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RESEARCH DEPARTMENT

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WP 23-22

PUBLISHED
October 2023

ISSN: 1962-5361

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DOI: https://doi.org/10.21799/frbp.wp.2023.22

Institutional Housing Investors and the Great Recession[†]

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June 2023

Abstract

Before the Great Recession, residential institutional investors predominantly bought and rented out condos, but then they increased their market share of rental houses from 17 percent in 2001 to 28 percent in 2018. Along with this change, rental survey data show that the annual house operating-cost premium of institutional investors relative to homeowners fell from 44 percent in 2001 to 28 percent in 2015. To measure how these reduced costs affected the housing bust of 2007–2011, I build a heterogeneous agent model of the housing market featuring corporate investors and two types of dwellings: condos and houses. A transition experiment intended to replicate the Great Recession yields three results. First, house prices would have fallen by 1.6 percentage points more without the corporate-cost reduction. Second, the corporate-cost reduction can explain the fall in the homeownership rate. Third, the cost reduction produced a welfare gain of 0.4 percent for homeowners and 0.6 percent for individual investors.

Keywords: general equilibrium; housing; investors; housing prices; homeownership
JEL codes: D10, D31, E21, E30, E51

[†]I would like to thank my advisors, José-Víctor Ríos-Rull, Enrique Mendoza, and Dirk Krueger. For helpful comments and discussions, I would like to thank James Vickery, Thorsten Drautzburg, Enghin Atalay, and Ryan Zalla. I have also benefited from feedback by seminar participants at the University of Pennsylvania Macro Lunch and the Federal Reserve Bank of Philadelphia. Data provided by Zillow through the Zillow Transaction and Assessment Dataset (ZTRAX). More information on accessing the data can be found at http://www.zillow.com/ztrax. The results and opinions are those of the author and do not reflect the position of Zillow Group.

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1 Introduction

The housing boom of the mid 2000s ended with the Great Recession, culminating in a housing bust. Both house prices and the homeownership rate started a steep and continuous decline. While house prices bottomed out in 2011, the homeownership rate kept falling until 2016. The shift from owning to renting was accompanied by a rise in investor purchases. Hence, institutional investors entered the market for houses, while historically they had primarily bought and rented out apartments.

There is a growing empirical literature studying the rise of institutional investors in the housing market and the rationales behind it, such as Lambie-Hanson et al. (2022); Schnure (2014); Smith and Liu (2017); Garriga et al. (2023, 2021); Allen et al. (2018); Mills et al. (2019); Graham (2020). Factors such as a large supply of foreclosed properties, low price to rent ratios, and constrained credit during the Great Recession enabled institutional investors to purchase a large number of houses. These factors alone, however, would have had only a largely temporary effect on the share of houses owned by residential institutional investors.[1]

This paper argues that there was a structural shift from owning to renting by households after the Great Recession due to a fall in house operating costs for institutional investors relative to owner-occupiers. Operating costs are the annual maintenance costs and management costs, plus the average annual improvement costs of owner-occupiers. These empirical findings are rationalized in this paper by proposing a joint theory of household formation, household dwelling allocation, and property ownership. More specifically, the paper proposes a heterogeneous-agents life-cycle model with a housing market that features two dwelling types, "mom-and-pop" investors and a corporate rental sector. The model is used to study housing-market equilibrium responses to the observed reduction in corporate operating costs during a crisis episode meant to reflect the Great Recession. This cost reduction increased the institutional investors' market share of rental houses, which permanently lowered equilibrium rental rates. The fall in rental rates increased (rental) housing demand, moderating the fall in house prices during the bust by 1.6 percentage points. Even though residential institutional investment is associated with more stable house prices, it is also as-

[1] After credit constraints eased and income levels recovered, the institutional housing rental share should have been expected to revert to its original trend level or its long-run average.

sociated with a 3.7 percentage points larger decline in the homeownership rate. While the majority of homeowners benefited from higher house prices, renters either gained or lost depending on their age and wealth: rental rates fell, but house prices rose when renters faced tighter credit constraints and lower income. In sum, the corporate-cost reduction for houses caused a fall in the homeownership rate that was welfare increasing.

The empirical analysis provides evidence of these key facts. First, the empirical analysis documents the fall in operating costs for corporate-owned rental houses relative to owner-occupiers. Dwellings with 1-4 units in the same structure are defined as houses, and dwellings with 5+ units in the same structure are defined as apartments/condominiums ("condos"). House operating costs are defined as annual maintenance costs and management costs, plus the average annual improvement costs of owner-occupiers for 2005–2019. Controlling for house value and number of units in the structure, the house operating-cost premium for residential institutional investors relative to homeowners fell from 44 percent in 2001 to 28 percent in 2015, or from $1,350 in 2001 to $940 in 2015 (in 2018 dollars), while the operating-cost premium for individual investors *did not change*. Institutional investors needed to have a minimum scale to achieve lower operating costs, and the Great Recession provided an opportunity to expand their portfolios. Digital innovations rationalize this fall in operating costs for institutional investors. These innovations since the 2008 crisis were required to automate core functions, such as rent collection and maintenance, in order to efficiently manage large, geographically dispersed property portfolios (Fields, 2022).

Next, the paper provides evidence that institutional investors got larger post-crisis, enabling them to use economies of scale that can explain the concurrent fall in operating costs after the Great Recession. Housing transaction data from the Zillow Transaction and Assessment database (ZTRAX) shows that firms have grown larger in 2015 relative to 2007, which confirms that firms increased their portfolio sizes (Zillow, 2022).[2]

The total house market share owned by institutions increased after the crisis, both in terms of house purchases and rental stock owned. Institutional investors have increased their rental housing share from 16 percent in 2001 to 28 percent in 2018 for 1-4 unit dwellings,

[2]Companies are identified by names (names must be at least 8 characters long) and using a fuzzy matching algorithm on addresses.

owning 57 percent of all rental units in 2018. The growth of institutional investors can be confirmed using the housing transaction data from the ZTRAX dataset: their purchase share has increased from 8 percent pre-crisis to 14 percent post-crisis and has been stable since 2014. Moreover, tracking the houses bought over time shows that institutional investors remain net buyers of houses.

To rationalize these empirical findings, this paper proposes a heterogeneous-agents life-cycle model with a housing market that features mom-and-pop (non-corporate) investors and a corporate rental sector. Households face uninsurable income risk and can choose to rent or buy a dwelling.[3] Households can use long-term mortgages to finance dwelling purchases. Homeowners are subject to two additional idiosyncratic shocks: 1) they face the risk of disliking their primary home, and 2) they could get the opportunity to buy a second dwelling and become a mom-and-pop investor. Those investment dwellings can be used as collateral for mortgage borrowing and generate rental income and possibly capital gains.

The housing market consists of two dwelling types: condos and houses. Dwellings can be owned by homeowners, mom-and-pop investors, or the corporate sector, and these owners differ in the required maintenance costs. The corporate sector buys and rents out both types of dwellings, and these dwellings, while identical to individual-owned, differ in their associated persistent maintenance cost draw. The corporate sector exhibits two key features: constant returns to scale and free entry. The constant returns to scale assumption allows the model to focus on the observed cost reduction, abstracting from a size distribution.

To conduct the Great Recession experiment, I model economies of scale through the housing stock owned by the corporate rental sector. The free-entry condition provides an expected zero profit condition, with entrants drawing maintenance costs before deciding to purchase a dwelling. A mutual fund, which is owned by all households in proportion to their assets, owns all the corporate purchases.

The model is used to study housing-market equilibrium responses to the observed reduction in corporate operating costs during a crisis episode. The economy is perturbed with unexpected exogenous contractions in mortgage credit and income, which are expected to last forever but then revert after six years. The equilibrium responses with and without a

[3] Younger agents have the option to live rent-free with their parents, not occupying any dwelling.

reduction in corporate operating costs for houses are then compared. The corporate costs for houses are assumed to fall after four years in the housing bust. This delayed reduction in costs is motivated by the fact that 1) it takes time to achieve economies of scale, and 2) the institutional investor purchase share only rose in 2010–2011. The exogenous crisis shock lowers the demand for both houses and condos, lowering both dwellings' prices and rental rates, and lowering homeownership rates. The reduction in corporate costs for houses increases rental demand, which moderates the fall in house prices by 1.6 percentage points. A steady-state comparison shows a total welfare gain of 0.29 percent in consumption equivalent variation. The majority of the households are better off with the cost reduction due to a rise in the house price and a fall in the rental price. During the transition path, however, the welfare gains are concentrated among homeowners and mom-and-pop investors (0.4 and 0.6 percent, respectively) as they experience an immediate capital gain, while renters only benefit from a lower house rental rate at the end of the crisis.

This paper is related to the growing literature that studies the empirical importance of housing investors during the 2000s housing boom-bust cycle. For example, Lambie-Hanson et al. (2022) use an instrumental-variables identification strategy involving the First Look program to show that higher institutional investment was associated with higher house prices and lower homeownership during the housing bust. Mills et al. (2019) document the increase in "buy-to-rent" investors in the single family detached housing market and how this resulted in higher house prices and lower vacancy rates. Ganduri et al. (2023) find that institutional investors provide valuable liquidity and spur the recovery of distressed housing markets. Similarly, Allen et al. (2018) find that investors create positive price externalities for other properties. Garriga et al. (2023) study how institutional investors impacted housing affordability. They show that investors' purchases increase the price-to-income ratio. Graham (2020) finds that, following a mortgage credit contraction, house prices fall by more in markets where household investors absorb larger shares of house purchases. In terms of implications for renters' welfare, Gurun et al. (2023) find that while institutional landlords extract greater surplus from renters, they also improve the quality of rental service by improving neighborhood safety. The contribution of this paper to this literature is to show that institutions increased their rental stock of houses persistently post-crisis, and that firms increased their portfolio sizes from 2007 to 2015. Their rise can explain the persistent fall in the homeownership rate and increased welfare.

The literature has proposed different explanations for why institutional investors increased their house purchase share during the housing bust episode. Lambie-Hanson et al. (2022) propose two possible reasons. First, the Great Recession lowered bank capital, which led banks to adopt more stringent lending standards (Bassett et al., 2014). As a result, the mortgage supply was restricted for households. Second, a downward trend in housing prices eroded existing owners' equity, which made it harder for them to move. The lower moving activity, in addition to the persistent effects of foreclosures, created a buying opportunity for institutional investors. Mills et al. (2019) identify two additional reasons for the large-scale "buy-to-rent" investors to enter the single family detached housing market. They argue that a large inventory of geographically concentrated homes and technological developments that improved management efficiencies were key. Garriga et al. (2021) document that the new institutional investors are mainly focused on the reach for yield. This paper focuses on the fall in the operating costs for institutional investors, which could either have been the cause or the outcome of the increased share.

The fall in operating costs for institutions is related to the work of Fields (2022), who studies how digital technologies have enabled institutional investors to enter the single-family rental housing market post-2008. Fields (2022) provides several examples of improved efficiency for large firms. For instance, to acquire individual homes efficiently, large firms use acquisition engines / platforms around data fed into underwriting algorithms, with the goal to scale up portfolios rapidly in the right submarkets. To manage large numbers of scatter-site properties, large firms often focus on acquisitions of geographically dense portfolios of relatively new homes. As newer homes may be more similar to one another than older homes, this simplifies the processes of rehabilitation and maintenance. Digital technology, such as smartphones and online portals, enables digitally mediated landlord-tenant relations, search, rent collection and maintenance requests.

