We use two moments to pin down the two parameters. The first moment is the fraction of households in the metro area that lives in the urban core. In 2017 data for the largest 74 U.S. MSAs, that fraction is 22.8%. The second moment is the long-run housing supply elasticity in the metro area. Saiz (2010) estimates housing supply elasticities for the largest 50 MSAs; they range from 0.6 for Miami to 1.70 for Albany. We target a value of 1.0, the weighted average of the housing supply elasticities, weighted by the MSA population shares. The model generates a supply elasticity of 0.94; Appendix D contains the derivation. The housing supply elasticity is much lower in zone 1 (0.45) than in zone 2 (0.99), because in zone 1 the housing stock is much closer to $\overline{H}^1$ (50.8% from the constraint) than it is in zone 2 (85.9% 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.[17]

---

[17] In recent work, Baum-Snow and Han (2020) find slightly lower average housing supply elasticities of

We set the maximum loan-to-value ratio (LTV) on mortgage debt at 90% ($\kappa = 0.90$), 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.

We set the property tax rate $\tau^P = 6.30\%$ or 1.58% per year. This is the population-weighted average property tax rate among the 74 largest MSAs in 2016, using data from the American Community Survey and the Zillow Home Value Index. Separate calculations for property tax rates in zones 1 and 2 of these MSAs show nearly identical averages.

We assume that property depreciates at 2.45% per year and set $\delta = 0.0946$. This is the average depreciation rate for privately-held residential property in the BEA Fixed Asset tables for the period 1987-2016.

The price for the one-period (4-year) bond is set to $Q = 0.825$ to match the population-weighted average house price-to-rent ratio in the largest 74 MSAs using Zillow data. This ratio is 13.03. The model delivers 13.02. The implicit interest rate is 4.93% per year.[18]

Finally, we impose a minimum housing size of 720 square feet, or 45.1% of the average housing unit size. According to the American Housing Survey, the average housing unit (including single- and multi-family units) built after 1960 is about 1,600 square feet big.

III.E Commuting Costs

We set the time cost of commuting to the observed commuting time in the largest 74 MSAs. The average one-way commuting time to work in the data is 28.6 minutes according to the 2017 American Community Survey of the U.S. Census. This data number

---

0.6-0.7 at the MSA level as Saiz (2010). Looking at more disaggregate data, they also find that housing supply elasticities are substantially lower in the urban core than in the periphery.

[18]Households in the model only have access to a real bond to save in (beside housing). In reality, a wider range of investment opportunities is available and governs wealth accumulation in the data. The average real return on a 50-50 bond-stock portfolio over the period 1987-2018 is 5.05%, where the bond is the five-year constant maturity Treasury and the stock is the CRSP value-weighted stock index.

is a weighted average of commutes within zone 1 and from zone 2 to zone 1. Since the model normalizes the commuting time within zone 1 to zero, we target the additional commuting time of zone 2 residents of 24.2 minutes per trip for 10 commuting trips per week.[19] The 4.0 hours represent 3.6% of the 112 hours of weekly non-sleeping time. Hence, we set $\phi_T^2 = 0.036$.

The financial cost of commuting ϕ_F^2 is set to 3.3% of average labor earnings, or \$2,478 per household per year. This is a reasonable estimate for the commuting cost in excess of the commuting cost within zone 1, which is normalized to zero.[20]

III.F OOT share

We set the low OOT state to reflect a situation without (before) OOT real estate purchases: $OOT^L = 0$. Given the empirical evidence discussed in Section 2 for several of the world's major MSAs, we target a 10% share of housing demand by OOT buyers in the city center and a 5% share in zone 2. We set the parameter a_ℓ in equation (8) to obtain the target share, given the value for b.

For the price elasticity of demand coefficient b, we consider two values. First, Suher (2016) estimates a price elasticity of 0.6 using a 2013 experiment in New York City when a property tax abatement was phased out for non-residents only. We use this 0.6 estimate as our benchmark value for b. The second value comes from matching the observed

---

[19]Given that 22.8% of the population lives in zone 1 as in the data (and matched by the model), and assuming a 10 minute commute within zone 1, the metro-wide average commute of 28.6 minutes implies an average commute from zone 2 to zone 1 of 34.2 minutes, or 24.2 minutes longer than the commute within zone 1. Under this assumption, commutes within zone 1 represent 8% of total commuting time.

[20]Aggregate spending on transportation services accounts for 3.9% of aggregate non-durable and services consumption and the same fraction of compensation of employees. We choose a slightly lower number given that only zone 2 residents commute. A 2015 survey by Citi, the Citi ThankYou Premier Commuter Index, finds that the average commuter spends \$2,600 per year on their commute, which is close to our chosen value.

change in OOT home purchases in Vancouver in response to the introduction of the OOT transaction tax in August 2016. The 15% transaction tax raised prices for OOT buyers by 15%. The share of OOT purchases in Vancouver in the five weeks prior to the OOT tax was 10%.[21] After the tax was introduced the OOT share fell to 4.1% of purchases.[22] The implied price elasticity is $(\log(0.041) - \log(0.10))/(\log(1.15) - \log(1)) = 6.4$. This much higher sensitivity may reflect substitution of foreign purchases to other Canadian or U.S. cities (e.g., Toronto and Seattle) in response to the Vancouver tax increase. We use this second value for an important sensitivity check.

We assume a state transition probability between the low and the high OOT regimes of 10% per 4-year period. That is, $\pi = 0.90$. Given the uncertainty regarding these numbers, we explore changing a, b, and π below.

IV Baseline Model Results

This section discusses the baseline results. In the next section, we switch off several features of the model one by one, to explain and quantify the role of the various model ingredients.

---

[21]Official statistics indicate a 10% share for the period from June 10 until July 16, 2016. This period excludes the two weeks prior to the announcement of the tax and another month prior to the introduction of the tax, during which anticipation buying may have artificially inflated the foreign purchase share. Several articles indicate that a foreign purchase share of 10-13% was common for metro Vancouver in the months before June 10, 2016. E.g., http://www.rew.ca/news/foreign-purchases-of-vancouver-homes-rise-slightly-as-market-adjusts-to-tax-1.3412049.

[22]The 4.1% share is for January 2017. Because of the initial bunching of OOT purchases prior to August 2016, there was a sharp drop-off in the immediate aftermath of the introduction of the tax. The foreign share was only 1.8% in September 2016 and gradually started to increase to 3-4% in the October 2016-January 2017 period. Foreign purchases fell from 4.1% to 2.5% by mid-2017 before rising again to 4.9% in early 2019. The post-January 2017 changes are likely due to reasons other than the transaction tax.

IV.A Earnings, Wealth, and Home Ownership

A first check on the model concerns its ability to broadly match observed patterns in income, wealth accumulation and home ownership over the life cycle.

The top panels of Figure 2 show pre-tax earnings by age in the data (left panel) and in the model (right panel). The solid black line shows the well-known hump-shaped labor income profile over the life cycle for the median household. The dashed red line shows average labor income in the bottom 25% of the labor income distribution, the dash-dotted blue line reports average income among the middle 50% of the income distribution, and the dotted green line shows the average income among the top-25% of the distribution. The model matches the observed labor income profiles closely. Since hours worked are a choice variable, the good fit of labor earnings means that model has realistic implications for hours worked. Our assumption of a constant income in retirement after age 65 causes a more discrete decline in income than in the data, presumably because some people continue to work after age 65 in the data.

Wealth and home ownership result from households' optimal consumption and investment decisions. The middle panels of Figure 2 plot household net worth, defined as real estate wealth plus financial wealth minus debt. The bottom panels plot the home ownership rate.

The model generates a home ownership rate of 63.4% (62.8% prior to the OOT inflow), close to the observed home ownership rate of 60.6% for the average U.S. MSA in 2016. The model fits the life-cycle patterns of wealth accumulation and home ownership well. The average home ownership rate starts out below 20% for the youngest households and displays a hump-shaped pattern over the life-cycle. It peaks at about 80% around age 70 in both model and data. It then declines in retirement. Home ownership rates were not targeted in the calibration, so this is an important success for the model.

The model also generates about the right amount of average wealth at different ages during the working stage of life. Households accumulate about $250,000 by age 40 and

Figure 2. Earnings, Net Worth, and Home Ownership across Age and Income groups
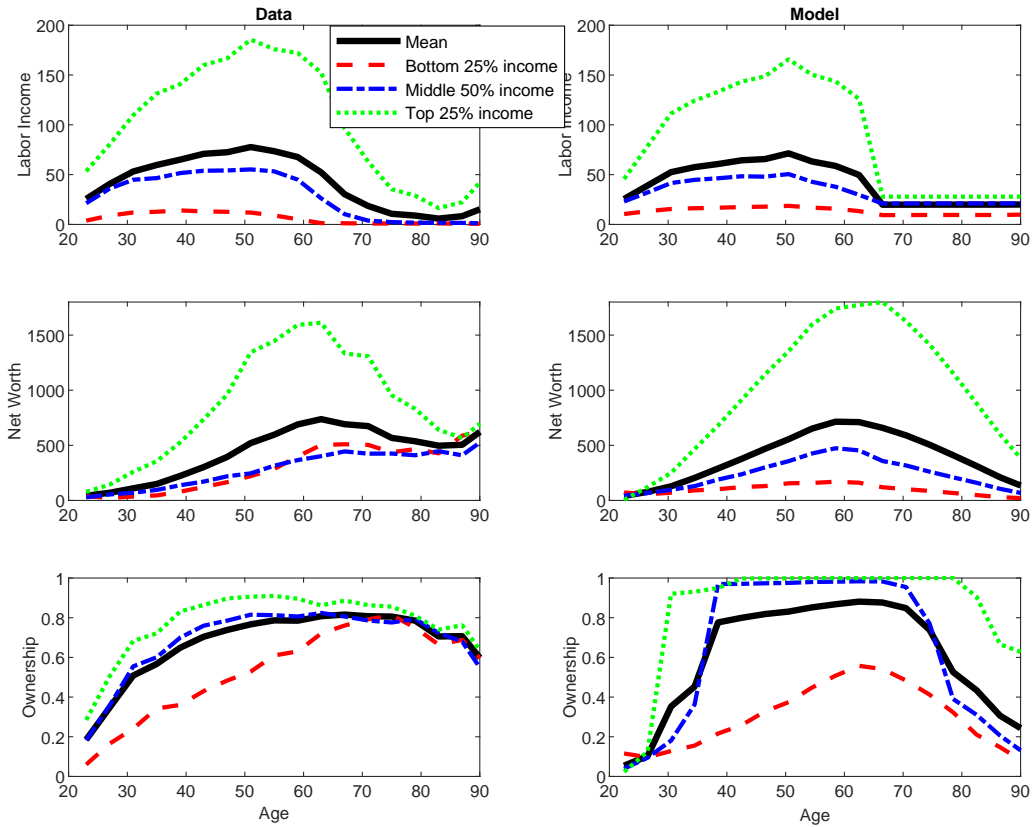
Notes: The left panels are for the data and based on the Survey of Consumer Finance (all 1983-2010 waves). All survey data are first expressed in 2010 real dollars before averaging across survey waves. The right panels are for the benchmark model. The top row denotes household earnings. The middle row denotes household wealth. The bottom row denotes the home ownership rate.

$650,000 by age 65, on average, in both model and data. Wealth gradually declines in retirement, in large part because home ownership rate declines. Both the decline in home ownership and total wealth are steeper in the model than in the data, and closely connected to each other.[23]

The model generates substantial cross-sectional variation in wealth and home own-

---

[23]Allowing for an intentional bequest motive and/or adding late-in-life medical/long-term care risk would give households additional motives to slow down wealth decumulation (Ameriks, Caplin, Laufer, and Van Nieuwerburgh, 2011). So would giving elderly people a preference for "aging in place" or letting them forgo housing maintenance (Cocco and Lopes, 2017). Adding these motives would overly complicate the model whose main purpose is to analyze the effect of OOT investors.

ership across cohorts and income groups that is broadly consistent with the data. The model matches the Gini coefficient for wealth (0.78 in model and 0.78 in data), which substantially exceeds the Gini of income (0.43 in model and 0.46 in data).

IV.B   House Prices and Rents

House prices, rents, and wages are determined in equilibrium. Since risk premia are small, as can be expected from a model with CRRA preferences and risk aversion of 5, the house price-to-rent ratio is close to the one arising from the user cost formula:$(1 - Q \times (1 - \delta - \tau^P))^{-1} = 3.28$ or 13.1 annualized. This 13.1 ratio in the model is close to the 13.0 average across the 75 largest MSAs in the U.S. data. The model also matches the relative ratio of rents between zones by virtue of the calibration. The quantity and price results suggest that the model is well positioned to quantitatively evaluate both the average and the distributional consequences of OOT purchases.

IV.C   Main Results: Increase in OOT Purchases

Table II summarizes how key prices and quantities adjust in response to the OOT shock. The first row reports the short-run response, in the first (four-year) period after the economy switches from the low to the high OOT state. These short-run changes are denoted by Δ_1 and expressed as percentage changes. The second row reports long-run changes, denoted by Δ_{ss}, measured as the difference between the high-OOT and low-OOT stochastic steady states. The last three columns report welfare effects for the average renter, for the average home owner, and average across all households.

Short-run response   The increase in OOT demand for housing is partly met by new construction. In zone 1, where the OOT inflow is 10%, residential investment increases by 9.20% in the short-run. Additional construction accommodates 16% of the OOT housing demand. The low housing supply elasticity (due to stricter zoning) is responsible for the

less than one-for-one supply response. To clear housing markets, locals must therefore consume less housing. To induce a sufficiently large decline in local housing demand, rents rise by 10.96% in zone 1. House prices rise by 6.54%. Thus, the arrival of OOT investors leads to a significant increase in the cost of housing in the first four years. It not only increases the prices of owner-occupied housing, which the OOT investors buy, but it has an even larger effects on rents. Rental and owner-occupied units are part of the same market for space.