The literature on residential investors during the housing bust has been growing rapidly. There are three related papers on the influence of the rental sector setup on the housing boom-bust episode. Kaplan et al. (2020) model a competitive rental sector that owns and rents out housing units. These housing units of different sizes can be frictionlessly recombined into other housing sizes. The resulting equilibrium rental rate equals the user cost of housing. During a mortgage credit contraction, the rental sector acts as a stabilizing force on the house prices. Greenwald and Guren (2021) study a model with market segmentation between rental and owner-occupied property. They find that the extent to which credit insensitive agents absorb credit-driven demand is key to account for the observed effect of mortgage credit on house prices. Graham (2020) studies the factors that affect the housing demand of investors. He models both constrained household investors and an imperfectly elastic corporate rental firm with convex portfolio holding costs to account for variation in the house price response to a mortgage credit contraction. This paper expands on these two papers by providing a joint theory of household formation, dwelling allocation (as in Kaplan et al. (2020)), and property ownership (as in Graham (2020)). More specifically, the model of this paper features two types of dwellings, similar to Kaplan et al. (2020), and a corporate sector, similar to Graham (2020). The novelty here is the distinction between the two dwelling types (condos and houses) and the modelling of the corporate sector with free entry and constant returns to scale. This setup allows the model to capture the shift from owning to renting after a reduction in corporate costs for houses post-crisis.

The rest of the paper is organized as follows. In Section 2, I describe motivating evidence regarding the rise of institutional investors. Section 3 documents empirical evidence of reduced operating costs for institutions, together with evidence of larger firms post-crisis. Section 4 discusses the model setup. Section 5 discusses the calibration and the model's steady state. Section 6 presents the findings from the main numerical experiments during the housing bust. Section 7 concludes.

2 Motivating Evidence

The rise of institutional investors in the market for houses is documented using both housing stock and transaction data. First, I show that institutional investors own a rising share of rental houses. Second, transaction data show that institutions increased house purchases post-crisis. Third, I show that the market share of large institutional investors has grown.

2.1 Rental stock ownership

Institutions have increased their ownership of rental houses, both in terms of units and market share. This is documented using data from the Residential Finance Survey (U.S. Census Bureau: RFS, 2022) for 2001, the Rental Housing Finance Survey (U.S. Census Bureau: RHFS, 2022) for 2015 and 2018, and the American Community Survey (U.S. Census Bureau: ACS, 2022) for 2001, 2015, and 2018.[4]

The rental housing surveys are used to distinguish rental dwellings along two dimensions: the number of units in the same structure (1-4 units: houses vs. 5+ units: condos) and the ownership type (individual vs. non-individual investors).[5] The survey weights are used to compute the non-individual rental ownership share for both rental houses and condos. The non-individual housing stock is estimated by combining these rental ownership shares with the ACS rental survey weights by structure size.[6]

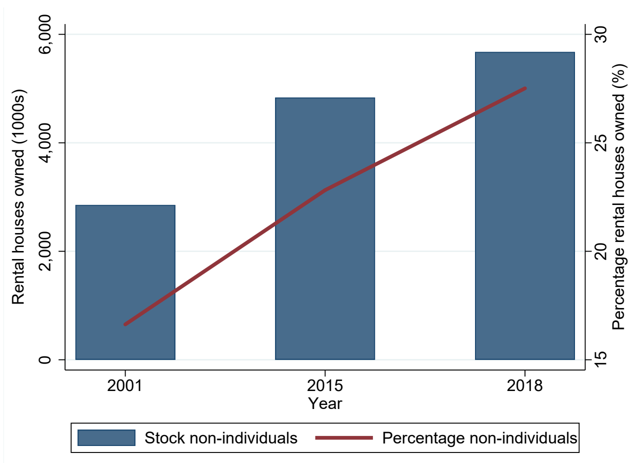


Figure 1: Ownership of rental houses from the RFS and the RHFS. Houses (1-4 units in structures). Used counts of total dwellings per structure size and rental share from the ACS.

Figure 1 shows that the non-individual stock of rental houses increased from 2.9 million

[4]The RFS and the RHFS collect data on the financial, managerial, and physical characteristics of rental properties nationwide. All three surveys used here are conducted by the U.S. Census Bureau.

[5]The individual investor includes joint ownership by two or more individuals, such as husband and wife, or by estate. In Appendix A, I show that the results are robust to alternative criteria for non-individual investors. In addition, I provide a detailed description of all data selection choices.

[6]Counts of total dwellings per structure size and the associated rental share are taken from the American Community Survey (2001, 2015, 2018). Ownership information (individual vs. non-individual) is taken from the Residential Finance Survey (2001) and the Rental Housing Finance Survey (2015, 2018). Appendix A shows that the rental stock of houses and condos held by non-individuals is even higher if I use only information from the RFS and RHFS.

in 2001 to 4.8 million in 2015, and to 5.7 million in 2018. The right y-axis shows that the percentage of rental houses held by non-individuals also increased, from 16.6 percent in 2001 to 22.8 percent in 2015 to 27.5 percent in 2018. In sum, while the stock of rental houses grew between 2001 and 2018, non-individuals owned an even larger share compared to individuals. The increase in rental house ownership by non-individuals has been large and persistent post-crisis. Using the RFS and the RHFS, rental houses can be split by year of construction. The increase in the rental housing stock owned by non-individuals is prevalent for both older and newer houses. Appendix A summarizes this information.

2.2 Housing purchase share

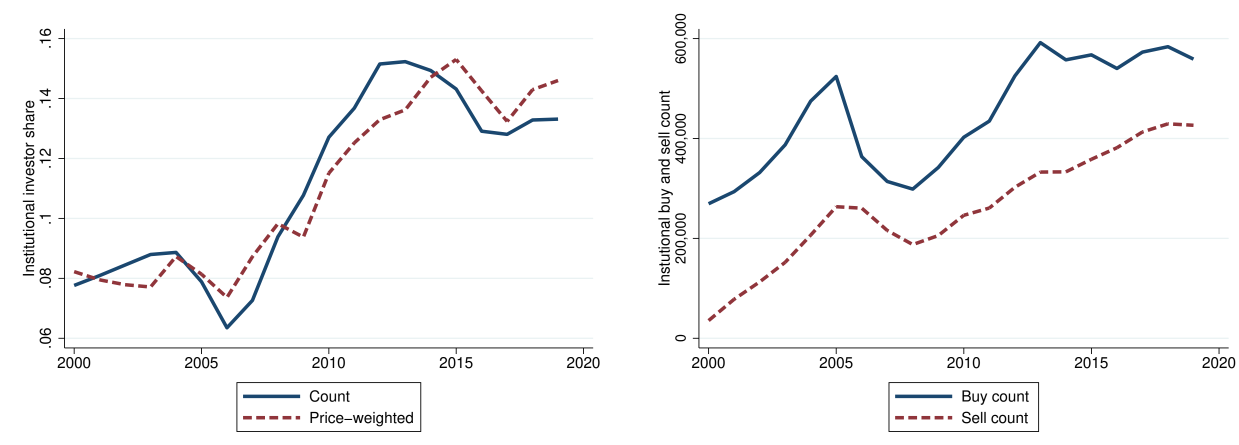
Next, I use transaction data to show that institutions increased house purchases after the Great Recession. The core data used in this analysis come from the Zillow Transaction and Assessment Dataset (ZTRAX). The database covers all ownership transfers as recorded by the counties' deeds in the United States. The database contains ownership transfers of residential properties, both multi-family and single-family properties. This analysis focuses on transactions between January 1st, 2000, and December 31st, 2019.

To identify institutional investors, I first define buyers as individuals if there is no non-individual name. Then, using the transaction records with a non-missing, non-individual name, I define institutional investors as legal partnerships, private companies, and trusts. Hence, I exclude builders/developers, government agencies, national and regional authorities, nonprofit organizations, homeowner associations, hospitals, universities, churches, airports, banks, thrifts, credit unions, relocation companies, living trusts and family trusts.[7] I exclude government agencies and nonprofit organizations because these agencies do not operate for profit and are often given incentives to transact during the crisis. Banks, thrifts, savings and loans companies, as well as credit unions are (for the most part) sellers in foreclosure and REO sales and therefore also not included. Finally, I treat living trusts as individuals. As I want to know the firm size distribution before and after the Great Recession, I match buyer address and buyer names to account for possibly misspelled buyer address records or name records. I explain this procedure in detail in Appendix B, in addition to the

[7] In this definition, I follow Lambie-Hanson et al. (2022) and Garriga et al. (2023).

categorization of the non-individual names to identify institutional investors.[8]

Figure 2 shows the increase in purchases by institutional buyers for dwellings with 1-4 units in the same structure. Panel (a) shows that the purchase share of institutional buyers for dwellings with 1-4 units in structure is increasing both in terms of unit count and in terms of price-weighted share (from 8 percent to 14 percent). The purchase share rises during the Great Recession and stays around that elevated level post-crisis. This observation aligns with the evidence in Section 2.1, indicating that the arrival of institutional investors is persistent. Panel (b) shows the number of units bought and sold over time by institutional investors, for dwellings with 1-4 units in the same structure. It is clear that the buy count in each year is larger than the sell count, so that institutional investors remain net buyers in all years post-crisis.



(a) Purchase share

(b) Buy and sell count

Figure 2: Market share institutional investors. Panel (a) shows purchase share by number of units and price-weighted (as fraction). Panel (b) shows the buy and sell count of institutional investors by year. Only dwellings with 1-4 units are used. Data from ZTRAX (Zillow, 2022).

2.3 Firm sizes

Last, I compare the distribution of firm sizes between the end of 2007 and the end of 2015 for dwellings with 1-4 units in structure. I categorize firms by sizes of 1 unit, 2-9 units and 10+ units. To compare firm sizes for existing firms between the end of 2007 and the end of 2015, I focus on a balanced panel of firms that held at least one dwelling at the end of both years.

[8]This matching procedure does not account for subsidiaries and therefore provides a lower bound for the market share of larger firms.

In addition, I record the firms that entered in between: firms that did not have a dwelling at the end of 2007 but did have at least one dwelling at the end of 2015. Table 1 reports the share of operating firms, the average size, and the market share for all three firm sizes for 1) firms at the end of 2007 that had at least one dwelling in 2015, 2) firms at the end of 2015 that had at least one dwelling in 2007, and 3) firms in 2015 without a dwelling in 2007.

		Firms existing in 2007 & 2015		New firms
		2007	2015	2015
1 unit	Share of operating firms (%)	81.3	78.7	73.5
	Market share (%)	44.9	37.0	33.3
	Average size	1.00	1.00	1.00
2-9 units	Share of operating firms (%)	17.1	19.3	24.2
	Market share (%)	28.4	27.9	34.6
	Average size	3.01	3.08	3.16
10+ units	Share of operating firms (%)	1.5	2.1	2.3
	Market share (%)	26.7	35.0	32.1
	Average size	31.55	36.28	31.21
Total	**Average size**	**1.81**	**2.12**	**2.21**

Table 1: Distribution of non-individual buyers over total unit categories 1, 2-9 and 10+ units, for dwellings with 1-4 units in structure. Data from ZTRAX (Zillow, 2022).

Table 1 shows that existing firms increased in size. More specifically, the share of operating firms of size 1 dropped from 81.3 percent to 78.7 percent between 2007 and 2015, with the market share falling from 44.9 percent to 37.0 percent. While the market share for smaller-sized firms fell, it was primarily the market share of larger firms (10+ units) that increased: from 26.7 percent to 35.0 percent. With the rise in market share, the share of operating firms and the average size in the 10+ units category also increased, from 1.5 percent to 2.1 percent and from 31.55 to 36.28, respectively.

New firms, those that had a dwelling with 1-4 units in structure at the end of 2015 but not at the end of 2007, also increased in average size. In particular, we see that the share of operating firms and the market share of 1 unit firms fell between 2007 and 2015. The highest rise in market share is visible in the size bin of 2-9 unit firms from 28.4 percent to 34.6 percent. However, the 10+ unit firms also saw an increase in market share from 26.7

percent to 32.1 percent. In total, the average size of firms existing in both 2007 and 2015 was 1.81 in 2007 and 2.12 in 2015. The average size of new firms (since 2007) was 2.21 in 2015. The data thus show that the firm size distribution shifted towards larger firms in 2015 relative to 2007, both due to existing firms increasing in size and the entry of larger firms post-crisis.

In Appendix C, I show that the firm size distributions are robust to both the choice to match on buyer name and the fuzzy matching algorithm on address. More specifically, even if I match firms based only on address or require an exact address match, there is a rise in market share for larger firms for both existing firms and new firms post-crisis.

3 Empirical Analysis

This Section shows that the operating-cost premium for institutional investors relative to homeowners fell from 44 percent in 2001 to 28 percent in 2015.

3.1 Operating costs

I study annual dwelling operating costs for different types of owners: owner-occupiers, individual investors and non-individual investors. Data for owner-occupied dwellings are from the American Housing Survey (U.S. Census Bureau: AHS, 2022) for the years 2001, 2015 and 2018. Rental dwellings data are from the RFS for 2001 and the RHFS for 2015 and 2018.[9]

Since the institutional share of rental houses in 2001 was only 16.6 percent, one can argue that institutions faced a cost disadvantage relative to mom-and-pop investors. Household investment has been heavily concentrated among buyers purchasing a single property (Graham, 2020), which is reflected in mortgage data: about 70 percent of mortgage borrowing associated with household investors accrued to those with two mortgages (for their primary dwelling and investment dwelling, Haughwout et al. (2011)). As mom-and-pop investors usually hold only one rental dwelling, they could maintain the property without incurring management costs. In contrast, institutional investors incur management (and

[9] A key aspect of the RFS in 2001 and of the RHFS in 2015 and 2018 is that the unit of reference is the property/structure itself, not the housing unit as in other surveys.

payroll) costs. With a small stock of rental houses, these management costs would constitute a large part of the total annual costs. Institutional investors historically focused on buying and renting out condos for which it is easier to reach a geographically concentrated minimum scale for efficiency. A higher geographically concentrated scale of operations could lower the institutional cost disadvantage for houses.

Operating costs for dwellings are defined as annual maintenance costs and management costs, plus the average annual improvement costs of owner-occupiers for 2005–2019. While maintenance and management costs are factored in for investors, only maintenance costs are used for owner-occupiers. I add the average annual improvement costs of owner-occupiers to all operating cost estimates and not to the reported dwelling specific improvement cost. This choice makes the resulting operating cost estimates more robust to outliers in the smaller samples of the RFS and the RHFS. Improvement costs are especially affected by outliers, as they occur more infrequently than routine maintenance costs.

The average annual improvement costs are \$2,406 in 2018 dollars for houses and \$1,245 for condos.[10] Appendix D provides more information on the datasets used. I use a linear regression to estimate the operating-cost gap between different owners, with the following indicator variables for individual and non-individual investors:

$$\begin{aligned} \ln Costs_{i,t} = {} & \beta_1 Mom\&Pop_i + \beta_2 Institution_i + \delta_1 Mom\&Pop_i \times \mathbb{1}_t + \delta_2 Institution_i \times \mathbb{1}_t \\ & + \alpha_t \mathbb{1}_t + \gamma_1 \ln P_{i,t} + \gamma_2 \ln P_{i,t} \times \mathbb{1}_t + \gamma_3 \ln P_{i,t}^2 + \gamma_4 \ln P_{i,t}^2 \times \mathbb{1}_t + \Gamma Controls + \epsilon_{i,t}, \end{aligned} \quad (1)$$

where the subscripts i and t denote survey record and year, $Mom\&Pop_i$ and $Institution_i$ are investor indicator variables, $\alpha_t \mathbb{1}_t$ capture year effects, and $\ln P_{i,t}$ controls for the dwelling's market value. The regression also contains time interactions of investor indicator variables.

The interaction effects of investor types with time t capture possible changes in the operating costs investors pay relative to owner-occupiers. The coefficients δ_1 and δ_2 capture how the operating-cost gap changes over time, and together with coefficients β_1 and β_2, they de-

[10] In addition, the average maintenance cost for houses using the same sample is \$874 in 2018 dollars. I truncate both the reported maintenance and the reported improvement costs at \$20,000 in 2018 dollars to calculate the weighted averages. The total average operating cost for houses of \$2,403 in 2003 dollars is close to other estimates in the literature. For instance, Davidoff (2004) found that households spent \$2,346 per year on maintenance and additions in 2003 dollars using the AHS 1985–2001, while Fisher and Williams (2011) found that households spent \$2,257 per year on maintenance and additions, using the Consumer Expenditure Survey for 1984–2005.

termine the predicted operating costs by investor type. I focus on operating costs for houses (1-4 units in structure), using the years 2001 and 2015. I do not use the survey weights.

Dependent variable: ln*Costs*	(1)	(2)	(3)	(4)	(5)
Mom&pop	0.228***	0.226***	0.250***	0.213***	0.207***
	(0.008)	(0.009)	(0.010)	(0.010)	(0.010)
Mom&pop x 2015	0.016	0.016	0.017	-0.009	- 0.001
	(0.021)	(0.021)	(0.022)	(0.022)	(0.022)
Institution	0.438***	0.436***	0.457***	0.356***	0.350***
	(0.023)	(0.023)	(0.024)	(0.024)	(0.024)
Institution x 2015	-0.159***	-0.158***	-0.146***	-0.129***	-0.114***
	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)
House value controls	Y	Y	Y	Y	Y
Structure size controls	N	Y	Y	Y	Y
Property tax controls	N	N	Y	Y	Y
Property manager control	N	N	N	Y	Y
Year purchased controls	N	N	N	N	Y
N	57,806	57,806	57,806	57,806	57,806
R^2	0.0902	0.0903	0.0963	0.1009	0.1054

This table reports regressions of log operating costs for houses on indicator variables for individual and non-individual investors, year fixed effects (2001 and 2015) and controls for the house value. The coefficients can be interpreted as operating-cost premium (%) relative to owner-occupiers. Data sources: AHS, RFS, and RHFS. Standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 2: Regressions of ln*Costs* on owner type: owner-occupier, individual investor and non-individual investor, including interaction effects with time. Use only the years 2001 & 2015.

Table 2 provides regression results for five regression specifications. First, the regression is estimated without controls. By running a regression on the logarithm of operating costs, with owner-occupiers in 2001 as base, the coefficients β_1 and β_2 represent the operating-cost premiums relative to owner-occupiers for, respectively, mom-and-pop investors and institutions in 2001. Using specification (1), the operating-cost premium in 2001 for mom-and-pop investors is 22.8 percent and for institutions is 43.8 percent. Using the interaction effects with the year 2015, the operating-cost premium for mom-and-pop investors is estimated to remain flat, while the operating-cost premium for institutions falls by 15.9 percentage points. This result is robust to the other regression specifications (2)-(5). For the second specification, I control for structure size: a categorical variable for 1 unit, 2 units, 3–4 units, 5–9 units, 10–19 units, 20–49 units and 50+ units in the same structure. The regression results show that the premium for individual investors relative to owner-occupiers remains stable from 2001 to 2015 (22.6 percent to 24.2 percent), but the premium for non-individual investors falls from 43.6 percent to 27.8 percent.[11] Third, I control for property taxes using the property tax categories that are publicly available in the RHFS. Given that the unit of reference in the RFS and the RHFS is the property itself (not the housing unit as in the AHS), with a different property tax categorization if there is more than one unit in the property, I interact the property tax variable with an indicator variable for more than one unit in the same structure.[12] Fourth, I control for employment of a property manager. Finally, I control for year purchased.[13]

Figure 3 shows the decline of the operating-cost premium for investors relative to owner-occupiers between 2001 and 2015, using regression specification (2). The fall in operating-cost premium for institutions was significant, and in 2015 the operating-cost premium difference between individual and non-individual investors became insignificant. Using the average owner-occupier operating costs of $3,090 in 2001 and $3,368 in 2015 (in 2018 dollars), the regression results in specification (2) predict that the non-individual operating costs fell from $4,436 to $4,304. In other words, the operating-cost gap between owner-occupiers and non-individual investors fell by 30 percent from $1,346 to $936, and the difference in operating costs between the two investor types is no longer statistically significant.

Robustness exercises are provided in Appendix E, where the same regression specifications are estimated including the data from 2018 and using the respective survey weights. While survey weights do not materially impact the estimated coefficients, including the survey year of 2018 shows a smaller reduction in operating costs in 2018 than in 2015 (-0.104 vs.

[11] The premiums can be calculated by adding up the investor coefficients with the time interactions for 2015.

[12] If there is 1 unit in the structure, the categories are 0, 1–999, 1,000–2,499, 2,500–4,999, 5,000–9,999, 10,000 or more. If there is more than 1 unit in the structure, the categories are 0, 1–999, 1,000–2,499, 2500–4,999, 5,000–9,999, 10,000–17,499, 17,500 or more. For the AHS, as this survey's unit of reference is a housing unit, I categorize the property taxes according to the rule of 1 unit in structure.

[13] The ten categories of year purchased are: 2016–2018, 2013–2015, 2010–2012, 2005–2009, 2000–2004, 1990–1999, 1980–1989, 1970–1979, 1969 or earlier, Unknown.

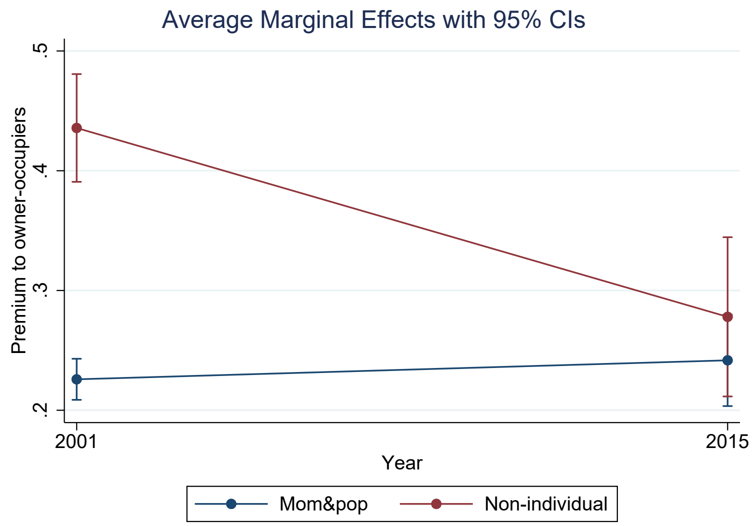


Figure 3: Premium in operating costs for investors relative to owner-occupiers for houses (dwellings with 1-4 units in structure). Operating costs are annual maintenance costs and management costs, plus the average annual improvement costs of owner-occupiers for 2005–2019. Sources: AHS for owner-occupiers and RFS (2001) & RHFS (2015) for investors. Regression specification (2).