Because OOT demand is mean-reverting, an OOT inflow today implies lower expected future OOT demand and hence rental growth. Prices go up by less than rents since they capitalize the expected lower rent growth; the price-rent ratio declines (-3.98%).[24]

In zone 2, where the OOT inflow is 5%, residential investment increases by 10.83% in the short-run. The larger expansion in the housing stock in zone 2, despite the smaller OOT inflow, is due to the larger housing supply elasticity in zone 2 which itself reflects the larger availability of undeveloped space $\overline{H}^2$. Zone-2 rents rise by 10.68% and prices rise by 6.27%, nearly as much as in zone 1 despite the smaller relative OOT demand and the larger supply response. In the MSA's spatial equilibrium, changes in rents and prices in zone 2 cannot differ by too much from changes in zone 1, lest they trigger large migration from zone 1 to zone 2. Commuting costs and amenity differences segment the housing markets of the two zones but spatial equilibrium forces bind them together.

The model's predicted response of house prices to an increase in OOT buyers is similar to that estimated in recent empirical work. Using a difference-in-differences design, Gorback and Keys (2020) estimate that U.S. zip codes with a high foreign-born population share experienced a 3.2% larger increases in foreign demand, price increases of around 5%, and housing stock increases of around 1.6% relative to zip codes with low

---

[24]The risk premium associated with OOT demand fluctuations is small, and does not fluctuate much with the OOT state. Discount rate variation explains little of the price-rent dynamics. To generate meaningful variation in housing risk premia would require additional sources of aggregate risk such as changes in mortgage lending standards as in Favilukis, Ludvigson, and Van Nieuwerburgh (2017).

foreign-born shares.[25] These numbers are broadly consistent with our baseline model where OOT purchases of 6% (10% in zone 1 and 5% in zone 2) of the housing stock lead to short term (4-8 years) price increases of 6.4% and supply increases of 1%. The price increase is smaller and the supply increase is bigger in the long run.

Composition effect   An interesting population composition effect takes place in response to the OOT inflow which helps explain the rent and price effects. High-wealth, middle-aged households leave zone 1 for zone 2; they sell to the OOT buyers. The average wealth and income of zone-1 residents in the 44-64 age group falls by 21.0% and 5.4%, respectively. The home ownership rate among locals in zone 1 falls by 4.8% since many in this demographic are owners. The increase in house prices brought about by the OOT inflow makes living in a large zone-1 home expensive for this group. The higher prices also make it harder to satisfy the housing collateral constraint for households that are not already owners in zone 1. By the same token, this group now demands a lot of housing in zone 2 where house prices are much lower per square foot. The increase in demand for zone-2 housing by this group helps explain the large rent and price increases in zone 2. It also explains the increase in home ownership among locals in zone 2 (+ 1.1%).

In contrast, after the OOT inflow, the young (and thus low-wealth), high-income group becomes more prominent in zone 1. Due to its high productivity, this group has a high opportunity cost of commuting and a high marginal value for zone-1 housing. They tend to live in smaller housing units. This reverse population flow of the young high-productivity households helps explain why the zone-1 local population only falls modestly (-0.17%). The OOT inflow crystalizes who among the locals has the highest value of space.

---

[25]The instrumented increase in foreign purchases understates total OOT purchases because (i) it excludes domestic OOT buyers, (ii) the foreign purchase surge lasted longer than 4 years, (iii) their DiD estimates do not include non-Chinese foreign-born residents, and (iv) the DiD estimates cannot capture any aggregate trend affecting all zip codes at the same time.

Housing affordability   The price-income ratio in the model, denoted HP/Y in the table, is computed as the average house price per square foot, P, multiplied by the average house size in square feet divided by the average earnings of working-age households Y. Because we want to compare the same house across OOT states, we hold the average house size in a zone fixed at its unconditional average. The price-income ratio in zone 1 (zone 2) increases by 13.86% (4.29%). These changes are much larger (smaller) than house price changes in zone 1 (zone 2) since some higher-income households move from zone 1 to zone 2 in response to the outflow, lowering (increasing) average income in zone 1 (zone 2). A second major housing affordability indicator is the fraction of income spent on rent, denoted HR/Y. Average rent is the rent per square foot R multiplied by the average house size; it is divided by average working-age earnings. The rent-income ratio rises by 18.58% in zone 1 (8.61% in zone 2). By these common metrics, OOT buyers reduce housing affordability substantially. They do so disproportionably in the city center.

Labor Market   OOT demand drives up wages by 0.59%. The share of construction employment increases by 17.6% (construction share of hours worked rises from 5.6% to 6.6%) as additional housing is built upon the OOT inflow. The construction employment share then slowly falls, but remains at a higher level as long as OOT demand remains high because the higher housing stock requires more maintenance. To reallocate workers from the non-housing to the housing sector, equilibrium wages must rise. Higher city-wide wages lead to lower aggregate labor demand, with hours worked falling 0.7%. In sum, the OOT influx prompts an increase in wages and a boom in the non-tradable sector, but also to a loss in competitiveness and a fall in employment in the tradable sector.[26] The increase in wages is offset by a reduction in hours worked, leaving average earnings down by 0.08%. Cost of housing increases translate (slightly more than) one-for-one into cost of

---

[26]Although housing is the only non-tradable good in our model, the same intuition carries over to any other non-tradable goods and services that OOT consume when they are in town, e.g., restaurants or entertainment.

living increases.

Long-run effects   The second row of Panel A shows the long-run effects. Effects on prices and rents are long-lasting. While the OOT shock itself is persistent, it will eventually mean-revert. Also construction has more time to adjust in the long-run. But because of decreasing returns to scale and zoning restrictions, housing supply is not perfectly elastic even in the long run. The housing stock in zone-1 (zone 2) is permanently higher by 3.87% (6.18%). The long-run cost of rental housing increases by 8.75% (8.39%) and the cost of owner-occupied housing by 4.98% (4.69%). The larger quantity and smaller price response in zone 2 is due to the more elastic housing supply and the population relocation effects described above. The wage effect is also permanent due to higher maintenance on a larger housing stock.

Welfare   What are the welfare effects from an increase in OOT demand? The average household in the baseline model is worse off with a welfare loss of 0.61% in consumption equivalent units, as shown in the column labeled $\mathcal{W}$. To understand this headline welfare number, it is important to consider how different agents are affected. The average renter is severely hurt by the inflow and would be willing to give up 2.02% of lifetime consumption to avoid the OOT capital inflow. In contrast, an average home owner benefits by 0.43% of lifetime consumption.

   The top panel of Figure 3 splits out these welfare gains and losses for owners and renters by age. Overall, the young and the old suffer from the OOT inflow while the middle-aged benefit. This pattern reflects both the home ownership rate over the life-cycle and how renters and owners fare individually. Renters of all ages are hurt by the higher OOT demand since their current and future housing expenditures rise. Working-age renters receive some relief in the form of higher current and future wages. This benefits the young more, given their longer expected work life. However, rents go up far more than earnings. Renter losses start to grow meaningfully after age 60. An average 75-year

Table II. Effect of OOT Demand

	W	R^1	R^2	P^1	P^2	INV1	INV2	P^1/R^1	P^2/R^2	HP^1/Y	HP^2/Y	HR^1/Y	HR^2/Y	$Pop^{1\%}$	$\mathcal{W}$	$\mathcal{W}_r$	$\mathcal{W}_o$
								Panel A: **Baseline Model**									
Δ_1	0.59	10.96	10.68	6.54	6.27	9.20	10.83	−3.98	−3.98	13.86	4.29	18.58	8.61	−0.17	−0.61	−2.02	0.43
Δ_{ss}	0.36	8.75	8.39	4.98	4.69	3.87	6.18	−3.46	−3.41	11.04	4.93	15.01	8.63	−2.37	−	−	−
								Panel B: **OOT Parameters**									
$\Delta_1\ OOT_1^H=15\%, OOT_2^H=0\%$	0.24	5.30	4.28	3.36	2.64	3.49	4.48	−1.84	−1.57	7.24	1.29	9.25	2.90	−9.50	−0.27	−0.97	0.24
$\Delta_1\ OOT_1^H=15\%, OOT_2^H=7.5\%$	0.91	17.41	16.86	10.05	9.64	14.12	16.83	−6.27	−6.17	19.69	6.86	27.70	13.90	−2.30	−0.96	−3.09	0.62
$\Delta_1\ OOT_1^H=5\%, OOT_2^H=2.5\%$	0.24	4.80	4.74	3.01	2.92	3.18	5.00	−1.71	−1.73	8.38	1.40	10.26	3.19	1.07	−0.23	−0.90	0.25
$\Delta_1\ b=6.4$	0.56	10.07	9.85	6.08	5.87	8.01	10.11	−3.62	−3.62	14.87	3.35	19.19	7.23	0.44	−0.50	−1.82	0.47
$\Delta_1\ \pi=.75$	0.49	11.06	10.86	4.71	4.60	4.93	6.93	−5.71	−5.65	13.64	2.08	20.52	8.20	0.31	−0.45	−1.59	0.38
$\Delta_1\ \pi=.95$	0.60	10.58	10.30	7.20	6.93	10.01	12.03	−3.06	−3.05	15.71	4.79	19.36	8.09	−0.67	−0.62	−2.13	0.48
								Panel C: **Housing supply and demand elasticities**									
$\Delta_1\ \bar{H}_1=\bar{H}_2=3.30$	0.66	9.99	10.17	5.69	5.64	8.16	9.39	−3.90	−4.10	8.16	4.13	12.56	8.58	1.28	−0.41	−1.25	0.19
$\Delta_1\ \bar{H}_1=0.11, \bar{H}_2=3.30$	0.51	10.72	10.73	6.44	6.44	8.61	11.26	−3.86	−3.87	9.74	5.73	14.15	9.99	−12.94	−0.83	−2.35	0.27
$\Delta_1\ (1-\epsilon)^{-1}=0.33$	0.84	23.90	24.24	13.90	13.90	21.31	25.82	−8.05	−8.31	17.08	13.07	27.36	23.32	−4.02	−1.08	−3.66	0.47
$\Delta_1\ (1-\epsilon)^{-1}=0.5$	0.64	15.35	15.32	8.82	8.67	12.06	15.53	−5.66	−5.76	10.95	8.22	17.61	14.84	−4.04	−0.71	−2.55	0.48
$\Delta_1\ (1-\epsilon)^{-1}=1.0$	0.38	6.50	6.15	4.12	3.77	3.83	6.39	−2.23	−2.24	5.51	3.29	7.92	5.65	−3.74	−0.65	−1.65	0.10
								Panel D: **OOT rent out property**									
$\Delta_1\ b=0.6$	0.01	−0.05	0.11	−0.08	−0.10	0.29	−0.25	−0.03	−0.21	3.49	−0.94	3.52	−0.74	2.24	0.18	0.31	0.09
$\Delta_1\ b=6.4$	0.01	−0.14	0.05	−0.12	−0.06	0.46	−0.17	0.01	−0.11	3.49	−1.08	3.48	−0.98	2.25	0.04	0.09	0.01
								Panel E: **Model variants**									
$\Delta_1\ \beta^H=\beta^L$	0.57	10.91	10.84	6.52	6.38	8.57	11.11	−3.95	−4.02	9.44	5.82	13.95	10.25	−2.96	−0.05	−1.13	0.50
$\Delta_1\ LTV=80$	0.54	10.83	10.64	6.42	6.23	8.85	10.86	−3.98	−3.98	15.11	3.69	19.88	7.99	0.29	−0.62	−1.96	0.47
$\Delta_1\ LTV=95$	0.55	10.79	10.56	6.43	6.20	8.29	10.79	−3.93	−3.94	12.80	4.46	17.41	8.75	−1.11	−0.45	−1.81	0.40
$\Delta_1\ H_{min}=0$	0.48	9.55	9.36	5.67	5.34	7.04	9.22	−3.54	−3.67	8.11	4.53	12.07	8.52	−0.92	−0.07	−0.85	0.28
Δ_1 Profit redistribution	0.00	8.33	8.36	4.99	5.00	6.55	9.42	−3.08	−3.10	8.23	4.91	11.67	8.26	−0.99	−0.17	−0.46	0.49
$\Delta_1\ \underline{c}=0$	0.56	10.25	10.84	5.83	6.24	7.04	10.85	−4.00	−4.15	7.18	8.80	11.66	13.51	−5.88	−0.26	−1.89	0.81
Δ_1 Only owners	0.54	−	−	5.82	5.87	7.72	9.98	−	−	4.16	6.92	−	−	−4.70	0.24	−	0.24