-0.158) in specification (2). However, once more control variables are added, as in specifications (4) and (5), the investor interaction effects with year for 2015 and 2018 are the same. I also run the same regressions and robustness exercises for the operating costs of condos (5+ units in structure), which I use in the calibration exercise of Section 5.

4 Model

The goal of the model is to measure how the permanent reduction in house maintenance costs for institutions may have affected the housing market bust of the Great Recession and the subsequent recovery. For that purpose, and in line with the existing literature such as Kaplan et al. (2020) and Graham (2020), I build a discrete-time heterogeneous-agents life-cycle model of the housing market. I model two types of investors: individual (mom-and-pop) and non-individual (institutional) investors, and two types of dwellings: condos and houses. The key experiment is to perturb the initial steady state with a Great Recession shock, with and without the reduction in corporate costs for houses. The reduction in house maintenance costs lowers the house rental rate and thus raises demand for houses, raising prices. While moderating the housing bust magnitude could be advantageous for homeowners, renters have to trade off the lower rental rate with a rise in house prices while facing credit constraints.

Dwellings can be owned by the corporate rental sector, homeowners, or mom-and-pop investors. Households make endogenous rental, homeownership, and housing investment decisions in a housing market with two types of dwellings: condos and houses. Rental dwellings are supplied by mom-and-pop investors and the corporate rental sector. Both homeowners and mom-and-pop investors have access to long-term mortgages, while the corporate sector can borrow at the risk-free rate. Equilibrium dwelling prices equate total rental and ownership demand by households and the corporate sector with the dwelling supply by the construction sector.

Maintenance costs differ between dwelling owners. Homeowners face the lowest maintenance costs for both dwellings. They could draw the technology to buy and maintain a second dwelling, becoming mom-and-pop investors. The corporate rental sector features constant returns to scale and free-entry, and draws dwelling maintenance costs from a cost distribution above the costs of mom-and-pop investors. Both investor types pay rental income taxes but can deduct depreciation expenses from their tax bill due.

4.1 Households

Demographics Households are finitely-lived, with age indexed by $j \in [1, ..., J]$. Households work from period 1 to $J_{ret} - 1$, after which they are retire at age J_{ret}. All households die with certainty at age J.

Preferences Household preferences are defined over non-durable consumption c, housing services s, and end-of-life bequests of wealth w. Bequests are used to capture the pattern of homeownership in old ages. Expected lifetime utility is given by

$$\mathbb{E}\bigg[\sum_{j=1}^{J} \beta^{j-1} u(c_j, s_j) + \beta^J v(w_{J+1})\bigg]. \tag{2}$$

Period utility is given by

$$u(c, s) = \frac{(c^{\alpha_u} s^{1-\alpha_u})^{1-\rho_u}}{1-\rho_u}, \tag{3}$$

where α_u is the share of consumption in non-housing services, c is the consumption of non-housing services, and s is the consumption of housing services. The bequests function $v(\cdot)$ describes a bequest motive defined over net worth remaining at the end of life w_{J+1}, as in De Nardi (2004):

$$v(w) = \psi \frac{(w + \underline{w})^{1-\rho_u}}{1-\rho_u}, \tag{4}$$

where w is the size of the bequest, ψ is the strength of the bequest motive, and $\underline{w}$ proxies for the luxuriousness of bequests.

Endowments Households receive endowment income during working life and a Social Security benefit during retirement. Working-age households receive an idiosyncratic income y_j^w given by

$$\log y_j^w = \log \Theta + \chi_j + \epsilon_j,$$

where Θ can be viewed as an index of aggregate productivity, χ_j is a deterministic age profile that is common to all households, and ϵ_j is an idiosyncratic component that follows a first-order Markov process. The replacement rate of income during retirement is a fraction ρ_{ss} of $y_{J_{ret}}^w$, the realization of earnings received in the final period of working life. Households are born with initial wealth that is correlated with the initial productivity y_1^w.

Liquid Assets A household can save, but not borrow, in a liquid asset a. The rate of return to savings in the mutual fund is r', which will be specified later. It is the return of a mutual fund that owns all corporate purchases and mortgages in the economy in addition to some foreign net asset position at fixed interest rate r^*. Obviously, in steady state, $r' = r^*$.

Housing Households consume housing services by living with their parents, renting or owning a dwelling. In addition, households may purchase dwellings for the purposes of investment, but they must own a primary dwelling before purchasing an investment dwelling. Dwellings are characterized by their sizes and belong to the finite set $\mathcal{H} = \{h_{\text{par}}, h_c, h_h\}$, where $h_{\text{par}} < h_c < h_h$. The smallest dwelling size h_{par} can be consumed only by the young (with $j \leq 5$, ages 22-31), as they have the option to free-ride (i.e. living with their parents). By allowing the young to live with their parents, the household formation rate is endogenous.[14] The other dwellings, h_c (condos) and h_h (houses), can be rented or purchased.

If a household rents, it has to pay the per rental unit prices of r_c and r_h, respectively. Renting generates housing services one for one with the size of the house, that is, $s = h$. In case a household purchases a dwelling, condos and houses can be purchased at the per-unit price of P_c and P_h, respectively. The primary dwelling is denoted as h^o. To capture the fact that there may be additional utility from homeownership, I assume that an owner-occupied house generates $s = \omega h$ units of housing services, with $\omega \geq 1$. Absent from the proportional transaction costs of buying f_b and selling f_s and fixed selling costs F_s, markets for rental and owner-occupied housing are both frictionless and competitive, meaning that buying or selling does not take time and that the law of one price holds for each dwelling type.

Each owner of dwellings has to pay property taxes and maintenance costs. Property taxes are in proportion to the dwellings' value: $\tau_p P_i h_i$, $i \in \{c, h\}$. Homeowners pay a per-period maintenance cost in proportion to dwelling size of δh_i, where $i \in \{c, h\}$, which fully offsets the physical depreciation of the dwelling δh_i. Homeowners could draw the technological opportunity $\underline{\phi}$ to buy a second dwelling h^{mp} and become a mom-and-pop investor. More specifically, each period homeowners draw a persistent per-unit second dwelling maintenance cost $\phi \in \{\underline{\phi}, \overline{\phi}\}$, determining jointly with their age, assets and income whether or not to buy an investment dwelling. This second dwelling maintenance cost is strictly above the dwellings' true maintenance costs δ, and its distribution differs by dwelling type. This higher cost represents additional maintenance and management costs associated with renting property to non-owner occupying tenants, as documented in Section 3.1. The maintenance cost draws for second condos are $\underline{\phi}_c$ and $\overline{\phi}_c$, and for second houses, the draws are $\underline{\phi}_h$ and $\overline{\phi}_h$. I model the maintenance cost draws as a two-point Markov chain.[15]

[14]There are two reasons for modelling a free-riding option for households. First, the monthly Current Population Survey shows that 40 percent of young people (18-30), who are not in high school or college, lived with an older person (31-65) between 1990–2008. After the Great Recession, this fraction rose to 46 percent. My estimate of an increase of 6 percentage points conforms with the estimate of Dyrda et al. (2019), who also document an increase of more than 5 percentage points. This observation relates to the fall in the household formation rate (Furlong, 2016). Including a free-ride option allows me to capture this full array of choices of young households and how it changed post-crisis. Second, as the average household size rose after the Great Recession, the homeowership rate based on the observed number of households only provides a lower bound of the true shift away from owning a house, both towards renting and living with parents longer.

[15]The Markov chain transition matrix parameters are $\Pi^c_{\underline{\phi},\underline{\phi}}$, $\Pi^c_{\underline{\phi},\overline{\phi}}$, $\Pi^c_{\overline{\phi},\underline{\phi}}$, $\Pi^c_{\overline{\phi},\overline{\phi}}$ for condos. For houses, the

New homeowners start with a high second dwelling maintenance cost draw: $\phi = \overline{\phi}$.

Each period, mom-and-pop investors get rental income at rental rate $r_i h_i$, where $i \in \{c, h\}$. While all household owners of dwellings pay property taxes and maintenance costs, only investors can write off the depreciation and maintenance costs from their rental income taxes due. More specifically, mom-and-pop investors receive net rental income of $(r_i h_i - \phi_i h_i - \tau_p P_i h_i)(1 - \tau_{hi}) + \tau_{hi} m_\tau P_i h_i$, where the last term is the tax write-off for the depreciation of the second dwelling owned.

To create turnover in ownership, owners are subject to a persistent idiosyncratic mismatch shock ($\gamma = 1$), lowering the households' housing services enjoyed from an owned dwelling to the level of living with their parents. New buyers always start without mismatch shock ($\gamma = 0$). I model the mismatch shock as a two-point Markov chain.[16]

Mortgages To finance purchases of dwellings, households can use mortgage debt. A single mortgage is used to finance all dwelling purchases by households. Mortgages are (i) long-term, (ii) paid in advance unless the mortgage is refinanced or dwellings are sold and the mortgage is repaid, (iii) subject to a fixed F_o origination cost, and (iv) amortized over the remaining lifetime of the buyer at mortgage interest rate $r_b > r^*$.

Let b be the outstanding mortgage balance. At age j, the current payment is:

$$\pi_j(b, r_b) = \frac{r_b(1 + r_b)^{J-j+1}}{(1 + r_b)^{J-j+1} - 1} b.$$

This payment is fixed over the life of a household, conditional on not refinancing the mortgage. Given the payment-in-advance structure, the end-of-period mortgage balance reflects the added interest to the previous mortgage balance, minus the mortgage payment: $b' = (1 + r_b)b - \pi_j(b, r_b)$. When a household refinances, buys a dwelling, or sells a dwelling while remaining a homeowner, a new mortgage is originated. At origination, mortgages are subject to a maximum loan-to-value (LTV) ratio constraint and a payment-to-income (PTI) constraint. First, the LTV ratio constraint requires that the initial mortgage balance b must

Markov chain transition parameters are $\Pi^h_{\underline{\phi},\underline{\phi}}$, $\Pi^h_{\underline{\phi},\overline{\phi}}$, $\Pi^h_{\overline{\phi},\underline{\phi}}$, $\Pi^h_{\overline{\phi},\overline{\phi}}$.

[16] The Markov chain parameters for this shock are $\gamma_{0,0}, \gamma_{0,1}, \gamma_{1,0}, \gamma_{1,1}$.

be less than a fraction λ_{LTV} of the total value of the dwellings owned:

$$b \leq \lambda_{LTV}(P_i h_i^o + P_j h_j^{mp}),$$

where both $i \in \{c, h\}$ and $j \in \{c, h\}$. Second, the PTI constraint requires that the fixed mortgage payments $\pi_j(b, r_b)$ must be less than a fraction λ_{PTI} of the total labor income:

$$\pi_j(b, r_b) \leq \lambda_{PTI}\, y_j^w(\epsilon).$$

When a new mortgage is originated, households are required to pay origination costs, as in Graham (2020). There is a fixed cost, F_o, which is paid regardless of the size of the mortgage. These fixed costs reflect origination fees associated with new mortgages.

4.1.1 Household decision problems

Figure 4 provides an overview of the household decision problems. A full description of the recursive nested household problems can be found in Appendix F.

A household at the beginning of a period can be a non-owner, an owner or a mom-and-pop investor. During the period, there are three subperiods: the selling step, the tenure step and the dwelling step. This nested setup allows me to introduce extreme value shocks in the tenure and dwelling steps, while preserving independence of irrelevant alternatives. The idiosyncratic shock realizations — i.e. the income shock, the mismatch shock and the maintenance technology shock — are observed at the start of a period, before the selling stage.

A household that starts the period as a non-owner has no dwelling to sell in the first subperiod but has to make a tenure choice in the second subperiod. The household can choose to free-ride, rent, or buy a dwelling. Those who keep renting can then choose the dwelling type to rent, the quantity of nondurable goods to consume, and how much to save in the liquid asset. Those who choose to buy a dwelling have to choose the dwelling they want to buy instead of rent, together with the mortgage debt to take on. When a dwelling is purchased, the household has to pay mortgage payments, maintenance costs and property taxes. The mortgage debt at origination is subject to the LTV and PTI constraints.

A household that starts the period as a homeowner first has to decide whether to sell its primary dwelling or not. If it decides to stay (i), it can decide to (i.a) not adjust, (i.b) refinance, or (i.c) buy a second dwelling. In case of choice (i.c), the homeowner receives after-tax rental income net of maintenance costs and property taxes and a tax write-off due to depreciation of the dwelling. If it decides to sell (ii), it can decide to (ii.a) free-ride, (ii.b) rent, or (ii.c) buy a new primary dwelling. If the household chooses to rent or buy in the second subperiod, at the end of the period it has to make a dwelling choice.

A household that starts the period as a mom-and-pop investor first decides to stay or sell its second (investment) dwelling. If it keeps (i) the second dwelling, it can decide to (i.a) not adjust, (i.b) refinance or (i.c) move primary dwelling. In any of these three cases, the mom-and-pop investor gets after-tax rental income net of maintenance costs and property taxes and a tax write-off due to depreciation of the dwelling. If it decides to sell (ii) the second dwelling, it can decide to (ii.a) not adjust, (ii.b) buy a new second dwelling, or (ii.c) move primary dwelling. If the household chooses to rent or buy in the second subperiod, at the end of the period it has to make a dwelling choice.

The problem of the non-owner is discussed here, whereas the problems of the owner and the mom-and-pop investor are discussed in Appendix F.

The non-owner decides whether to live with their parents, rent or buy.

$$\bar{\boldsymbol{V}}_j^{no}(a,\epsilon) = \max\{V_j^p(a,\epsilon), \bar{V}_j^r(a,\epsilon), \bar{V}_j^b(a,\epsilon)\}, \tag{5}$$

where $\bar{\boldsymbol{V}}_j^{no}$ is the total value function of a non-owner, V_j^p is the value function of a non-owner that chooses to live with their parents, $\bar{V}_j^r$ is the value function of a non-owner that chooses to rent, and $\bar{V}_j^b$ is the value function of a non-owner that chooses to buy.

Those who choose to live with their parents consume housing services $h_{parents}$, consume non-durable goods, and save in liquid assets. All agents get a lump-sum transfer T. Non-owners at age j who decide to live with their parents solve:

$$\begin{aligned} V_j^p(a,\epsilon) &= \max_{c,a'} u(c,s) + \beta E[\bar{\boldsymbol{V}}_{j+1}^{no}(a',\epsilon')] \\ s.t.\quad & c + a' \leq a(1+r) + y(\epsilon) + T, \\ s &= h_{parents}. \end{aligned} \tag{6}$$

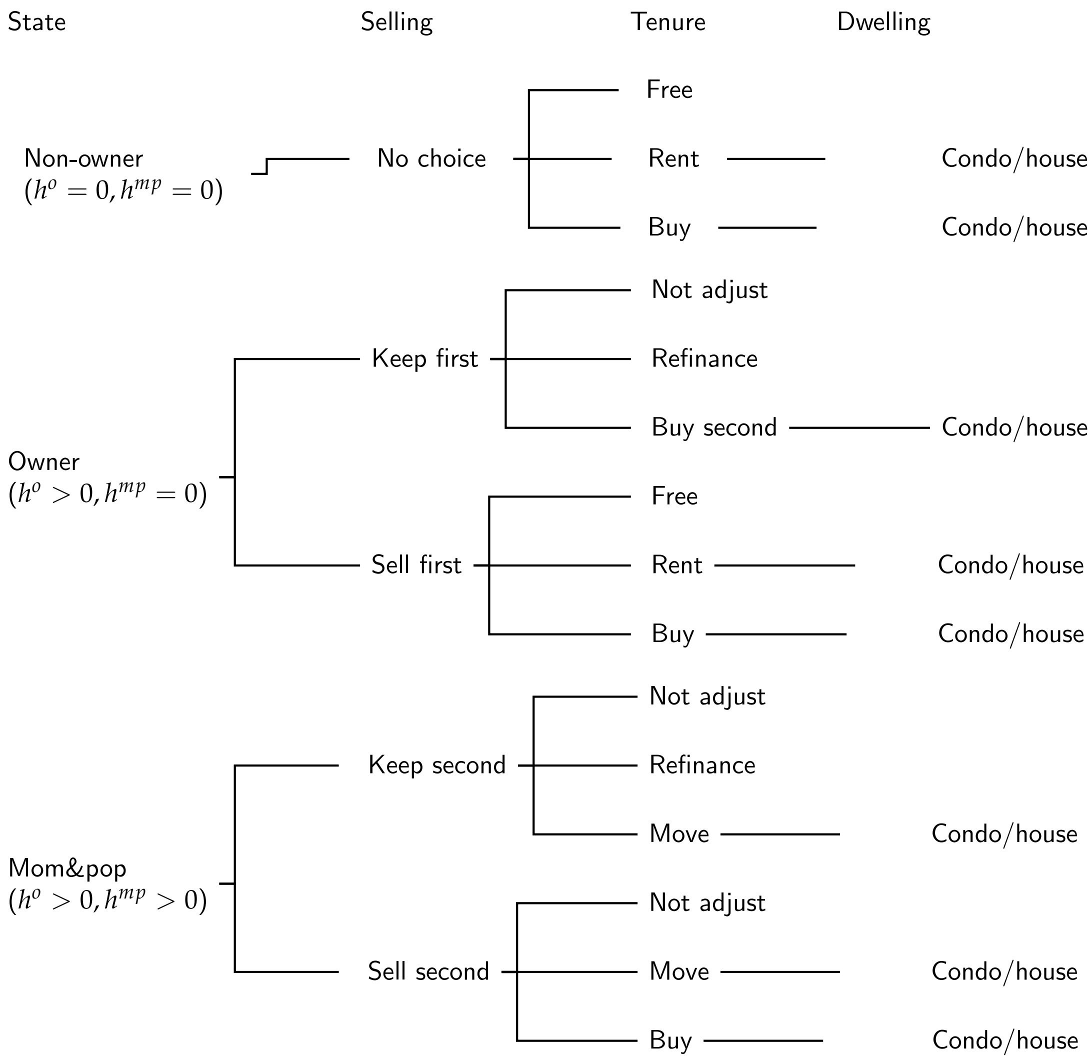


Figure 4: Household decision problem overview

Those who choose to rent have to choose the dwelling type $i \in \{c, h\}$, consume non-durable goods, and save in liquid assets. Non-owners at age j who decide to rent solve:

$$\bar{V}^r_j(a, \epsilon) = \max_{i \in \{c,h\}} V^r_{j,i}(a, \epsilon), \tag{7}$$

$$V^r_{j,i}(a, \epsilon) = \max_{c,a'} u(c, s) + \beta E[\bar{\boldsymbol{V}}^{no}_{j+1}(a', \epsilon')] \tag{8}$$

$$s.t. \quad c + r_i s + a' \leq a(1 + r) + y(\epsilon) + T,$$

$$s = h_i.$$

Those who choose to buy have to choose the dwelling type $i \in \{c, h\}$ to buy, originate a new mortgage, pay mortgage payments, pay maintenance costs and property taxes, consume non-durable goods, and save in liquid assets. Non-owners at age j who decide to buy solve:

$$\bar{V}_j^b(a,\epsilon) = \max_{i\in\{c,h\}} V_{j,i}^b(a,\epsilon), \tag{9}$$

$$V_{j,i}^b = \max_{c,a',b} u(c,s) + \beta E[\bar{\boldsymbol{V}}_{j+1}^o(a',\epsilon',\phi',b',h_i^o,0,\gamma')] \tag{10}$$

$$s.t. \quad c + h_i^o[(1+f_b)P_i + \delta + \tau_p P_i] + a' + \pi_j(b,r_b) \le a(1+r) + y(\epsilon) + b - F_o + T,$$

$$b' = (1+r_b)b - \pi_j(b,r_b), \;\; b \le \lambda_{LTV} P_i h_i, \;\; \pi_j(b,r_b) \le \lambda_{DTI} y(\epsilon),$$

$$s = \omega h_i^o, \;\; \phi = \overline{\phi}, \;\; \gamma = 0.$$

4.2 Corporate rental sector

There is a corporate rental sector that owns and rents out condos and houses to households. The corporate rental sector cannot perform maintenance itself. It has to hire a management company, which implies dwelling maintenance costs are higher than those for homeowners and mom-and-pop investors. For both condos and houses, there is an infinite mass of firms with constant returns to scale that all draw a maintenance cost and can buy up to one dwelling.[17] For condos, firms draw maintenance cost m_c from the distribution $G_c(\cdot)$, while for houses, firms draw maintenance cost m_h from the distribution $G_h(\cdot)$.

To simplify the explanation of the corporate sector, I focus on houses only, but the same logic applies for condos. All houses purchased by the corporate rental sector differ in the associated m_h draw, but are otherwise identical. Each period the m_h distribution of all houses owned by the corporate sector evolves following the transition matrix $\tilde{G}_h(\cdot)$. Each period every corporate house can be kept or sold. The house price and rental price are summarized as p. There are two possible reasons for a corporate rental house to be sold: either the current maintenance draw is too high, or the house and its manager get hit with a suitability shock δ_{exit} that affects a constant fraction of corporate housing inventory. If the house is kept, the corporate rental house provides after-tax cash flow of $\pi(m_h;p) = (r_h h_h - m_h h_h - \tau_p P_h h_h)(1-\tau_{ci}) + \tau_{ci} m_\tau P_h h_h$, where τ_{ci} is the corporate rental tax rate. The house provides cash flow of the rental income minus maintenance costs and property taxes, net of corporate income taxes, plus a depreciation tax write-off in proportion m_τ to the house value. If the house is sold, the house provides sale proceeds of $P_h h_h$.

[17] By using constant returns to scale, I do not have to keep track of a firm size distribution.