Notes: The table reports averages from a long simulation of the model. It reports the wage W, the rent per sqft R, the house price per sqft P, the price-rent ratio (each expressed per square foot and rent expressed annually), the home value-to-income ratio HP/Y (price divided by average annualized income in the working–stage of life), the rental expenditure share (rent times average house size among all residents divided by annualized income in the working–stage of life), the home ownership rate *Own* (including OOT owners), the average welfare change from an increase in OOT buyers among all residents $\mathcal{W}$, the welfare change among renters $\mathcal{W}_r$, and among owners $\mathcal{W}_o$. Panel A is for the baseline calibration. The first row, labeled Δ_1, shows the percentage change in the variables in the first period of the transition from the low to the high OOT housing demand. The second row, labeled Δ_{ss} shows the percentage difference between the variables in the stochastic stead states of high and low OOT home demand. Panels B-K report variants of the baseline model. described in the main text.
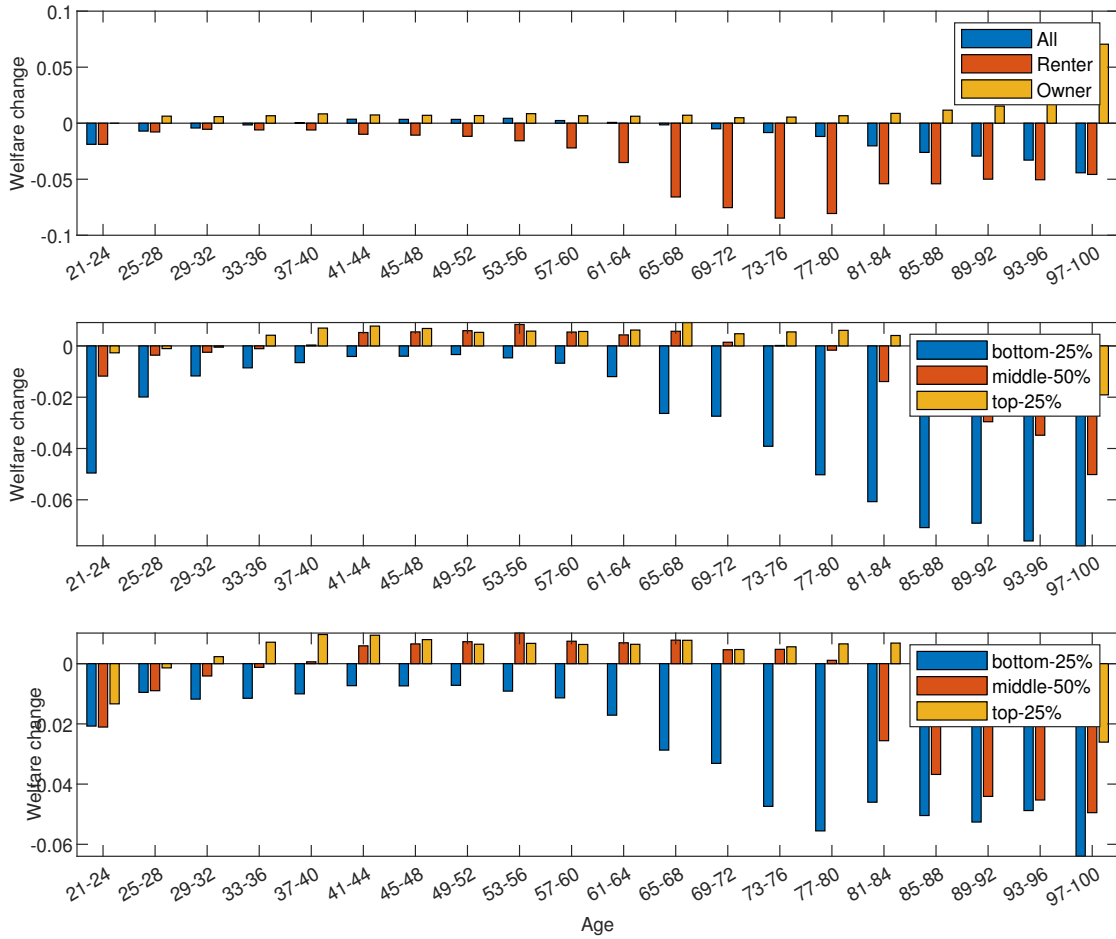
old renter would be willing to give up 9.42% of lifetime consumption to avoid the OOT inflow, while an average 40-year old renter would give up only 0.86%.

Owners benefit from higher OOT demand because they reap capital gains on their house. This increases their wealth, expanding their consumption opportunity set. Owners also earn higher rents on their rental properties. The gains are larger for owners who expect to remain owners but expect their housing consumption to fall. These typically older households are not worried about the higher future rents and prices brought about by the OOT inflow. The capital gains effect is weaker for younger owners because they tend to own relatively little real estate and expect their housing consumption to increase in the future as they move up the housing ladder. The positive wage effect we described for renters also applies to owners. The confluence of these factors generates a welfare benefit for the average owner that increases from 0.62% at age 40 to 1.99% at age 95. OOT inflows are not unambiguously good for owners. About 5.1% of 25-year old owners and 28.1% of 75-year old owners are hurt by the inflow. These owners have much lower wealth than the owners who benefit from the inflow.

Panel B of Figure 3 reports the welfare effects for households sorted by income, and panel C for households sorted by net worth. The welfare costs are disproportionately born by low-income households, especially younger and elderly low-income households. Not only are these households much more likely to be renters, they also have high marginal utility of consumption which makes them vulnerable to the increase in the cost of living caused by the OOT inflow. The welfare effects along the wealth distribution are similar, with elderly and low-wealth households suffering the most and middle-aged, middle-class households gaining modestly. In sum, the OOT shock is regressive.

This discussion makes clear why the model needs to feature a rich cross-section of agents in terms of age, earnings, wealth, and home ownership. House price, rent, and wage changes induced by an increase in OOT demand will affect these agents differently.

41

Figure 3. Welfare Effects of Increase in OOT Housing Demand

IV.D   Political Economy of OOT Purchases

Although the average welfare effect of OOT buyers is negative, it is not evenly distributed. Owners make up 62.8% of the resident population prior to the inflow, and owners on average benefit from an inflow. Renters, which are a numerical minority, are hurt by much more than the owners gain. If each household received one vote, a 55% majority of the population would vote in favor of the OOT inflow, despite the aggregate welfare loss it causes. OOT home purchases are a divisive political issue: 84% of owners prefer

the inflow, but only 5% of renters do. Policies aimed at curbing OOT purchases, such as those analyzed in Section 7, may not only be welfare improving but also politically unpopular. This calculus would change in cities like New York City, where the majority of the population rents. There, voting outcomes and welfare would move in the same direction.

V Exploring Key Drivers of the Model

To better understand the workings of the model and to gauge the sensitivity of its welfare implications, we now explore versions of the model where we switch off model ingredients or change key parameters. Panels B-E of Table II report the results. The first set of experiments involve the OOT housing demand process itself.

V.A Properties of OOT Demand

The first model variant concentrates all OOT purchases in zone 1. The high OOT state features a 15% share of OOT purchases in zone 1 and 0% in zone 2, compared to 10% in zone 1 and 5% in zone 2 in the baseline model. Since zone 1 is significantly smaller than zone 2, this experiment also features lower aggregate OOT housing demand. Prices and rents in zone 1 now rise by significantly more than in zone 2. However, given that there is no direct effect from OOT demand in zone 2, this case also illustrates the strong spillover effects across housing markets. There is a much larger displacement effect in this experiment, as the resident population of zone 1 falls by -9.5% and relocates to zone 2. The aggregate welfare change is -0.27%.

In the second model variant, we increase the size of the OOT inflow in each zone by 50%. The welfare cost to society is -0.96%. Both owners and renters see 50% larger welfare effects in absolute values. Rents in zone 1 are up 17.4% compared to 11.0% in the baseline. Comparison to the previous case shows that increasing OOT demand in zone 2

43

from 0% to 7.5% results not only in much higher rents in zone 2 but also in strong spatial spillovers to zone 1.

In the third row, we cut OOT demand in the high state in half compared to the baseline. The overall welfare loss is less than half as large, driven by the smaller loss for renters. Rent and price increases are also less than half as large as in the benchmark. In sum, results display some convexity in the OOT share.

Next, we consider a much higher value for the price sensitivity of OOT demand ($b = 6.4$), based on the Vancouver experience around the 2016 introduction of the OOT tax. We recalibrate the parameter a so that the unconditional size of the inflow is the same. With more elastic OOT demand, rent and price increases are smaller as is the welfare loss. Overall, the results are not much affected by the price elasticity of demand of the OOT investors.

In the baseline calibration, each OOT state has an expected duration of 40 years. We study a faster mean-reverting OOT process with persistence of $\pi = 0.75$ (16-year duration) and a slower one with $\pi = .95$ (80 years). Higher persistence increases the welfare cost. But even a large reduction in the expected length of each OOT regime from 40 to 16 years lowers the aggregate welfare cost only modestly from -0.61% to -0.45%. There is an asymmetry. Increasing persistence barely increases the welfare cost to -0.62%. To understand this, note that housing investment responds more strongly if the inflow is more persistent, reducing the need for rents to adjust as much. In fact, the increase in rents is highest when the OOT inflow is the least persistent. This is not true for prices, which reflect the persistence of the rent increases. The stronger rent responses help understand the modest decline in the welfare cost from less persistence.

All six experiments show results that are robust to the details of the specification of the OOT demand function.

V.B Housing supply and demand elasticities

Our baseline model generates a housing supply elasticity of 0.94, matching that in the average U.S. MSA. It generates a lower elasticity in zone 1 (0.45) than in zone 2 (0.99). The first row of Panel C studies a case in which we increase the land available for construction in zone 1 to the same level as that in zone 2, keeping the latter at the baseline value. When it is easier to build in zone 1, rents and prices increase by less in response to the OOT shock. This is not only the case in zone 1, but also in zone 2 due to spatial equilibrium effects. The lower price response in turn blunts the incentive to develop, so that residential construction responds less to the OOT inflow in equilibrium.

In the second row, we cut the maximum housing supply in zone 1 $\overline{H}^1$ by half. When the OOT shock hits, there is a large outflow of locals from zone 1. Prices in zone 1 rise by more than in the baseline. This in turn spurs on construction, which rises modestly in zone 1 despite the low housing supply elasticity. Construction in zone 2 rises strongly, in part due to the migration. Welfare effects are substantially larger in absolute value when housing supply is more inelastic; the aggregate welfare change is -0.83%. This exercise shows that supply-constrained cities like San Francisco, Miami, or New York show more adverse effects from OOT purchases. The case with lower housing supply elasticity is also relevant in light of recent estimates of housing supply elasticity by Baum-Snow and Han (2020) using more disaggregate data. Their estimates indicate much lower housing unit supply elasticity in the city center than further away from the center. When aggregated to the MSA-level, the supply elasticity is somewhat lower than found in Saiz (2010).

The last three rows of Panel C vary the elasticity of housing demand, governed by the intra-temporal elasticities of substitution between housing and non-housing consumption. Two cases have lower elasticity than in the baseline (0.67), $(1 - \epsilon)^{-1} = 0.33$ and 0.50, and one case has a larger elasticity of 1, corresponding to the Cobb-Douglas case. The literature has found a wide range of estimates for this parameter.[27] The welfare costs of

---

[27]For example, Hanushek and Quigley (1980) report values of 0.45-0.65 for a range of cities, Stokey (2009)

OOT inflows are substantially larger when housing demand is more inelastic. The aggregate welfare cost is -1.08% for an elasticity of 0.33 and -0.71% when the elasticity is 0.50. When households are less willing to adjust housing quantities relative to non-housing consumption, rent and house prices must do much more of the adjustment. The OOT inflow triggers a rent (house price) increase of 23.90% (13.90%) when the elasticity is 0.33, more than twice as large as in the baseline calibration. Such large price increases trigger a large equilibrium construction response. The opposite is true with Cobb-Douglas preferences. Rents and house prices increase by less upon an OOT inflow as households are now more willing to substitute between housing and non-housing consumption. This limits the welfare cost to renters and the welfare gain to owners.

V.C OOT Buyers Rent Out Property

The inability or unwillingness of OOT buyers to rent out their properties to locals is key for the welfare results. Panel D of Table II computes a model where OOT buyers rent out all of their real estate to local residents. The welfare loss disappears, and turns into a small welfare gain. The welfare change is essentially zero when OOT demand is more price elastic than in the benchmark. Rent and price increases are de minimis. Renters, who previously rented from local home owners, now rent from OOT buyers. As long as rents do not change much, renters are indifferent about the identity of their landlords. Local real estate investors who have been displaced by OOT buyers now invest in the risk free asset. Because the housing risk premium is small, the risk free asset has a similar rate of return, so local investors are also indifferent. Prices, quantities, and welfare are nearly unaffected; only the investment portfolio of local investors changes. This result highlights that the main welfare cost of OOT investors is their decision to keep the property vacant. Leaving aside monitoring and compliance issues, "ghost" or "empty home" taxes like the

uses 0.5 based on CEX data for 27 cities, Li, Liu, Yang, and Yao (2016) estimate 0.48, and the CBO uses 0.4. Flavin and Nakagawa (2008) uses the PSID but a different measure of housing and estimate a value of 0.13.

ones introduced in Sydney and Vancouver directly addresses the vacancy issue and could eliminate the welfare cost.

V.D   Robustness

Panel E explores the robustness of the results to further variations in model parameters.

No Patience Heterogeneity   When all agents have the same subjective time discount factor ($\beta^H = \beta^L$=0.91, chosen to match the average wealth to average income ratio of the baseline model and the data), the model generates an aggregate welfare loss from OOT purchases of only -0.05%. This is despite generating similar increases in prices and rents as in the baseline. The welfare cost for renters is only half as large as in the homogenous-β model. Since this model substantially understates wealth inequality, it generates too few poor renters and therefore too few losers from the OOT influx. When renters are much richer (than in the data), the welfare losses they suffer are smaller. The exercise underscores the importance of generating a realistic wealth distribution for assessing the welfare cost of increasing OOT real estate investment. It is also a cautionary tale for using price and rent increases as sufficient statistics for the welfare costs of OOT purchases.

LTV limit   The next two rows change the LTV limit for mortgages from the baseline value of 90% to 80% and to 95%. The welfare loss from OOT purchases is lower with looser mortgage lending standards. The effect from tightening LTV constraints is quantitatively small. With looser LTV constraints, the baseline home ownership rate in the low OOT state is higher, which affects the composition of winners and losers from the OOT inflow.

No minimum housing size   The baseline model features a minimum housing size. Without constraint, the aggregate welfare effect turns from -0.61% to -0.07%. Nevertheless,

even with no minimum housing size, the small average welfare loss masks cross sectional differences: renters suffer with a -0.85% welfare change, while owners benefit by 0.28%. Price and even rent changes are only modestly smaller, in contrast, because the (wealth-weighted) average owner and renter are not much affected by the minimum house size constraint. The change in renter welfare is driven by the poorest renters who can reduce housing consumption in the face of an increase in rents, thereby limiting the adverse welfare effect. This is particularly true if their housing demand is sufficiently elastic, as in the baseline model. A minimum house size requirement hurts the poorest households by eliminating this margin of adjustment.[28] Allowing for smaller dwellings is a welfare-increasing policy in the wake of an OOT inflow.

Profit redistribution   The baseline model assumes that all firm profits leave the city. The row "profit redistribution" studies an economy where half of firm profits remain in the city and are transferred lump-sum to local residents. The profit redistribution cushions the welfare loss from the OOT inflow to renters since renters are now much richer in this economy than in the baseline.[29]

No luxury amenity shifter   The last row of Panel E considers a model where the amenity benefit of zone 1 applies to all households, rather than only to those who consume above a minimum threshold. Given that $\chi^W > 1$ and $\chi^R > 1$ in the baseline, this both weakens the appeal of zone 1 and makes the population share of zone 1 more sensitive to the OOT inflow. Because more people leave zone 1, rents and prices do not need to go up by as

---

[28]In the model, 32.8% of the population is at the minimum housing constraint. This fraction is 31.9% when OOT is low and rises to 33.7% when OOT is high, and hence does not fluctuate much with the OOT state. The constraint disproportionately affects poor households. Conditional on being in the lowest productivity quartile, 95.8% of the households are constrained, and this rises to 100% if they also live in zone 1. Poor households are hurt because their housing costs increase and they are unable to downsize.

[29]This model would need to be recalibrated to deliver an income and wealth distribution that matched inequality statistics in the data.

much in response to the OOT inflow in zone 1. Rents go up by more in zone 2 than in the baseline model. The aggregate welfare loss is muted when local residents' preference for zone-1 living is weaker.

Owners Only Finally, we ask whether there is a set of parameters for which the welfare effects of OOT purchases are a net positive to the city. The last row of Panel E presents an example of such an economy with a 0.24% benefit. It requires several strong assumptions that bring the model closer to a representative agent economy: (i) all local residents must be home owners, (ii) no patience heterogeneity, (iii) no minimum housing size, (iv) no bequest heterogeneity, and (v) all bequests are received at age 21.[30] With these changes, the capital gain effect dominates and the welfare effect is positive. This case illustrates the importance of allowing for tenure choice and generating realistic wealth inequality, including through bequests.

VI   Tax Policy Responses

Having established a net welfare loss from OOT purchases, a natural question is whether policy can offset these welfare costs. We have considered two effective policy responses already. The first one was to force OOT buyers to rent out their property. The second one was to abolish minimum house size requirements. In this section, we consider an additional policy response motivated by the empirical evidence discussed in Section I, namely a tax on OOT buyers. In a first variant, the extra tax revenue increases public goods' provision. In a second variant, we use the tax revenue to lower property taxes for local home owners. In the third variant, we transfer the extra tax revenue to low-income households. In all variants, we ask whether the tax policy can offset the welfare costs obtained in the baseline economy.

---

[30]The last two assumptions are necessary if renting is not an option. Otherwise, some households would enter the model with zero wealth at age 21 and could not afford to own a house, violating assumption (i).

VI.A OOT Tax Increases Public Goods

We model the OOT tax as a property tax surcharge, τ^{OOT}. We calculate the present-value equivalent of the tax by taking into account the time value of money as well as the transition probabilities between the OOT regimes. For example, a tax rate of $\tau^{OOT} = 3.46\%$ per four years, or 0.86% per year, is equivalent to a one-time 15% transaction tax. Adding this surcharge to the property tax rate of 6.3% charged to locals (1.58% per year), results in a OOT tax rate of 9.76% (2.44% per year). Higher property taxes allow for a higher level of public goods provision.

Table III reports the aggregate welfare effect $\mathcal{W}$ of OOT purchases for various tax rates on OOT buyers τ^{OOT}, presented in the rows of the table. The third column reports the one-time transaction tax that is equivalent in present value terms to the per-period tax rate in the first column. The left panel uses the baseline price-elasticity of OOT demand while the right panel is for the alternative higher value. The various columns correspond different values for the utility benefit from public goods θ, where $\theta = 1.15$ is the benchmark value. The (1,3) entry in the left panel table is the baseline model's 0.61% aggregate welfare loss from an OOT inflow.

Table III. Welfare Effects From OOT Tax

OOT tax			Panel A: Price elasticity $b = 0.6$				Panel B: Price elasticity $b = 6.4$			
τ^{OOT}		PV-equivalent	Public Good Utility Parameter θ				Public Good Utility Parameter θ			
4yr	1yr	transaction tax	0	0.75	1.15	1.55	0	0.75	1.15	1.55
0%	0%	0%	−0.80	−0.65	−0.61	−0.48	−0.73	−0.57	−0.50	−0.41
1%	0.25%	4.4%	−0.80	−0.62	−0.52	−0.42	−0.68	−0.51	−0.42	−0.33
2%	0.5%	8.7%	−0.79	−0.59	−0.48	−0.37	−0.64	−0.46	−0.36	−0.26
3.46%	0.86%	15.0%	−0.78	−0.55	−0.42	−0.30	−0.59	−0.38	−0.27	−0.17
5%	1.25%	26.1%	−0.78	−0.51	−0.36	−0.22	−0.54	−0.32	−0.20	−0.08
7.5%	1.88%	34.8%	−0.77	−0.44	−0.27	−0.09	−0.46	−0.22	−0.09	0.03
10%	2.5%	52.2%	−0.75	−0.38	−0.18	0.02	−0.39	−0.14	−0.01	0.13

Notes: The table reports the net aggregate welfare effect $\mathcal{W}$ of an increase in OOT purchases from the low state to the high state, aggregated across all the agents in the economy. The numbers represent a consumption equivalent variation, expressed in percent. Each entry is for a different combination of the OOT tax rate τ^{OOT} (per 4 years), listed in the first column, and the utility parameter for local public goods θ, listed in the top row. Note that residents pay a property tax rate of τ^P while OOT investors pay a property tax rate of $\tau^P + \tau^{OOT}$. The second column expresses the tax rate surcharge into an annual number while the third column reports the present-value equivalent one-time transaction tax rate. Panel A assumes that OOT housing demand in the high state has a price elasticity of 0.6, while panel B assumes a price elasticity of OOT demand in the high state of 6.4.

Reading down the third column of Panel A, increasing the OOT surcharge from 0% to 10%, the aggregate welfare cost of the OOT influx to local residents decreases from 0.61%

to 0.18%. The table also suggests that a 15% transaction tax, as enacted in Vancouver in 2016, eliminates about one-third of the aggregate welfare cost.

When property tax revenue is wasted ($\theta = 0$, first column), the baseline welfare cost of an OOT inflow is larger at 0.80%. It also falls by much less as OOT tax revenues rise. This clarifies that the tax is not only about keeping out OOT investors, thereby preserving more housing for locals, but also about generating extra revenue to pay for valuable public goods. Reading across the columns for a given OOT tax rate, the greater is the utility from public goods, the higher is aggregate welfare. The increase in welfare from higher OOT taxes is larger the higher public good utility is. For $\theta = 1.55$ and $\tau^{OOT} = 10\%$, the OOT inflow becomes welfare increasing.

Panel B of Table III explores how sensitive these results are to the price elasticity of OOT demand. While the results are qualitatively unchanged, OOT demand declines more rapidly when the tax rate increases for $b = 6.4$. Put differently, it takes a smaller tax surcharge to dissuade OOT investors from buying. This explains why welfare increases more rapidly in the tax rate holding constant θ. For the benchmark value of $\theta = 1.15$, a 15% transaction tax eliminates half of the welfare loss. With more elastic OOT purchases, owners gain less from the OOT tax increase than renters since capital gains are not as large and rents fall by more than when $b = 0.6$. The price elasticity of OOT demand therefore affects the distribution of winners and losers from the OOT tax policy.

VI.B   OOT Tax Lowers Local Property Taxation

In a second tax experiment, we levy a property tax surcharge on OOT buyers and simultaneously reduce property taxes on local residents so as to keep total tax revenue constant before and after the OOT inflow. This exercise does not require taking a stance on the utility value of public goods θ.

The first row of Table IV reports the baseline economy where the property tax rate is 6.3% for everyone; it generates higher tax revenue in the high than in the low OOT

state. Row 2 shows that a property tax rate on 6.3% on OOT buyers, 6.3% on locals in the low OOT state, and 5.45% on locals in the high OOT state generates the same property tax revenue in the low and the high OOT states. This model generates a welfare loss of 0.64 % and is the point of comparison for this experiment. This welfare loss is slightly greater than in row 1 because the average level of tax revenue is slightly lower, reducing public good provision which agents care about. From row 3 down, the tax rate on OOT investors is gradually raised while the tax rate for locals is lowered so as to keep tax revenue constant. Naturally, when OOT demand is more price elastic (Panel B), OOT demand in the high state falls more as taxes rise. As a result, taxes on residents cannot be lowered as much as in the benchmark (Panel A).

Increasing taxes on OOT investors curbs the welfare losses from the OOT inflow. By dissuading OOT investors, they result in smaller rent increases, which benefits renters. This effect is stronger when OOT demand is more price elastic (Panel B). By lowering property taxes for locals, they are a boon for home owners and amplify the gains from the OOT inflow observed in the baseline economy. The positive welfare effect for owners is stronger when OOT demand is more inelastic (in Panel A) because the property tax reduction and the capital gains on housing are both larger. In sum, when the elasticity of OOT demand is high, the policy generates larger overall welfare gains and benefits renters more than owners. When OOT demand is more inelastic, the property tax cut for locals disproportionately benefits owners.

VI.C Redistributing OOT Tax Revenue to Poor Residents

A final variant of the OOT tax experiment transfers tax revenue collected from OOT buyers to low-income households, specifically to households in the first quartile of the productivity distribution. Since labor supply is endogenous, our model captures the distortions that the transfers have on labor supply. Figure 4 reports the results. The top left panel shows the baseline economy where OOT buyers pay the same property tax rate of

## Table IV. Welfare Effects From Alternative Tax Policy

$\tau^P + \tau^{OOT}$	Panel A: Price elasticity $b = 0.6$				Panel B: Price elasticity $b = 6.4$			
	τ^P	$\mathcal{W}$	$\mathcal{W}_r$	$\mathcal{W}_o$	τ^P	$\mathcal{W}$	$\mathcal{W}_r$	$\mathcal{W}_o$
6.3%	6.3%	−0.61	−2.02	0.43	6.3%	−0.50	−1.81	0.46
6.3%	5.84%	−0.64	−2.10	0.44	5.85 %	−0.55	−1.90	0.45
7.3%	5.78 %	−0.61	−2.07	0.47	5.81%	−0.48	−1.77	0.47
8.3%	5.71%	−0.58	−2.04	0.51	5.77 %	−0.43	−1.66	0.48
9.76%	5.61 %	−0.53	−2.00	0.55	5.73 %	−0.35	−1.51	0.50
11.3%	5.52 %	−0.49	−1.96	0.61	5.69 %	−0.29	−1.37	0.51
13.8%	5.36 %	−0.41	−1.89	0.68	5.65 %	−0.20	−1.16	0.52
16.3%	5.21 %	−0.34	−1.83	0.76	5.63 %	−0.12	−0.98	0.52

Notes: The table reports the effects of charging property taxes on OOT investors, listed in the first column. Except for the first row, the property taxes charged on residents, τ^P, listed in columns 2 and 6 are such that property tax revenue is unchanged between the low OOT state and the high OOT state. In the first row, we report a baseline case where residents and OOT investors face the same tax rate. That case has larger tax revenue in the high OOT state compared to the low OOT state. The price elasticity of OOT demand in the high state is $b = 6.4$ in panel A and $b = 0.6$ in panel B. The table reports the aggregate welfare effect from a change from the low OOT to the high OOT state, $\mathcal{W}$, the average welfare effect for renters $\mathcal{W}_r$, and the average welfare effect for owners $\mathcal{W}_o$. The welfare effects are expressed as percentages of consumption equivalent units.

6.3% per 4 years as locals, and all property tax revenue goes towards local public goods. The top right panel shows a case discussed in section 7.1 which levies an extra property tax surcharge of 3.46% on OOT buyers. This extra revenue finances more public goods, which raises all local residents' welfare modestly. In the bottom left panel, we transfer the extra tax revenue (from the 3.46% surcharge) to low-productivity households. It results in a dramatic increase of the welfare for these households, turning the aggregate welfare loss into a small gain (+0.13%). Public good provision in this case is the same as in the benchmark model, so there is no cost to the local residents in terms of a reduction in public goods provision. Finally, in the bottom right panel, we transfer all revenue from OOT property taxes to low-income households rather than just the surcharge. This leads to large increases in welfare for the bottom-quartile households, and modest losses for all other locals because of reduced public goods consumption. Aggregate welfare increases 1.30% in this case.

In conclusion, various tax policies can be used to turn OOT home buying from a net negative to a net positive for the local economy. Different policies have different distributional consequences.