As the corporate house value is linear in the house size h_h, I define the corporate house value as the shadow price per unit of house size, given m_h:

$$\Pi_h(m_h;p) = \max_{g_{sell}\in\{0,1\}} (1-\delta_{exit})(1-g_{sell})V_{stay}(m_h;p) + (\delta_{exit} + (1-\delta_{exit})g_{sell})V_{exit}(p), \tag{11}$$

$$V_{stay}(m_h;p) = (r_h - m_h - \tau_h P_h)(1-\tau_{ci}) + \tau_{ci} m_\tau P_h + \frac{1}{R} E\Big[\Pi_h'(m_h';p')\Big], \tag{12}$$

$$V_{exit}(p) = P_h. \tag{13}$$

Define m_h^{*stay} as the highest m_h for which $g_{keep} = 1 - g_{sell} = 1$. For the marginal stayer, it holds that $\Pi_h(m_h^{*stay};p) = P_h$.

To finish the corporate rental sector setup, the free-entry condition is:

$$V^E(p) = \int_{m_h} \max\{\Pi_h(m_h;p)h_h - P_h h_h(1+f_b), 0\} dG(m_h) - c_E P_h h_h = 0. \tag{14}$$

Firms enter the market until the expected zero-profit condition is satisfied, only drawing m_h after paying the entry cost. Firms can leave within the period they enter. Let the decision to buy a house after drawing be denoted by $g_{enter} \in \{0,1\}$. Given the cost c_E and the proportional buying costs f_b, the maximum cost to enter is below the maximum cost to stay: $m_h^{*stay} > m_h^{*enter}$. With exogenous exit δ_{exit}, the marginal decision for the corporate sector is made by the marginal buyer and not the marginal stayer.

4.3 Construction sector

The competitive construction sector operates the CES production technology for both types of dwellings separately: $I_i = \left[\gamma_h (I_i^s)^\rho + (1-\gamma_h)(L_{i,avail})^\rho\right]^{1/\rho}$, with $\rho \in (0,1)$ and $i \in \{c,h\}$, where $L_{i,avail}$ is the the leftover land that can be used for new housing construction and I_i^s is the investment in structures by the construction sector. Given that a fraction δ of dwellings get destroyed each period, the dwelling stocks evolve according to: $H_{i,t} = (1-\delta)H_{i,t-1} + I_i$, with $i \in \{c,h\}$.[18] The production factor land $\bar{L}_i$, $i \in \{c,h\}$ is in fixed supply and comes in

[18]Other maintenance costs than δ represent management expenses for rental dwellings.

different sizes for condos and houses. The leftover land $L_{i,avail} = \bar{L}_i - (1-\delta)H_{i,t-1}$ can be used for investment each period. The construction sectors solve the following problem:

$$\max_{I_i^s} P_i \left[\gamma_h (I_i^s)^\rho + (1-\gamma_h)(L_{i,avail})^\rho \right]^{1/\rho} - a I_i^s - p_L L_{i,avail}, \tag{15}$$

where $i \in \{c, h\}$. The resulting optimality condition states that

$$P_i \gamma_h (I_i^s)^{\rho-1} \left[\gamma_h (I_i^s)^\rho + (1-\gamma_h)(L_{i,avail})^\rho \right]^{\frac{1-\rho}{\rho}} = a. \tag{16}$$

4.4 Mutual fund

The representative risk-neutral mutual fund owns the corporate rental sector and all mortgages given to households. On the liabilities side, all household savings are aggregated in this mutual fund. To equate the liabilities and assets of the mutual fund, it has an international asset position B, ensuring the clearing of intertemporal savings.

The total amount of liquid assets by households in the economy is

$$L^+ = \int a'(a, \epsilon, \phi, b, h^o, h^{mp}, \gamma) d\mu, \tag{17}$$

and the total amount of mortgages by households in the economy is

$$L^- = \int b'(a, \epsilon, \phi, b, h^o, h^{mp}, \gamma) d\mu. \tag{18}$$

The net foreign asset position or holding in the international bond is the excess of the mutual fund's liabilities over its assets:

$$B = L^+ - \left(\tilde{F} + \frac{1}{1+r^*} L^- \right), \tag{19}$$

where

$$\tilde{F} = \int_{i \in \{c,h\}} \left(\int_{m_i} \Pi_i(m_i; p) h_i d\mu([0, m_i^{*stay}]) - \int_{m_i} \pi(m_i; p) d\mu([0, m_i^{*stay}]) - \int_{m_i} P_i h_i d\mu([m_i^{*stay}, \infty]) \right), \tag{20}$$

represents the (ex dividend and sales) present value of all corporate dwellings, after entry.

The ex-post return of the mutual fund r' is the return on its assets plus the new value of its dwelling stock, divided by its liabilities. The ex-post return can then be written as:[19]

$$1 + r' = \frac{F' + (1 + r^*)B + L^-}{L^+}, \tag{21}$$

where F is the value of the corporate sector, before entry of new firms.

4.5 Government

The government collects property tax τ_p in proportion to the value of a dwelling. In addition, the government obtains rental income tax at rate τ_{hi} from mom-and-pop investors and rate τ_{ci} from the corporate sector. Both types of investors can write off the depreciation from their rental income taxes. All revenues are redistributed lump sum with a tax refund T.

4.6 Equilibrium and solution method

The solution of the model consists of general equilibrium for the markets for condos and houses. More specifically, the prices P_c and P_h are such that markets clear: the dwelling demand from homeowners, mom-and-pop investors and corporate investors is satisfied by the supply of dwellings. Similarly, the rental prices are such that total rental demand by dwelling equals total rental supply, provided by mom-and-pop and the corporate sector. As households can choose to live with their parents, the house price and rental price are determined jointly. In equilibrium the return of the mutual fund r' equals the fixed interest rate r^*. Appendix G contains a formal definition of the recursive competitive equilibrium.

To solve the equilibrium, I use the nested endogenous grid method as developed by Druedahl (2021). Appendix H provides more details on the algorithm for computing equilibrium, and a description of the solution method.

5 Calibration and Steady State

The model is calibrated to capture features of the U.S. housing market in 2007, prior to the housing bust. Part of the model parameters are assigned externally, without solving the

[19] While ex-ante it is expected that $r' = r^*$, any ex-post losses are absorbed by savers through the ex-post return on their liquid assets.

model equilibrium. The remaining parameters are chosen to minimize the distance between a chosen set of equilibrium moments and their data counterparts (calibrated internally).

5.1 External calibration

First, I discuss the model parameters I calibrate to data moments, without solving the model. Table 3 summarizes these parameter values.

Demographics The model period is two years. Households enter the model at age 22, retire at age 66 (corresponding to $J^{ret} = 23$) and live until age 82 (corresponding to $J = 30$).

Preferences I set $\rho_u = 2$, which implies an elasticity of intertemporal substitution of 0.5. I use the consumption expenditures equivalence scale $\{ej\}$ to reproduce the McClements (1977) scale, a commonly used consumption equivalence measure in the literature. I set the utility-benefit from owner-occupied housing relative to rental housing, ω, at 1.05, following Kaplan et al. (2020). This choice translates into a consumption-equivalent gain from owning for the median working-age home owner of 0.54 percent, which is slightly above the implied consumption-equivalent gain from owning for the median home owner of around half a percentage point as used by Kaplan et al. (2020).[20]

Endowments The deterministic age-specific component of earnings $\{\chi_j\}$ comes from Hansen (1993). The stochastic component of earnings ϵ_j is modeled as an AR(1) process in logs with annual persistence of 0.97, and annual standard deviation of innovations of 0.2, following Kaplan et al. (2020). This process is discretized into a three-state Markov chain using the Tauchen and Hussey (1991) procedure. The aggregate level of income, Θ, is set to 1. The median annual household income is set to \$52,000, following the 1998 Survey of Consumer Finances (Board of Governors of the Federal Reserve System: SCF, 2022). The choices above imply that one unit in the model equals \$58,000. The initial wealth endowments are chosen to match the distribution of net worth for young households in the SCF 2007. More

[20]The consumption equivalent gain of owning is calculated relative to selling and becoming a non-owner, without incurring selling transaction costs.

specifically, I split households of age 22-23 into three earnings bins, and within each bin keep only the households with strictly positive net worth, along with their median net worth values. The corresponding median net worth values are then scaled by the median earnings in that earnings bin. I compute the standard deviation and the mean of that ratio for each bin. Liquid assets for newborns in each income bin are then allocated by drawing bequests from a normal distribution with the observed bin-specific standard deviation around its mean net worth ratio, rescaled with the initial income draw of households in the model. I do not allow negative initial assets.

Financial parameters The risk free rate r^* is set at 2.0 percent per annum, to match the real rate on the 10-year Treasury Bills reported by the FRED for 2005-2007 (Federal Reserve Bank of Cleveland: REAINTRATREARAT10Y, 2022). The mortgage rate markup is 1 percent per annum, matching the real rate on 30-year fixed-rate mortgages for 2005–2007 (Freddie Mac: MORTGAGE30US, 2022; U.S. Bureau of Labor Statistics: CPIAUCSL, 2022). The mortgage origination cost F_o is set at 0.0207, or \$1,200 in the model, as in the boom of Kaplan et al. (2020). This origination cost corresponds to the sum of application, attorney, appraisal and inspection fees. The cost of refinancing F_{refi} is set at 0.0345 (\$2,000 in the model), following Wong (2019). The maximum LTV and PTI ratios are set to 0.90 and 0.50, respectively, consistent with mortgage originations during the boom (Greenwald, 2018).

Housing transaction costs and stock I set the transaction cost of buying a dwelling for households and corporate firms, f_b and $f_{b,corp}$, at 5 percent of the dwelling value, in line with Wong (2019). In terms of selling costs, the proportional transaction cost of selling a dwelling f_s is set at 7 percent of the dwelling value, a value taken from Gruber and Martin (2003). The fixed cost of selling F_s is calibrated to be \$7,000, corresponding to the sum of cleaning, staging, landscaping, home improvement, marketing costs, pre-inspection, and professional photos costs (Zillow (2022)).[21] Next, I set the initial steady-state housing stocks $\{H_{\text{parents}}, H_f, H_h\}$. The dwelling stock H_{parents} is set such that 40 percent of households with age less than or equal to 30 live with their parents, as recorded in the Current Population

[21] Other examples can be found at https://www.zillow.com/sellers-guide/costs-to-sell-a-house/

Survey (U.S. Census Bureau: CPS, 2022) between 1990–2008. Then, the households who do decide to rent or own have an inventory of 18.25 percent of flats and 81.75 percent of houses, calibrated to the values of the American Community Survey (2001). The construction sector's production technology is set to its Cobb-Douglas version by setting $\rho \to 0$. This choice implies that the housing supply price elasticity equals $\frac{1}{1-\gamma_h}$. I normalize the marginal cost of building structures a to 1. Then, the construction technology parameter γ_h is set to $1/3$ to obtain a price elasticity of housing supply of 1.5, the median value across MSAs estimated by Saiz (2010). Given the equilibrium dwelling prices, the construction sector's maximization problem, and the dwelling stocks in the initial steady state, the required total land stock by dwelling type can be backed out to achieve a steady state. These total land stocks remain unchanged during the transition and other steady states.