Figure 4. Redistributing OOT Tax Revenue to Low-Income Households
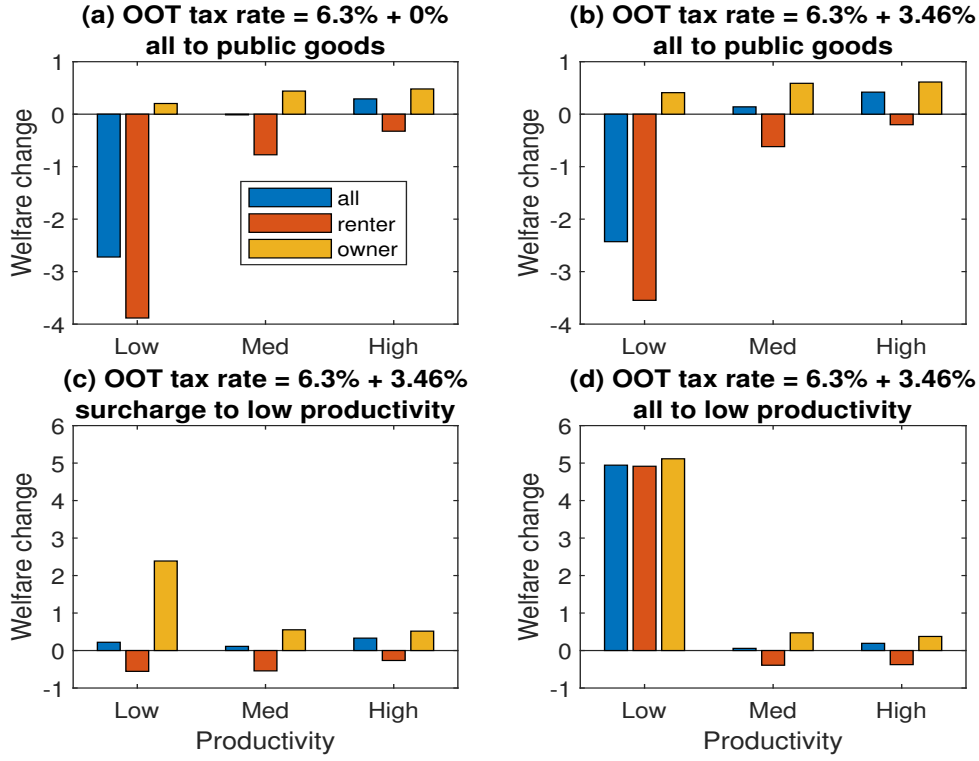
Notes: Panel (a) plots the effect of an OOT inflow on welfare by productivity group in the baseline model. Panel (b) plots the same statistic for an alternative model where OOT buyers are charged an extra 3.46% property tax on top of the baseline property tax rate, 6.3%. In panel (c), we report the same statistic when the extra tax revenue from OOT property tax surcharge is redistributed to the low-productivity households. In panel (d), all of the tax revenue raised from the OOT buyers is redistributed to the low-productivity households.

VII Extension with Luxury Housing

This section sets up and solves an extended model with an additional housing market: luxury housing in the city center.

VII.A Changes to the Model

Luxury housing is both more costly to build and more enjoyable. Profits from luxury housing construction are given by:

$$\Pi_{h,t}^{1,L} = \max_{N_{h,t}^L} P_t^L \left(1 - \frac{H_{t-1}^1 + H_{t-1}^L}{\overline{H}^1} \right) \left(N_{h,t}^L \right)^{\rho} - W_t N_{h,t}^L * S_{lux}, \tag{14}$$

54

where $S_{lux} > 1$ is a cost shifter for the production of luxury housing. Household preferences are still given by (1)-(2) subject to (3), except that housing consumption is now:

$$\begin{cases} h_t \text{ if non-luxury} \\ \left(Z_{lux} + h_t^{e_{lux}}\right)^{\frac{1}{e_{lux}}} \text{ if luxury} \end{cases}$$

where Z_{lux} governs the strength of the preference for luxury housing and $1/(1 - e_{lux})$ is the elasticity of substitution between the luxury nature of housing and housing size. The empirically relevant case is complementarity between luxury housing and unit size: $e_{lux} < 0$. In that case, a more negative Z_{lux} implies a stronger preference for luxury.[31]

We set S_{lux} and Z_{lux} to match two moments in the data. First, we target a share of luxury housing in zone 1 housing (in terms of square feet) of 23%. Second, we target a ratio of luxury to non-luxury house prices per square foot of 2.3. The two targets are obtained from data on the luxury and non-luxury housing market for Manhattan between 2010 and 2019 from the brokerage house Douglas-Elliman.[32] A natural target for e_{lux} would be the ratio of the average net worth for owners of luxury housing to average net worth for everyone else. We lack such data, and simply set $e_{lux} = -1$. This parameter implies an average net worth ratio of 16.6, which seems realistic.[33]

---

[31]An alternative specification is $Z_{lux}h_t^{e_{lux}}$. In this case, the response of luxury and non-luxury house prices to an OOT inflow must be identical in percentage terms. This is because every household is indifferent between consuming non-luxury housing, or $1/Z_{lux}$ fewer square feet of luxury housing. Therefore, the price ratio of luxury to non-luxury housing must be Z_{lux}. We chose a richer specification that allows for a differential response of luxury and non-luxury prices to an OOT inflow. Setting $e_{lux} > 0$ leads to substitutability between luxury housing and unit size. In this case, households living in luxury housing tend to be poorer than those in non-luxury housing, which is at odds with the data.

[32]Direct evidence on construction costs is consistent with luxury housing costing at least twice as much to build. Some of the higher cost is materials, some is a better location reflected in a higher cost of land.

[33]According to the Survey of Consumer Finances, average household net worth in 2016 was $692,000. The top-10% of the net worth distribution had a net worth of $4.55 million while the bottom 90% had an average net worth of $263,000. The ratio of the two is 17.3.

We assume that OOT purchases are largest, as a share of the market, in the luxury segment. This is in line with anecdotal evidence. Specifically, we assume that OOT investors buy 27% of luxury housing and 5% of non-luxury housing in zone 1 and 5% of housing in zone 2. Since luxury housing is 23% of zone 1 housing, this ensures that overall OOT purchases are the same as in the benchmark model where OOT investors bought 10% of zone 1 housing and 5% of zone 2 housing (27%*23%+5%*77%=10%).

The value function maximizes over five housing choices: owning or renting non-luxury housing in zone 2 or in zone 1, and owning luxury housing in zone 1. Luxury housing has the same property tax rate and depreciation rate as normal housing. The existing housing stock in zone 1 consists of normal housing, H^1_{t-1}, and luxury housing, H^L_{t-1}. Both housing stocks need to be kept track of as separate state variables. The maximum permitted residential square footage $\overline{H}^1$ refers to the sum of these two housing types in zone 1. Labor market clearing becomes

$$n_f \left(N_{c,t} + N^1_{h,t} + N^2_{h,t} + N^L_{h,t} \right) = N_t.$$

Market clearing in the non-luxury housing market in zone 1 becomes:

$$(1 - \delta^1)H^1_{t-1} + \underbrace{n_f \left(1 - \frac{H^1_{t-1} + H^L_{t-1}}{\overline{H}^1} \right) \left(N^1_{h,t} \right)^\rho}_{INV} = H^{O,1}_t + \widehat{H}^1_t + OOT^1_t. \qquad (15)$$

and clearing in the luxury market:

$$(1 - \delta^1)H^L_{t-1} + \underbrace{n_f \left(1 - \frac{H^1_{t-1} + H^L_{t-1}}{\overline{H}^1} \right) \left(N^1_{h,t} \right)^\rho}_{INV} = H^{O,L}_t + OOT^L_t. \qquad (16)$$

The equilibrium ratio of the price per square foot of luxury to non-luxury housing in zone 1, P^L_t / P^1_t, will reflect the extra utility luxury housing provides, the higher construction cost, and of course the higher OOT demand.

Table V. Effect of OOT demand with luxury housing

	Baseline Model		Luxury Housing		
	Zone 1	Zone 2	Zone 1	Zone 2	Luxury
INV	9.20	10.83	8.89	10.99	13.12
P	6.54	6.27	6.36	6.36	8.45
R	10.96	10.68	10.98	11.07	–
$Pop\%$	−0.17	0.13	3.74	−0.51	−25.65
$\mathcal{W}$	−0.61		−0.58		
$\mathcal{W}_r$	−2.02		−1.93		
$\mathcal{W}_o$	0.43		0.40		

VII.B   Findings

Table V summarizes the main findings for the model with luxury housing. Upon the OOT inflow, construction of luxury housing grows substantially more than non-luxury housing. Luxury housing becomes 26.4% of zone 1 housing (in square feet) compared to 22.7% in the no-OOT investors state. A luxury construction boom accommodates at least some of the OOT investors, who make up 27% of all luxury square feet ownership after the inflow. The population share of locals in zone 1 luxury housing falls substantially. In sum, the OOT inflow results in more luxury housing, but fewer locals living in luxury housing.

House prices rise 8.45% in luxury housing and 6.36% in non-luxury housing. The model thus generates a price increase that is 33% larger in luxury than in non-luxury housing. The price rise in non-luxury housing is comparable to that in the baseline model, as is the increase in rent. Non-luxury house prices rise slightly less in zone 1 than in the baseline model, which attracts slightly more households from zone 2 to zone 1. In sum, while quality segmentation drives a wedge between house price increases, spatial equilibrium forces limit the size of the wedge, even when OOT purchases are concentrated in the luxury segment. Rental markets are not insulated from the OOT buying activity, even when that activity predominantly takes place in the luxury segment in the city center.

The last three rows of Table V show that the aggregate welfare effects, as well as the effects on owners and renters, are quantitatively similar to those in the baseline model.

VIII Conclusions

Recent years have seen a surge in out-of-town (OOT) home buyers in many gateway cities all over the world. This paper develops a dynamic spatial equilibrium model with wealth effects that allows for a quantitative analysis of such OOT purchases on house prices, rent, and household-level and city-wide welfare. The model not only matches patterns of wealth accumulation and home ownership over the life-cycle, but also results in realistic house prices, rents, and wages for the city. When OOT buyers represent 10% of housing demand in the city center and 5% in the surrounding suburbs, and they do not rent out their properties, house prices rise by 6.54% in the city center and 6.27% in the suburbs. Increases in rent are even larger, as OOT investors take up valuable space. The negative welfare effect on renters dominates the welfare gain for owners, resulting in a net aggregate welfare loss of -0.61% in consumption equivalent units. This loss is greater when housing supply or demand are more inelastic than in the average metro area. The model points to strong spatial equilibrium effects. A 15% transaction tax on OOT investors, as imposed by several major cities, offsets one-third of the welfare loss. Redistributing the extra tax revenue to low-income households successfully offsets their losses.

References

Agarwal, Sumit, Tien Foo Sing, and Long Wang, 2019, Information asymmetries and learning in commercial real estate markets, Working Paper Georgetown University.

Ameriks, John, Andrew Caplin, Steven Laufer, and Stijn Van Nieuwerburgh, 2011, The joy of giving or assisted living? using strategic surveys to separate public care aversion from bequest motives, *Journal of Finance* 66, 519–561.

Badarinza, Cristian, and Tarun Ramadorai, 2018, Home away from home? foreign demand and london house prices, *Journal of Financial Economics* forthcoming.

Badarinza, Christian, Tarun Ramadorai, and Chihiro Shimizu, 2020, Nationality bias at home and abroad: Theory and evidence from commercial real estate, Working Paper.

Barcelona, William, Nathan Converse, and Anna Wong, 2020, U.s. housing as a global safe asset: Evidence from china shocks, Working paper.

Baum-Snow, Nate, and Lu Han, 2020, The microgeography of housing supply, Working Paper Univeristy of Toronto.

Bayer, Patrick, Christopher Geissler, Kyle Magnum, and James W. Roberts, 2020, Speculators and middlemen: The strategy and performance of investors in the housing market, *Review of Financial Studies* forthcoming.

Behrens, Kristian, Gilles Duranton, and Frédéric Robert-Nicoud, 2014, Productive cities: Sorting, selection, and agglomeration, *Journal of Political Economy* 122, 507–553.

Berger, David, Veronica Guerrieri, Guido Lorenzoni, and Joseph Vavra, 2017, House prices and consumer spending, *Review of Economic Studies* 85, 1502–1542.

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

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

Chen, Hui, Michael Michaux, and Nikolai Roussanov, 2020, Housing as atms: Mortgage refinancing and macroeconomic uncertainty, *Journal of Finance* 75, 323–375.

Chinco, Alex, and Christopher Mayer, 2016, Misinformed speculators and mispricing in the housing market, *Review of Financial Studies* 29, 486–522.

Cocco, Joao, and Paula Lopes, 2017, Reverse mortgage design, *Working Paper London Business School and London School of Economics*.

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

Cvijanovic, Dragana, and Christophe Spaenjers, 2020, "we'll always have paris": Out-of-country buyers in the housing market, *Management Science* forthcoming.

Davis, Morris A., and Stijn Van Nieuwerburgh , 2015, *Handbook of Regional and Urban Economics* . chap. Housing, Finance, and the Macroeconomy, p. Chapter 12 (North Holland).

DeFusco, Anthony, Charles Nathanson, and Eric Zwick, 2018, Speculative dynamics of prices and volume, Working Paper.

Eeckhout, Jan, Roberto Pinheiro, and Kurt Schmidheiny, 2014, Spatial sorting, *Journal of Political Economy* 122, 554–620.

Favilukis, Jack, Sydney C. Ludvigson, and Stijn Van Nieuwerburgh, 2017, The macroeconomic effects of housing wealth, housing finance and limited risk sharing in general equilibrium, *Journal of Political Economy* 125, 140–222.

Favilukis, Jack, Pierre Mabille, and stijn Van Nieuwerburgh, 2021, Affordable housing and city welfare, Working Paper Columbia Business School.

Flavin, M., and S. Nakagawa, 2008, A model of housing in the presence of adjustment costs: A structural interpretation of habit persistence, *American Economic Review* 98, 474–495.

Gao, Zhenyu, Michael Sockin, and Wei Xiong, 2020, Economic consequences of housing speculation, *Review of Financial Studies* forthcoming.

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

Gorback, Caitlin, and Benjamin J. Keys, 2020, Global capital and local assets: house prices, quantities, and elasticities, *Unpublished*.

Greenwald, Daniel, and Adam Guren, 2020, Do credit conditions move house prices?, Working Paper.

Guerrieri, Veronica, Daniel Hartley, and Erik Hurst, 2013, Endogenous gentrification and housing price dynamics, *Journal of Public Economics* 100, 45–60.

Hanushek, Eric A., and John M. Quigley, 1980, What is the price elasticity of housing demand?, *The Review of Economics and Statistics* 62, 449–454.

Hizmo, Aurel, 2015, Risk in housing markets: An equilibrium approach, Working Paper New York University.

Kaplan, Greg, Kurt Mitman, and Gianluca Violante, 2020, Consumption and house prices in the great recession: Model meets evidence, *Journal of Political Economy* 128, 3285–3345.

Koijen, Ralph, Robert Richmond, and Motohiro Yogo, 2019, Which investors matter for equity valuations and expected returns?, Working Paper.

Krusell, Per, and Anthony A. Smith, 1998, Income and wealth heterogeneity in the macroeconomy, *Journal of Political Economy* 106, 867–896.

Li, Wenli, Haiyong Liu, Fang Yang, and Rui Yao, 2016, Housing over time and over the life cycle: A structural estimation, *International Economic Review* pp. 1237–1260.

Li, Zhimin, Leslie Sheng Shen, and Calvin Zhang, 2020, Capital flows, asset prices, and the real economy: A "china shock" in the u.s. real estate market, Working Paper federal Reserve Board.

Ortalo-Magné, François, and Andrea Prat, 2016, Spatial asset pricing: A first step, *Economica* 83, 130–171.

Parkhomenko, Andrii, 2020, Local causes and aggregate implications of land use regulation, Working Paper USC.

Piskorski, Tomasz, and Amit Seru, 2020, Debt relief and slow recovery: A decade after lehman, SSRN Working Paper 3303411.

Rossi-Hansberg, Esteban, Pierre Daniel Sarte, and Raymond Owens, 2010, Housing externalities, *Journal of Political Economy* 118, 485–535.

Ruf, Thomas, and Maurice D. Levi, 2011, The law of one price in unfamiliar places: The case of international real estate, Working Paper UBC Sauder School.

Saiz, Albert, 2010, The geographic determinants of housing supply, *Quarterly Journal of Economics* pp. 1253–1296.

Stokey, Nancy L., 2009, Moving costs, nondurable consumption and portfolio choice, *Journal of Economic Theory,* forthcoming.

Storesletten, Kjetil, Chris Telmer, and Amir Yaron, 2006, Asset pricing with idiosyncratic risk and overlapping generations, *Review of Economic Dynamics* Forthcoming Working Paper, University of Oslo.

Suher, Michael, 2016, Is anybody home? the impact and taxation of non-resident buyers, Working Paper Furman Center New York University.

Van Nieuwerburgh, Stijn, and Pierre-Olivier Weill, 2010, Why has house price dispersion gone up?, *Review of Economic Studies* 77, 1567–1606.

Wheaton, William, 2017, The determinants of housing price volatility; 2001-2016, Working Paper MIT.

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

A   Micro-foundation OOT Housing Demand

This appendix provides a micro-foundation for the OOT housing demand in equation (8). The analysis closely follows the model in Koijen, Richmond, and Yogo (2019). OOT investors are two-period lived, risk averse agents who start with an exogenous endowment A_t. They are replaced by a new set of identical investors in the following period. The representative OOT investor has CARA preferences and solves the portfolio choice problem:

$$\max_{OOT_t} \mathbb{E}_t[-\exp(-\tilde{\gamma}A_{t+1} + Z_{t+1})]$$

where OOT is the vector of investments in OOT housing in zones 1 and 2. OOT investors can also invest in an outside asset 0 which represents a local investment opportunity such as cash or a local bank account, and whose price and interest rate are normalized to 1 and 0, respectively. Absolute risk aversion is parameterized as $\tilde{\gamma} = \gamma^{OOT} A_t^{-1}$, mimicking more standard CRRA preferences while maintaining analytical tractability. Z_{t+1} represents other risk factors that impact the OOT investor that can result from outside income, time-varying investment opportunities, exchange rate fluctuations, political risk in the home country, et cetera. We assume $Z_{t+1} \sim \mathcal{N}(\mu_Z, \sigma_Z^2)$.

The optimization is subject to the intra-period budget constraint:

$$A_t = OOT_t'P_t + Q_t^0$$

The law of motion for wealth is:

$$A_{t+1} = A_t + OOT_t'(D_{t+1} - P_t)$$

where the risky payoff on housing in zone ℓ is:

$$D_{t+1}^\ell = P_{t+1}^\ell(1 - \delta^\ell - \tau^P)$$

Assume that

$$\mathbb{E}_t[D_{t+1}] = g_t + \beta F_{t+1} + \eta_{t+1}$$

where the factor $F_{t+1} \sim \mathcal{N}(0,1)$ and $\eta_{t+1} \sim \mathcal{N}(0, \sigma_t^2 I)$.

We assume that the investor's expected payoff and risk exposure depends on characteristics of the asset, x_t, and potentially other information captured by the terms v_t:

$$g_t = \lambda^{g\prime} x_t + v_t^g \tag{17}$$

$$\beta_t = \lambda^{\beta\prime} x_t + v_t^\beta \tag{18}$$

We think of x as containing the location of the house (zone 1 or zone 2) but there could also be other property characteristics or market conditions in this vector. We assume for the background risk factor that:

$$2Cov_t(D_{t+1}, Z_{t+1}) = z_t = \lambda^{Z\prime} x_t + v_t^Z.$$

The first-order condition for the OOT investor is:

$$(g_t - P_t) - \tilde{\gamma}(\beta_t \beta_t' + \sigma_t^2 I) OOT_t + z_t = 0$$

or equivalently

$$
\begin{aligned}
OOT_t &= \frac{1}{\tilde{\gamma}} \left(\beta_t \beta_t' + \sigma_t^2 I \right)^{-1} (g_t - P_t + z_t) & (19) \\
&= \frac{1}{\tilde{\gamma}\sigma_t^2} \left(I - \frac{\beta_t \beta_t'}{\beta_t \beta_t' + \sigma_t^2} \right) (g_t - P_t + z_t) & (20) \\
&= \frac{1}{\tilde{\gamma}\sigma_t^2} (g_t - P_t) - \frac{c_t}{\tilde{\gamma}\sigma_t^2} \beta_t + \frac{1}{\tilde{\gamma}\sigma_t^2} z_t & (21) \\
& & (22)
\end{aligned}
$$

where $c_t = (\beta_t' \beta_t + \sigma_t^2)^{-1} \beta_t'(g_t - P_t + z_t)$ is a scalar. Hence, the OOT investor's demand for OOT housing depends on the expected return (first term), the riskiness (second term), and the hedging benefit. Substituting in for (17) and (18) and for the expression for absolute risk aversion, we get:

$$OOT_t = -\frac{A_t}{\gamma\sigma_t^2} P_t + \frac{A_t}{\gamma\sigma_t^2} \left(\lambda^g - c_t \lambda^\beta + \lambda^Z \right)' x_t + \frac{A_t}{\gamma\sigma_t^2} \left(v_t^g - c_t v_t^\beta + v_t^Z \right) \tag{23}$$

This expression links OOT investment in each region to house prices (first term), observable asset

characteristics such as the zone location of the housing (second term), and other considerations reflecting non-characteristic related perceptions of expected return or risk (third term). The price elasticity of demand of OOT investment, $-\partial OOT_t/\partial P_t = A_t/\gamma\sigma_t^2$ depends on the wealth of OOT investors, their relative risk aversion, and the idiosyncratic risk of those housing investments. These factors are captured by the reduced-form coefficient b in the main text. The coefficient a_ℓ in the reduced-form equation (8) is given by the second term, assuming that the vector x captures the zone where the property is located. It encompasses the demand stemming from the hedging properties of OOT investment through the term $\lambda^{Z'}x_t$. Shocks to the last term can drive around OOT demand over time, and are what give rise to the regime-switching behavior we model in the main text.

B   Analytical solution for housing and labor supply choices

We will solve only the worker's problem here. A retiree's problem is analogous, but simpler because there is one fewer choice as $n_t = 0$. We omit the zone superscript for notational convenience.

First, consider the **renter's problem** and let λ_t be the Lagrange multiplier on the budget constraint, ν_t be the Lagrange multiplier on the borrowing constraint, ξ_t be the Lagrange multiplier on the labor constraint, and μ_t be the Lagrange multiplier on the housing constraint. The numerical strategy is to choose c_t in order to maximize the household's utility. Here we will show that the other choices (n_t and h_t) can be written as analytic functions of c_t.

Case 1: $\nu_t = 0$, $\xi_t = 0$, and $\mu_t = 0$. In this case the household is unconstrained. The first order conditions are:

$$
\begin{aligned}
&\mathcal{C}_t^{1-\gamma-\eta}(1-\alpha_N)(1-\alpha_H)((1-\alpha_H)c_t^\epsilon + \alpha_H h_t^\epsilon)^{\frac{\eta-\epsilon}{\epsilon}}c_t^{\epsilon-1} = \lambda_t \\
&\mathcal{C}_t^{1-\gamma-\eta}(1-\alpha_N)\alpha_H((1-\alpha_H)c_t^\epsilon + \alpha_H h_t^\epsilon)^{\frac{\eta-\epsilon}{\epsilon}}h_t^{\epsilon-1} = \lambda_t R_t \\
&-\mathcal{C}_t^{1-\gamma-\eta}\alpha_N\chi(1-n_t)^{\chi\eta-1} = \lambda_t G^a W_t(1-\tau^{SS}) \\
&\lambda_t Q = (1-p^a)\beta E_t\left[\frac{\partial V_{t+1}}{\partial x_{t+1}}\right]
\end{aligned}
\tag{24}
$$

<div style="text-align:center">64</div>

By rearranging, it can be shown that conditional on choosing non-durable consumption c_t,

$$h_t = \left(\frac{\alpha_H}{1-\alpha_H}\right)^{\frac{1}{1-\epsilon}} R_t^{\frac{-1}{1-\epsilon}} c_t \qquad (25)$$

and

$$n_t = 1 - c_t^{\frac{1-\eta}{1-\chi\eta}} \left(\frac{1}{(1-\tau)W_t G_a z_t}\right)^{\frac{1}{1-\chi\eta}} \left(\frac{\alpha_N \chi}{(1-\alpha_N)(1-\alpha_H)}\right)^{\frac{1}{1-\chi\eta}} \left(\frac{(1-\alpha_H)R_t}{\alpha_H}\right)^{\frac{\alpha_H \eta}{1-\chi\eta}}. \qquad (26)$$

Case 2: $\nu_t > 0$, $\xi_t = 0$, and $\mu_t = 0$. In this case the borrowing constraint binds and $b_{t+1} = 0$, but the labor constraint does not. The first order conditions in the first three lines of equation (24) are still correct. It is still the case that conditional on choosing c_t, h_t and n_t are described by the equations above. By plugging these into the budget constraint, it is also possible to explicitly solve for non-durable consumption.

Case 3: $\nu_t = 0$ and $\xi_t > 0$, and $\mu_t = 0$. In this case the borrowing constraint does not bind, but the labor constraint does, implying $n_t = \underline{n}$. The first order conditions in the first, second, and fourth lines of equation (24) are still correct. As in case 1, conditional each choice c_t, h_t is described by the equation above.

Case 4: $\nu_t > 0$ and $\xi_t > 0$, and $\mu_t = 0$. In this case both constraints bind, implying $n_t = \underline{n}$ and $b_{t+1} = 0$. The first order conditions in the first and second lines of equation (24) are still correct, as is the equation for h_t as a function of c_t. By plugging this into the budget constraint, it is also possible to explicitly solve for non-durable consumption.

Case 5: $\nu_t = 0$, $\xi_t = 0$, and $\mu_t > 0$. In this case the minimum housing constraint binds. We set $h_t = \underline{h}$ but the first order conditions for consumption and labor are unaffected, so equation (26) still holds. If this new housing choice violates the borrowing constraint, then conditional on each choice of c_t, we increase n_t until the borrowing constraint is satisfied. If the borrowing constraint is still not satisfied, we assign a large negative utility to this choice of c_t.

Case 6: $\nu_t > 0$, $\xi_t = 0$, and $\mu_t > 0$. In this case, both the minimum housing constraint and the borrowing constraint bind. Conditional on each choice of c_t, we set $h_t = \underline{h}$ and we increase n_t until the borrowing constraint is satisfied. If the borrowing constraint is still not satisfied, we assign a large negative utility to this choice of c_t.

Case 7: $\nu_t = 0$ *and* $\xi_t > 0$, *and* $\mu_t > 0$. In this case the labor constraint and housing constraint both bind. Conditional on each choice of c_t, we set $n_t = \underline{n}$ and $h_t = \underline{h}$. If this new housing choice violates the borrowing constraint, then we increase n_t until the borrowing constraint is satisfied. If the borrowing constraint is still not satisfied, we assign a large negative utility to this choice of c_t.

Case 8: $\nu_t > 0$ *and* $\xi_t > 0$, *and* $\mu_t > 0$. In this case all constraints bind. Identically to Case 7, we set $n_t = \underline{n}$ and $h_t = \underline{h}$. By using the budget constraint, it is possible to explicitly solve for non-durable consumption. If the necessary consumption is negative, we assign a large negative utility to this individual state.

Next, consider the **owner's problem** and let λ_t be the Lagrange multiplier on the budget constraint, ν_t be the Lagrange multiplier on the borrowing constraint, ξ_t be the Lagrange multiplier on the labor constraint, and μ_t be the Lagrange multiplier on the housing constraint. We also extend the baseline model in the text by allowing rental property to depreciate at an additional rate δ^I compared to owner-occupied property. The numerical strategy is to choose c_t and $\widehat{h}_t$ in order to maximize the household's utility. Here we will show that the other choices (n_t and h_t) can be written as analytic functions of c_t and $\widehat{h}_t$.