Maintenance cost and sizes The depreciation rate of the stock of dwellings, δ, is set to 2.3 percent per annum (U.S. Bureau of Economic Analysis, 2022).[22] I set the size of houses h_h to match the annual house operating costs for homeowners of \$3,090 found in the AHS 2001. Then, I use the ratio of house size to condo size of 1.64 from the AHS 2005 to set h_c. The maintenance costs for mom-and-pop households $\underline{\phi}_h$ and $\underline{\phi}_c$ are calibrated to the operating-cost premium over δ in regression specification (2) for houses and condos, respectively, as documented in Section 3.1 and Appendix E. I normalize the high maintenance cost for mom-and-pop investors to be $\overline{\phi}_h = 1$ and $\overline{\phi}_c = 1$. The corresponding Markov chain transition probabilities are calibrated internally.

The maintenance costs for institutions for condos and houses are modeled as an AR(1) process in logs with an annual persistence ρ_m and an annual standard deviation of innovations of σ_{mc} for condos and σ_{mh} for houses. For both condos and houses, I set the annual persistence ρ_m to a value of 0.975. Once I set the persistence parameter, I can calibrate the standard deviation of the AR(1) process to match the observed standard deviation in the data. Given the focus on houses in this paper, I set the standard deviation of innovations

[22] This estimate is taken from the U.S. Bureau of Economic Analysis (BEA). More specifically, it is the depreciation (current cost) divided by the net stock (current cost), of private residential fixed assets. See https://apps.bea.gov/national/FA2004/Details/Index.htm. This estimate is close to the depreciation rate of 2.5 percent found by Harding et al. (2007).

for condos, σ_{mc}, to 0.001. This choice also reflects the fact that institutions have had a high market share in renting apartments for decades, so one would expect a low dispersion of corporate efficiency. For houses, once the persistence ρ_m has been fixed, I calibrate σ_{mh} to the residual variance of the logarithm of the institutional operating costs in the data of 2001. The residual variance of institutional house operating costs is computed as the variance after controlling for the observables of regression specification (2) in Section 3.1.[23] I find that the residual standard deviation is 0.38, which results in $\sigma_{mh} = 0.1637$.[24] I truncate the maintenance costs from below at δ for condos and at $\underline{\phi}_h$ for houses, reflecting that empirically the cost premium for rental is lower for condos than for houses.

The maintenance costs for the corporate rental sector are centered at μ_{mc} for condos and μ_{mh} for houses. While I calibrate the value of μ_{mc} externally, I calibrate the value of μ_{mh} internally to match the empirical operating-cost gap of $1,345 in Section 3.1. I calibrate μ_{mc} to the average maintenance costs premium for condos for non-individual investors relative to δ in regression specification (2) in Section 3.1 and in Appendix E. More specifically, I set $\mu_{mc} = 0.0635$. I use the Tauchen method to discretize the corporate cost grids in 4000 points. At last, I set the corporate suitability shock parameter δ_{exit} to 0.2, based on the annualized fraction of houses sold by institutional investors of 0.205 for 2001–2019 (Zillow, 2022).

Taxation The property tax τ_p is set to 1 percent per annum, which is approximately the median rate in the AHS for 2009, 2011, and 2013. I set the household rental income tax at 20.4 percent (Elenev et al., 2016), and the corporate rental income tax at 24 percent, equal to the effective U.S. corporate tax rate for 2005–2007 as documented by Markle and Shackelford (2012). Mom-and-pop investors and corporate investors both pay rental income tax on rental income minus maintenance costs minus property tax, but they can write off depreciation expenses from the tax-bills due. Depreciation expenses are computed as rental

[23] For completeness, I regress the institutional house operating costs in 2001 on observables as used in regression specification (2) in Section 3.1. Then, I save the residuals, $\widehat{ln(Costs)}$, and I compute the variance $var[\widehat{ln(Costs)}]$. Then I solve σ_{mh} from $var[\widehat{ln(Costs)}] = \frac{\sigma_{mh}^2}{1-\rho_m^2}$, using the biannual value for ρ_m

[24] Appendix K provides a robustness exercise where I lower the standard deviation of the corporate maintenance costs for houses to zero. In that case, to calibrate to the operating costs in the data, I set the initial premium at 0.0661 and the post-crisis premium at 0.0588.

property value, excluding land, depreciating over a period of 27.5 years,[25] i.e., 3.636 percent per year of the property value. The land share of a property is set at 20.6 percent, taken from Davis et al. (2021). Hence, I set $m_\tau = 0.03636(1-0.206) = 0.0289$. To set the Social Security replacement rate ρ_{ss}, I proxy average individual lifetime earnings with the last earnings realization. I set the replacement rate at 0.4, following Kaplan et al. (2020).

Extreme value shocks To keep the model solution computationally tractable with two dwelling types, extreme value shocks are used in the tenure and dwelling steps of the household problem. Given the nested problem setup using the selling, tenure, and dwelling steps, the household's problem maintains independence of irrelevant alternatives. Fix a state $i \in \{1, ..., n\}$, and let $U(i, i')$ denote the utility associated with choice $i' \in \{1, ..., n'\}$. Then, the taste shock $\epsilon_{i'}$ is added to all discrete choices i', where $\epsilon_{i'}$ is a random variable for each i'. By assuming that $\{\epsilon_{i'}\}$ are i.i.d. and distributed Type-I extreme value, the choice probabilities have a closed-form expression (Gordon, 2019; McFadden, 1974):

$$P(i'|i) = \frac{\exp(U(i,i')/\sigma)}{\sum_{j'=1}^{n'} \exp(U(i,j')/\sigma)}.$$

In addition, one can obtain a closed-form expression for the expected value of the maximum of the discrete choice problem. I set $\sigma = 0.0025$ for all discrete choices. More specifically, extreme value shocks are used when i) the non-owner makes its tenure choice between living with its parents, renting, and buying, ii) the non-selling owner makes its tenure choice between not adjusting, refinancing, and buying, iii) the selling owner makes its tenure choice between living with its parents, renting, and buying, iv) the non-selling mom-and-pop investor makes its tenure choice between not adjusting, refinancing, and moving, and v) the selling mom-and-pop investor makes its tenure choice between not adjusting, moving, and buying. Given all the tenure choices, all agents who choose to rent or buy a dwelling face extreme value shocks at the dwelling step.

[25]See https://www.irs.gov/publications/p527

Description	Parameter	Value	Source
Length of life (years)	J	60	Standard
Working life (years)	$J - J_{ret}$	44	Standard
Risk aversion	ρ_u	2	Standard
Additional utility owning	ω	1.05	Kaplan et al. (2020)
Autocorrelation earnings	ρ_y	0.97	Kaplan et al. (2020)
Std. dev. earnings	σ_y	0.2	Kaplan et al. (2020)
Risk-free rate	r^*	2.0%	FRED
Mortgage interest rate	r_b	3.0%	FRED
Mortgage origination cost	F_o	0.0207	Kaplan et al. (2020)
Mortgage refinancing cost	F_{refi}	0.0345	Wong (2019)
Maximum LTV ratio	λ_{LTV}	0.90	Greenwald (2018)
Maximum PTI ratio	λ_{DTI}	0.50	Greenwald (2018)
Dwelling buying cost	f_b & $f_{b,corp}$	0.05	Wong (2019)
Dwelling selling cost	f_s & F_s	0.07 & 0.1207	Gruber and Martin (2003) & Zillow (2022)
Housing & flats supply	$\bar{H}_h$ & $\bar{H}_f$	0.7412 & 0.1654	CPS (2001)
Housing depreciation rate	δ	0.023	BEA (2006–2020)
Dwelling sizes	$\{h_c, h_h\}$	[1.41, 2.32]	AHS (2001, 2005)
Operating cost mom&pop	$\{\underline{\phi}_c, \underline{\phi}_h\}$	$\{0.0564, 0.0564\}$	Section 3.1 & Appendix E
Persistence corporate costs	ρ_m	0.975	Normalization
Std. dev. corporate costs	σ_{mc} & σ_{mh}	0.001 & 0.1637	Normalization & RFS (2001)
Mean corp. costs condos	μ_{mc}	0.0635	Section 3.1 & Appendix E
Corporate suitability shock	δ_{exit}	0.20	ZTRAX, 01-19 (Zillow, 2022)
Property tax	τ_p	0.01	AHS (2009, 2011, 2013)
Corporate income tax	τ_{ci}	0.24	Markle and Shackelford (2012)
Mom&pop income tax	τ_{hi}	0.204	Elenev et al. (2016)
Depreciation tax-deduction	m_τ	0.02424	Davis et al. (2021) & IRS
Retirement replacement rate	ρ_{ss}	0.4	Kaplan et al. (2020)

Table 3: Externally calibrated parameters (annualized)

5.2 Internal calibration

I use the simulated method of moments (SMM) to calibrate the 9 parameters in Table 4 to match 11 targeted moments. The discount factor β governs both household wealth accumulation and indebtedness. The parameter α_u sets the non-durable share in utility, which, jointly with the available house sizes, affects the homeownership and wealth accumulation. The bequest parameters ψ and $\bar{b}$ affect savings behavior, homeownership and wealth choices as households approach the end of their lives. Next, the dwelling size $h_{parents}$

affects the homeownership rate, indebtedness and wealth accumulation, primarily at the early stages of life. The idiosyncratic mismatch shock for homeowners affects homeownership and wealth. I simplify the mismatch shock by making a mismatch an absorbing state: $\gamma_{1,0} = 0$ and $\gamma_{1,1} = 1$. When a homeowner draws the mismatch shock, the only way it can avoid being mismatched is to sell its primary dwelling; the mismatch shock cannot revert in the future. Then, the one remaining parameter to be calibrated is $\gamma_{0,0}$. This transition probability affects homeownership and selling behavior. The internally calibrated parameters for mom-and-pop investors are the transition probabilities for condos and houses. The transition probabilities for mom-and-pop maintenance costs affect mom-and-pop investment levels and the life-cycle buying and selling behavior. Homeowners can draw a low second dwelling maintenance cost, and the cumulative probability increases over time once they have lived in the same dwelling for a while. To reflect increasing knowledge of the neighborhood they live in over time, without taking a stance on the type of dwelling they are more likely to buy, I set i) the low maintenance cost draw to be an absorbing state, and ii) the transition probabilities for condos and houses to be identical. Hence, once homeowners become mom-and-pop investors, they do not face the risk of drawing a high maintenance cost that forces them to sell their investment dwelling.

The parameters that are estimated for the corporate rental sectors for condos and houses are the unconditional mean of the house corporate costs, the entry costs and the suitability shock. The unconditional mean of the corporate costs for houses μ_{mh} affects the rental rate and rental ownership share of houses, which in turn affects the homeownership and wealth accumulation of households. The corporate entry costs affect the corporate sector's equilibrium maintenance cost and its investment share for both condos and houses. Finally, the corporate suitability shock affects the selling behavior of institutions.