Case 1: $\nu_t = 0$ *and* $\xi_t = 0$, *and* $\mu_t = 0$. In this case the household is unconstrained. The first order conditions are:

$$C_t^{1-\gamma-\eta}(1-\alpha_N)(1-\alpha_H)((1-\alpha_H)c_t^\epsilon + \alpha_H h_t^\epsilon)^{\frac{\eta-\epsilon}{\epsilon}}c_t^{\epsilon-1} = \lambda_t$$

$$C_t^{1-\gamma-\eta}(1-\alpha_N)\alpha_H((1-\alpha_H)c_t^\epsilon + \alpha_H h_t^\epsilon)^{\frac{\eta-\epsilon}{\epsilon}}h_t^{\epsilon-1} + (1-p^a)\beta E_t[\frac{\partial V_{t+1}}{\partial x_{t+1}}P_{t+1}(1-\delta-\tau^P)] = \lambda_t P_t$$

$$-C_t^{1-\gamma-\eta}\alpha_N\chi(1-n_t)^{\chi\eta-1} = \lambda_t G^a W_t(1-\tau^{SS})$$

$$\lambda_t Q = (1-p^a)\beta E_t[\frac{\partial V_{t+1}}{\partial x_{t+1}}]$$

$$(1-p^a)\beta E_t[\frac{\partial V_{t+1}}{\partial x_{t+1}}P_{t+1}(1-\delta-\tau^P)] = \lambda_t(P_t - R_t)$$

(27)

By rearranging, it can be shown that the equations for residential housing choice and hours are identical to equations (25) and (26) above.

Case 2: $\nu_t > 0$ *and* $\xi_t = 0$, *and* $\mu_t = 0$. In this case the borrowing constraint binds implying $x_t - P_t\widehat{h}_t - P_t h_t = -\kappa P_t(h_t + \widehat{h}_t)$, but the labor constraint does not bind. Eliminating b_{t+1} from the

budget constraint, we can solve for the residential housing choice as a function of $(c_t, \widehat{h}_t)$:

$$h_t = (x_t - (1 - \theta_{inv})P_t\widehat{h}_t)/((1 - \theta_{res})P_t). \tag{28}$$

The hours choice remains as in equation (26).

Case 3: $\nu_t = 0$ *and* $\xi_t > 0$, *and* $\mu_t = 0$. In this case the borrowing constraint does not bind, but the labor constraint does, implying $n_t = \underline{n}$. All but the third line of equation (27) are still correct. Conditional on choosing $(c_t, \widehat{h}_t)$, h_t is identical to Case 1.

Case 4: $\nu_t > 0$ *and* $\xi_t > 0$, *and* $\mu_t = 0$. In this case both constraints bind, implying $n_t = \underline{n}$ and $x_t - P_t\widehat{h}_t - P_t h_t = -P_t(\theta_{res}h_t + \theta_{in}\widehat{h}_t)$. Residential housing is identical to equation (28) in Case 2.

Case 5: $\nu_t = 0$ *and* $\xi_t = 0$, *and* $\mu_t > 0$. In this case the minimum housing constraint binds. We set $h_t = \underline{h}$ but the first order conditions for consumption and labor are unaffected, so equation 26 still holds. If this new housing choice violates the borrowing constraint, then conditional on each choice of $(c_t, \widehat{h}_t)$, we increase n_t until the borrowing constraint is satisfied. If the borrowing constraint is still not satisfied, we assign a large negative utility to this choice of $(c_t, \widehat{h}_t)$.

Case 6: $\nu_t > 0$ *and* $\xi_t = 0$, *and* $\mu_t > 0$. In this case, both the minimum housing constraint and the borrowing constraint bind. Conditional on each choice of $(c_t, \widehat{h}_t)$, we set $h_t = \underline{h}$ and we increase n_t until the borrowing constraint is satisfied. If the borrowing constraint is still not satisfied, we assign a large negative utility to this choice of $(c_t, \widehat{h}_t)$.

Case 7: $\nu_t = 0$ *and* $\xi_t > 0$, *and* $\mu_t > 0$. In this case the labor constraint and housing constraint both bind. Conditional on each choice of $(c_t, \widehat{h}_t)$, we set $n_t = \underline{n}$ and $h_t = \underline{h}$. If this new housing choice violates the borrowing constraint, then we increase n_t until the borrowing constraint is satisfied. If the borrowing constraint is still not satisfied, we assign a large negative utility to this choice of $(c_t, \widehat{h}_t)$.

Case 8: $\nu_t > 0$ *and* $\xi_t > 0$, *and* $\mu_t > 0$. In this case all constraints bind. Identically to Case 7, we set $n_t = \underline{n}$ and $h_t = \underline{h}$. By using the budget constraint, it is possible to explicitly solve for non-durable consumption. If the necessary consumption is negative, we assign a large negative utility to this individual state.

C   Labor Income Calibration

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

$$y_{i,a} = W_t n_t^i G^a z_{a,i}$$

where G^a is a function of age and $z_{a,i}$ is the idiosyncratic component of productivity.

The average idiosyncratic productivity, conditional on age, is one: $E[z_{a,i}|a] = 1$. We let $z_{a,i}$ depend on age a because, in the data, the cross-sectional dispersion of income grows with age. For a given age a, $z_{a,i}$ takes on one of three values (low, middle, high), but these values differ by age. Idiosyncratic productivity $z_{a,i}$ is stochastic, and its transition dynamics are governed by a Markov process $\mathcal{P}(i,i';\beta)$. Transition probabilities depends on i but not on a. Furthermore, we allow the transition probability matrix to differ for households with low saving motive ($\beta = \beta_L$) and high saving motive ($\beta = \beta_H$), as detailed below. This is done in order to induce a sufficiently positive correlation between income and wealth in the model.

We define earnings as labor income plus business income in the Survey of Consumer Finances (SCF). We use 10 survey waves from 1983-2010. For the purpose of these calculations, we exclude households that report negative or zero income. Below, we explain how we calibrate the three components of the income process: (A) the age profile G^a; (B) the idiosyncratic income relative to mean $z_{a,i}$; (C) the transition probability density of z, $\mathcal{P}$.

(A) For each SCF wave, 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. This is G^a.

(B) To compute the idiosyncratic income $z_{a,i}$ of each group $i \in (low, middle, high)$ 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 whether it was in the bottom 25%, middle 50%, or top 25% of earners of the same age. Thus, each household is defined as a low, middle, or high earner (relative to same-aged households).

Step 2: For each 4-year age bucket, we compute average earnings of all low earners and define this as $z_{a,j}^{\$}$ where a is the 4-year age group and $j = low$. We do the same for $j = middle$ and $j = high$.

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

$$z_{a,j} = \frac{z_{a,j}^{\$}}{0.25z_{a,low}^{\$} + 0.5z_{a,middle}^{\$} + 0.25z_{a,high}^{\$}}.$$

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 three 11x1 vectors $z_{a,low}$, $z_{a,middle}$, and $z_{a,high}$ 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 (low, middle, high), on a linear trend to get a linearly fitted value for each group's (low, middle, high) 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.

(C) Storesletten, Telmer, and Yaron (2006) estimate that the autocorrelation of the idiosyncratic component of labor income is 0.9. Thus, if the β_L and β_H agents had the same transition probability matrix $\mathcal{P}$, we would set

$$\mathcal{P}(i, i') = \begin{bmatrix} p & 1-p & 0 \\ .5(1-p) & p & .5(1-p) \\ 0 & 1-p & p \end{bmatrix}$$

for each agent, with $p = 0.9$. This matrix implies that the low, middle, and high income groups are, respectively, 25%, 50%, and 25% of the population, and that the persistence of the

idiosyncratic component is 0.9. However, setting this $\mathcal{P}$ for all agents results in a correlation between income and wealth that is too low compared to the data. For this reason, we adjust P in the following way. For β_H-agents, we raise the persistence of the high state, choosing $p_H > p$ in:

$$\mathcal{P}(i,i';\beta_H) = \begin{bmatrix} p & 1-p & 0 \\ .5(1-p) & p & .5(1-p) \\ 0 & 1-p_H & p_H \end{bmatrix}$$

We set $p_H = 0.95$ to approximately match the wealth share held by the top 25% of the income distribution. Note that this implies that among β_H agents, the low, middle, and high income groups are, respectively, 20%, 40%, and 40% of the population. In order to keep the unconditional fractions at 25%, 50%, and 25%, we must also change $\mathcal{P}$ for the β_L-agents. We set it to:

$$\mathcal{P}(i,i';\beta_L) = \begin{bmatrix} p & 1-p & 0 \\ .5(1-p) & p & .5(1-p) \\ 0 & 1-p_L & p_L \end{bmatrix}$$

where $p_L = 0.8667$ ensures that the unconditional fractions of low, middle, and high earners are 25%, 50%, and 25%. To sum up, we choose p, p_H, and p_L to match (i) the persistence of the idiosyncratic component of wages, (ii) the share of wealth held by the top 25% of income earners, and (iii) the unconditional fractions of low, middle, and high income earners.

The left panel of Figure 5 plots the age-earnings profile G^a. It shows the familiar hump shape over the life-cycle; G^a is set to zero for age 65 and older. The middle panel plots the idiosyncratic productivity grid at each age: $z_{a,low}$, $z_{a,middle}$, and $z_{a,high}$. It shows that at young ages, dispersion between the earnings groups muted, since the values are all close to 1. The lines diverge with age, implying a rising variance of earnings over the life-cycle. The right panel plots the product, $G^a z_{a,j}$, which are the efficiency units of labor for the various productivity groups.

In the model, we are calibrating each household's productivity. In the data, we do not observe productivity, but use earnings as our productivity estimate. If hours worked differed drastically across age and income groups, then the model's income distribution might look very different from that of the data. Hours worked are relatively flat across productivity and age, both in the

Figure 5. Labor Income Calibration
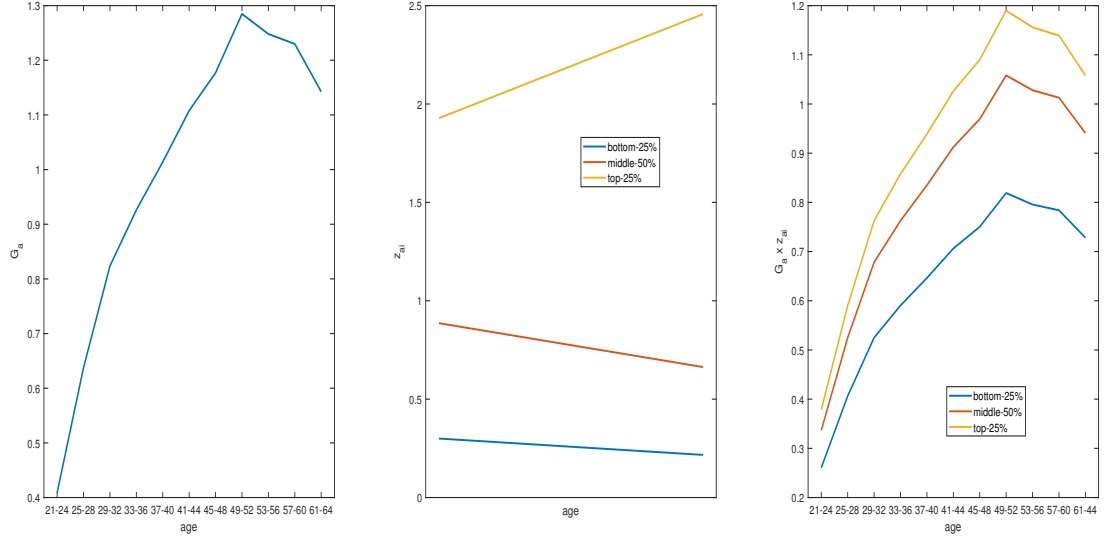
model and in the data. Therefore, the model's (endogenous) income distribution looks similar to the data, as can be seen from the top panels of Figure 2.

D 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 as:

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

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 (9) delivers:

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

Rewrite in logs, using lowercase letters to denote logs:

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

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

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

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

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

Invert this expression delivers the housing supply elasticity:

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

If the elasticity of wages to housing supply is small ($\frac{\partial w}{\partial h} \approx 0$), the housing supply elasticity simplifies to:

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

We will use this approximation to calibrate the housing supply elasticity to the data. Since, in equilibrium, $Y^h = \delta H$, $\partial y^h/\partial p = \partial h/\partial p$.

Note that $h - \bar{h}$ measures how far the housing stock is from the constraint, in percentage terms. As H approaches $\bar{H}$, the term $\frac{\exp(h-\bar{h})}{1-\exp(h-\bar{h})}$ approaches $+\infty$ and the elasticity approaches zero. If H is far below $\bar{H}$, that term is close to zero and the housing supply elasticity is close to $\frac{\rho_h}{1-\rho_h}$.

In the baseline calibration, $\rho_h = 0.66$, $H/\bar{H} = 0.16$ and $\frac{\partial w}{\partial h} = 0.25$. The latter is calculated as the percentage change in wages divided by the percentage change in housing. These numbers deliver a house price elasticity of 0.94, close to the target of 1.0.

E   Data Appendix

E.A   The Typical U.S. Metropolitan Area

We compile data on the largest 75 metropolitan statistical areas for the year 2016. From the Census Bureau, we collect population for each MSA and each county. We also obtain data on the number of residents that are above age 65 and the number of residents that are above 21. Their ratio is the share of retirees. Finally, we obtain counts of the number of owner- and renter-occupied housing units, allowing us to construct the home ownership rate. From the American Community Survey, we obtain average commuting time and average property tax revenue.

From Zillow, we collect the Zillow House Value Index (ZHVI) and the Zillow Rental Index (ZRI) for each MSA and each county. The ZHVI is the price of a typical dwelling (single-family, condo, coop), while the ZRI is the monthly rent for a typical house (single-family, apartment). Zillow uses a machine-learning algorithm to control for property characteristics so that the resulting ZHVI and ZRI indices pertain to the *same property* in a given period and location.

We match Census and Zillow data at the county level, which requires some manual work because of different naming conventions. The 75 MSAs are comprised of 487 counties. We split each MSA into two zones: the urban core, called zone 1, and the periphery containing the rest of the MSA, called zone 2. For the New York MSA, zone 1 is New York County (Manhattan), while for the Chicago MSA it is Cook County. For most MSAs (63 out of 75), zone 1 is a subdivision of a county (city) rather than an entire county. For example, Los Angeles county is far larger than the urban core, the city of Los Angeles. The same is true for Dallas County and Harris County in the Houston MSA. When using the county subdivisions, we collect data on population, income, retirees, owned and rented housing units, and property tax revenue from the ACS and prices and rents from Zillow for the constituent county subdivisions in order to allocate them to zone 1 and zone 2. We exclude the Greensboro MSA, the 75th largest MSA, since it consists of only one county. Our sample consists of the 74 largest MSA.

We then compute for all 74 MSAs the following 13 statistics: (1) MSA population, (2) MSA ZHVI P, (3) MSA ZRI R, (4) MSA price to annual rent ratio P/R, (5) the ratio of the msa population that is above age 65 to the msa population above age 21 (*reti*), (6) the home ownership rate in the

MSA (*Own*), (7) the average commuting time (*Commu*), (8) the ratio of retirees in zone 1 to zone 2 (*reti z1/z2*), (9) the ratio of home ownership in zone 1 to zone 2 (*Own z1/z2*), (10) the ratio of ZRI in z1 to z2 (*R z1/z2*), (11) the ratio of income in zone 1 to zone 2 (*Inc z1/z2*), (12) the property tax rate in zone 1, calculated as average tax revenue divided by the average ZHVI (*tax z1*), (13) the same statistic in zone 2 (*tax z2*). Tables VI and VI show these statistics for the largest 40 MSAs by population as well as the population-weighted average among all 74 MSAs.

We report 6 additional statistics which are (7) Table VI shows these statistics for the largest 40 MSAs by population as well as the population-weighted average among all 75 MSAs.

E.B Out-of-town Housing Demand

Out-of-town (OOT) housing demand is estimated using the data set compiled for us by `CoreLogic`. This confidential data set contains the monthly time series of number of housing purchases for Manhattan and for NYC MSA between January 2004 and September 2016. Housing purchases are defined as purchases of single-family, 2-4 family, condominiums, and co-ops. OOT purchases are identified using the reported mailing addresses on payment/tax forms. Specifically, if the address of a buyer is either abroad or not contained in the list of 1,304 ZIP codes inside NYC MSA, then the transaction is classified as an OOT purchase.

One complication arises because not only individuals but also companies purchase residential real estate. We include purchases by the following types of corporate entities: LLC, Inc, Corp, and Trust. Combined, these account for 7.28% of all purchases in the New York metro and even 11.13% in Manhattan. We have an address for these corporate purchases as well. Following the same address rules, we obtain the number of OOT corporate purchases and the number of NY MSA corporate purchases in each month. If the buyer of an apartment is a corporation, we can not be certain whether the individual who ultimately owns the apartment is a local or from OOT. Some OOT corporate purchases may be done by locals while some NY MSA corporate purchases may actually hide the identity of OOT investors. Under *assumption 1*, we assume that all OOT corporate purchases are by OOT investors and none of the NY MSA corporate purchases are by OOT buyers. Under *assumption 2*, we assume that 70% of all OOT corporate purchases are by OOT investors and 30% of the NY MSA corporate purchases are by OOT buyers. We have also

Table VI. U.S. Metropolitan Area Statistics: Part 1

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
MSA name	**Pop**	**P**	**R**	**P/R**	**reti**	**Own**	**Commu**
New York	20,153,634	498,955	2,404	17.30	19.1%	51.5%	36.3
Los Angeles-Long Beach-Anaheim	13,310,447	557,640	2,587	17.96	17.1%	48.4%	30
Chicago	9,512,999	200,328	1,655	10.09	17.7%	64.2%	31.6
Dallas-Fort Worth	7,233,323	184,461	1,534	10.02	14.8%	59.7%	28.1
Houston	6,690,766	179,457	1,575	9.49	14.2%	60.1%	29.7
Washington	6,131,977	398,394	2,194	15.13	15.6%	63.0%	34.6
Philadelphia	6,070,500	203,562	1,590	10.67	19.7%	67.4%	29.5
Miami-Fort Lauderdale	6,066,387	231,556	1,889	10.21	22.5%	60.1%	28.9
Atlanta	5,789,700	178,136	1,344	11.04	15.2%	63.0%	31.4
Boston	4,794,447	410,340	2,296	14.90	19.2%	61.3%	31.0
San Francisco	4,679,166	829,218	3,389	20.39	18.3%	53.7%	32.8
Phoenix	4,661,537	222,821	1,313	14.15	20.0%	61.4%	26.2
Riverside	4,527,837	308,608	1,704	15.09	17.3%	61.9%	32.1
Detroit	4,297,617	128,608	1,192	8.99	20.0%	68.6%	26.8
Seattle	3,798,902	418,325	2,072	16.83	16.5%	59.8%	30.1
Minneapolis-St Paul	3,551,036	229,230	1,558	12.26	17.1%	69.7%	25.3
San Diego	3,317,749	509,700	2,431	17.47	17.4%	52.7%	25.7
Tampa	3,032,171	165,687	1,329	10.39	24.6%	63.9%	27.1
Denver	2,853,077	341,064	2,016	14.10	15.9%	63.3%	27.5
Baltimore	2,798,886	240,402	1,766	11.35	19.0%	66.0%	30.8
St. Louis	2,785,284	143,490	1,140	10.49	20.1%	69.0%	25.6
Charlotte	2,442,133	167,584	1,249	11.18	17.2%	65.3%	26.5
Orlando	2,441,257	188,415	1,380	11.38	18.8%	60.2%	28.2
Portland	2,424,955	342,224	1,774	16.08	17.9%	60.8%	26.6
San Antonio	2,380,812	163,058	1,320	10.30	17.4%	61.8%	26.0
Sacramento	2,296,418	343,465	1,688	16.96	19.3%	59.0%	26.8
Las Vegas	2,155,664	208,300	1,241	13.99	18.3%	52.3%	24.5
Pittsburgh	2,155,452	122,317	1,107	9.21	24.0%	69.2%	26.7
Cincinnati	2,142,179	140,438	1,263	9.27	19.0%	65.8%	24.7
Austin	2,056,405	266,196	1,735	12.79	13.3%	58.1%	26.8
Cleveland	2,055,612	122,949	1,163	8.81	22.4%	65.0%	24.6
Columbus	2,041,520	144,022	1,330	9.03	16.7%	61.1%	23.7
Kansas City	2,028,527	158,908	1,264	10.48	18.4%	64.7%	23.0
Indianapolis	2,004,230	139,160	1,211	9.58	17.4%	64.7%	24.8
San Jose	1,978,816	945,350	3,496	22.53	16.7%	56.7%	28.2
Nashville	1,865,298	211,455	1,542	11.43	16.7%	65.3%	27.3
Virginia Beach	1,726,907	212,569	1,433	12.36	17.9%	61.0%	24.3
Providence	1,614,750	243,116	1,604	12.63	21.1%	60.5%	25.8
Milwaukee	1,572,482	178,678	1,302	11.43	19.2%	60.0%	23.1
Jacksonville	1,478,212	168,442	1,304	10.77	19.3%	64.5%	26.5
Pop-weighted avg 74 MSAs	6,075,613	297,875	1,775	13.03	18.3%	60.6%	28.64

Table VI. U.S. Metropolitan Area Statistics: Part 2

MSA name	(8) reti z1/z2	(9) Own z1/z2	(10) R z1/z2	(11) Inc z1/z2	(12) tax z1	(13) tax z2
New York	0.91	0.42	1.68	2.70	0.55%	1.89%
Los Angeles-Long Beach-Anaheim	0.87	0.68	1.06	0.91	0.89%	0.87%
Chicago	0.81	0.61	1.03	0.92	2.05%	3.06%
Dallas-Fort Worth	0.90	0.65	0.87	1.00	3.15%	2.17%
Houston	0.96	0.61	0.88	0.88	2.62%	2.32%
Washington	0.93	0.62	1.19	1.16	0.81%	1.19%
Philadelphia	0.83	0.72	0.72	0.85	1.27%	1.50%
Miami-Fort Lauderdale	0.92	0.49	1.16	0.69	1.60%	2.27%
Atlanta	0.94	0.66	1.08	1.48	2.20%	1.25%
Boston	0.70	0.53	1.12	1.01	0.86%	1.47%
San Francisco	0.92	0.63	1.44	1.40	0.89%	0.75%
Phoenix	0.62	0.80	0.93	0.90	0.63%	0.85%
Riverside	0.84	0.87	1.03	0.98	0.85%	1.05%
Detroit	0.88	0.67	0.59	0.48	2.86%	2.19%
Seattle	0.87	0.73	1.25	1.22	0.82%	1.08%
Minneapolis-St Paul	0.66	0.65	0.97	0.95	1.64%	1.40%
San Diego	0.86	0.81	1.01	1.06	0.86%	0.91%
Tampa	0.63	0.73	0.99	1.04	1.85%	1.24%
Denver	0.87	0.72	0.98	1.26	0.62%	0.70%
Baltimore	0.84	0.65	0.71	0.78	3.73%	1.29%
St. Louis	0.73	0.59	0.76	0.81	1.53%	1.87%
Charlotte	0.68	0.74	1.05	1.18	1.72%	1.08%
Orlando	0.69	0.56	0.92	0.90	1.36%	1.17%
Portland	0.78	0.83	1.05	1.05	2.19%	1.84%
San Antonio	0.86	0.72	0.86	0.77	1.12%	1.11%
Sacramento	0.84	0.75	0.85	0.83	2.22%	2.39%
Las Vegas	1.08	1.00	0.99	0.98	1.02%	0.97%
Pittsburgh	0.73	0.65	1.05	0.89	0.90%	0.86%
Cincinnati	0.83	0.53	0.81	0.81	2.83%	1.96%
Austin	0.68	0.64	1.09	1.12	1.90%	1.52%
Cleveland	0.77	0.59	0.68	0.56	1.97%	2.14%
Columbus	0.67	0.61	0.77	0.75	2.34%	2.43%
Kansas City	0.87	0.79	0.76	0.84	3.91%	2.51%
Indianapolis	0.83	0.72	0.83	0.94	1.41%	1.18%
San Jose	0.89	1.01	0.94	0.78	0.79%	0.74%
Nashville	0.81	0.74	0.99	1.19	1.08%	0.74%
Virginia Beach	0.91	1.05	1.10	1.19	1.07%	1.14%
Providence	0.61	0.54	0.88	0.76	2.77%	1.66%
Milwaukee	0.64	0.59	0.66	0.58	3.57%	1.99%
Jacksonville	0.76	0.78	0.76	0.80	1.37%	1.23%
Pop-weighted avg 74 MSAs	0.84	0.65	1.03	1.12	1.60%	1.57%

computed the OOT share assuming (90%,10%) and (80%,20%) assumptions and the results are in between those for assumption 1 and assumption 2. Since there are a lot more NY MSA corporate purchases than OOT corporate purchases, the OOT share under assumption 2 is higher than under assumption 1.

As described in Table VII, the average OOT purchase fractions are 9.2%/2.8% for Manhattan/Rest of NY metro under *assumption 1*, while the fractions are 11.6%/4.6% under *assumption 2*. Based on conversations with market participants, we believe assumption 2 comes closer to approximating the true OOT share. A full-sample OOT share of 5% for the entire NYC metro area and of 10% for Manhattan seem conservative (Panel C).

Table VII. Fraction of OOT Purchases of New York Housing Units

Assumption	2004.01-2016.09	2004.01 - 2007.12	2008.01 - 2011.12	2012.01 - 2016.09
Panel A: Manhattan				
1	9.2%	8.2%	9.0%	10.1%
2	11.6%	9.6%	11.4%	13.4%
Panel B: Rest of New York metro area				
1	2.8%	2.5%	2.6%	3.1%
2	4.6%	3.6%	4.4%	5.8%
Panel C: New York metro area				
1	3.3%	2.9%	3.3%	3.8%
2	5.3%	4.0%	5.0%	6.5%

Notes: Share of residential real estate purchases made by out-of-town (OOT) buyers in the New York metropolitan area. Source: Core Logic. Monthly data from January 2004 through September 2016.

E.C Migration

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 each county and survey wave, we compute net migration rates (inflow minus outflow divided by population). When one person enters the New York labor market and another one leaves, the model is unchanged, so net migration is the relevant concept for the model. We aggregate net migration for the 24 counties other than Manhattan and call them zone 2. The net migration rate over the 5-year period between 2010-2014 for the entire MSA is -0.15%, or -0.03% per year. First, this net migration rate is minuscule: only about 30,000 people moved in over a 5-year period on a MSA population of 20 million. Of course, this masks much larger gross flows: about 824,000 came into the MSA and

854,000 left. Second, Manhattan saw a net inflow of 30,000 people coming from outside the MSA while the rest of the MSA (zone 2) saw a net outflow to the rest of the country/world of 60,000. This is the opposite pattern than what we would expect if the OOT purchases prompted migration of residents, since OOT purchases were much stronger in Manhattan than in the rest of the MSA (twice as large). Third, comparing the net migration in the 2010-2014 period to that in the 2006-2010 period, we find that the net migration rate rose, from -73,000 to -30,000. The net migration rate rises from -0.38% in 2006-2010 to -0.15% in the 2010-2014 period. The rise in OOT purchases over time did not coincide with a decline in net migration, but with an increase. In other words, not only are the relevant net migration rates tiny, they also have the wrong-sign cross-sectional correlation with the spatial OOT pattern, and with the time-series of OOT purchases. We conclude that there is little evidence in the New York data of substantial net migration responses to OOT purchases.