Table 5 reports the fit between the model and data for the targeted moments. For the data, I use the mean size owned to rented dwelling of 1.5 from Chatterjee and Eyigungor (2015). For consistency with the definition of net worth in the model, net worth in the data is owner-occupied and investor property less mortgage debt, plus liquid assets minus liquid liabilities.[26] All mortgage holding rates, LTV ratios, debt-to-income ratios, and net worth

[26]Following Kaplan et al. (2014), liquid assets are defined as: checking, saving, money market and call

Description	Parameter	Value
Preferences		
Discount factor	β	0.9615
Non-durable share in utility	α_u	0.8372
Bequest luxuriousness	$\bar{b}$	10.5925
Bequest desirability	ψ	70.9995
Housing		
Smallest dwelling size	h_{parents}	0.25
Owners		
Mismatch shock transition	$\{\gamma_{0,0}, \gamma_{0,1}, \gamma_{1,0}, \gamma_{1,1}\}$	$\{0.9, 0.1, 0, 1\}$
Dwellings (mom&pop)		
Costs m&p transition probabilities	$\{\Pi_{\underline{\phi},\underline{\phi}}, \Pi_{\underline{\phi},\bar{\phi}}, \Pi_{\bar{\phi},\underline{\phi}}, \Pi_{\bar{\phi},\bar{\phi}}\}$	$\{1, 0, 0.35, 0.65\}$
Dwellings (institutions)		
Uncond. mean corp. costs houses	μ_{mh}	0.115
Corporate entry costs	c_E	0.01

Table 4: Internally calibrated parameters (annualized)

statistics are computed using both primary and secondary property mortgage debt.

Table 5 shows that the model moments match the data moments relatively well, particularly for the homeownership rates and mom-and-pop rental share of houses, which are the main focus of this paper. The mom-and-pop rental share of condos in the model is slightly below the one in the data, which could be caused by the assumption that the corporate sector has no dispersion in efficiency for condos. If the corporate sector has dispersion in efficiency for condos ($\sigma_{mc} > 0$), the condo rental rate would increase for the corporate sector to be able to supply rental condos, incentivizing households to invest in condos at a higher rate.

5.3 Steady state

To obtain more insight into the household choices over the life-cycle, Figure 5 shows the choices of agents over living with their parents, renting, owning, and being a mom-and-pop investor. Renters and homeowners are split by the dwelling they rent and own, respectively, while mom-and-pop investors are split by the second dwelling they own. Agents have the option to live with their parents until and including age 30 without forming a household.

accounts, plus directly held mutual funds, stocks, corporate bonds and government bonds. Liquid liabilities are: credit card balances.

Description	Model	Data	Source
Targeted Moments			
Total homeownership rate	0.71	0.69	FRED, 2006
Homeownership rate houses	0.83	0.78	ACS, 2001
Homeownership rate condos	0.16	0.12	ACS, 2001
Mom&pop rental houses stock share	0.88	0.83	ACS & RFS, 2001
Mom&pop rental condos stock share	0.09	0.26	ACS & RFS, 2001
LTV ratio, owners with mortgage, p50	0.47	0.51	SCF, 2007
LTV ratio, m&p w mortgage, p50	0.23	0.39	SCF, 2007
Dwelling value/income, owners, p50	2.70	3.09	SCF, 2007
Net worth/income, p50	1.41	1.13	SCF, 2007
Mean size owned to rented dwelling	1.24	1.5	Chatterjee and Eyigungor (2015)
Average premium corporate house costs	\$1,355	\$1,345	Section 3.1

Table 5: Annualized moments relative to the data

The other young agents choose to form a household by either renting a condo, renting a house, owning a condo, or owning a house. Given the nested setup described in Section 4, together with the extreme value shocks during the tenure and dwelling step, young agents make the following decisions in turn. First, young agents can choose to live with parents, rent, or own. This decision is affected by taste shocks perturbing the expected value of each of these three discrete choices. Once the tenure decision has been made, the dwelling decision between condos and houses is also affected by taste shocks perturbing the value to own/rent a condo or a house. Intuitively, a younger and poorer household is more likely to rent a condo than a house. Over the life-cycle, more households prefer owning a dwelling to renting, and the richest homeowners choose to become mom-and-pop investors. During retirement, households increasingly sell their dwelling and become renters.

The steady state provides thresholds of liquid assets for which agents choose to switch from living with their parents to renting, from renting to owning, and from owning to becoming a mom-and-pop investor. These thresholds depend on age, housing assets, mortgage debt, income, and both the mismatch and second maintenance cost shock.

Figure 6 compares the untargeted ownership rates and investment ownership rates over age and wealth. The fit for other non-targeted moments is summarized in Appendix I. As I focus on the shift of rental ownership to institutional investors during the Great Recession, it is important to understand the determinants of the steady-state distribution of rental

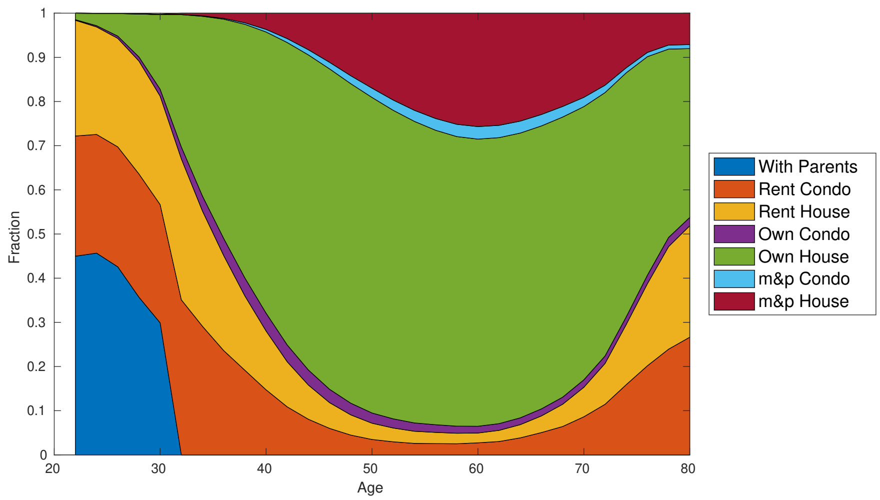
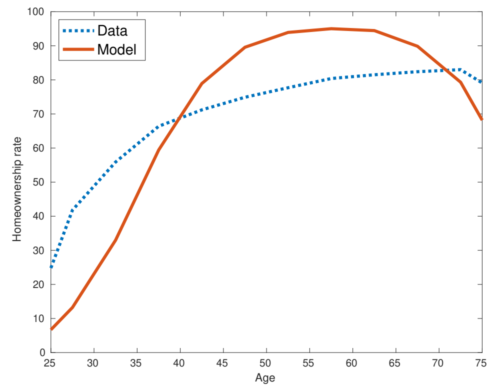
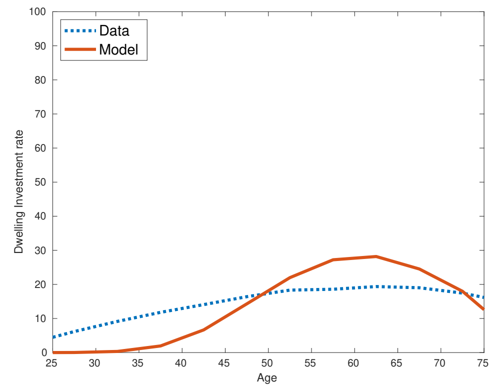


Figure 5: Steady-state distribution of tenure and dwelling type

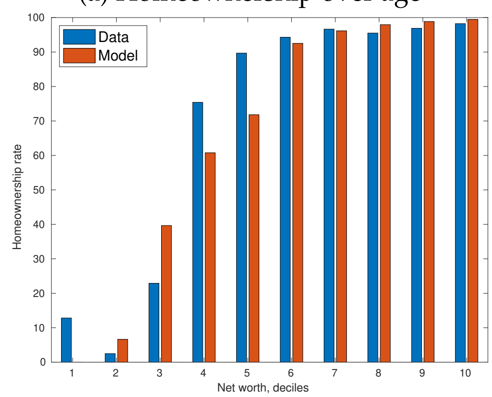
dwelling ownership. While the homeownership rate rises quickly with age, dwelling investment occurs later in life, primarily among wealthier households. There are a few reasons for why the homeownership and investment ownership rates rise with age and net worth. First, depending on the given bequest and initial income, it takes time for households to accumulate savings to satisfy the LTV and PTI constraints. Second, given the CRRA utility, the optimal portfolio allocation implies a roughly constant share of the risky asset. Hence, as wealth grows over the life cycle, so does the amount of the risky asset holdings: the homeownership and investment ownership rise. For households to own an investment dwelling, they must either make large mortgage payments or hold a large fraction of their wealth in housing. As younger households need to build up liquid wealth to insure against income shocks, they invest in dwellings less. Older and wealthier households invest at a higher rate as they value the rental income of investment dwellings when they begin to accumulate wealth for retirement and bequests. Older and wealthier households especially invest if their retirement income is much lower than the income they received during their working life. In addition to these life-cycle considerations, households also have to 1) own a house and 2) draw a low maintenance cost to buy a second dwelling. Given these requirements, the investment rate increases more gradually over age and net worth in the model than in the data.



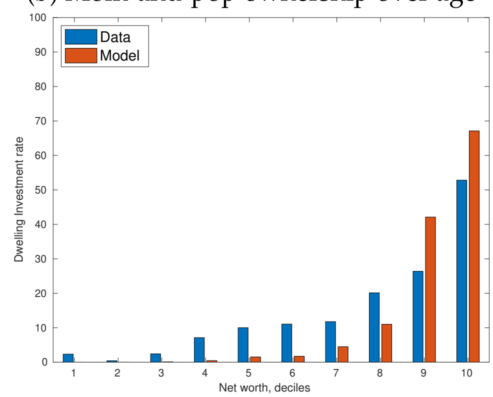
(a) Homeownership over age



(b) Mom-and-pop ownership over age



(c) Homeownership over wealth



(d) Mom-and-pop ownership over wealth

Figure 6: Ownership rates by age and net worth. Data moments computed from the SCF 2007. Moments by wealth are median values within each decile of the net worth distribution.

6 Results

I organize the quantitative findings around four questions:

1. What impact does the cost reduction have on the choices to rent, own, and invest?
2. How much worse would the crisis have been without the observed corporate-cost reduction?
3. Which households are better off due to the fall in costs, both in a steady-state comparison and during the crisis?
4. Would a home-buying credit have been effective to lower the crisis severity?

6.1 Steady-state comparison

In order to construct a counterfactual that captures the observed corporate-cost reduction post-crisis, I lower the parameter for the unconditional mean of the corporate-costs distribution for houses without changing any other parameters. The parameter μ_{mh} is reduced to a value such that the average cost premium for corporate-owned rental houses in equilibrium falls from \$1,345 to \$940 as estimated in the data (see Section 3.1). This requires lowering the value of μ_{mh} from 0.115 to 0.081 with an equilibrium cost gap of \$965.

Table 6 shows the steady-state impact of these changes. The corporate-cost reduction for houses causes the homeownership rate to fall from 0.71 to 0.66. In addition, the homeownership rate of houses falls, as does the mom-and-pop share of rental houses. The house price and house rental rate are key to understanding these changes. In the steady state with the corporate-cost reduction, the house price is 1.5 percent higher, but the house rental price is 3.6 percent lower. This fall in house rental rate makes renting more attractive, incentivizing agents who previously chose to live with their parents to now rent. With the higher rental income taxes, the lump-sum redistribution increases by 3.03 percent (\$73 p.a.). This increase is small relative to the reduction in the costs of renting a house (\$543 p.a.). Hence, the corporate-cost reduction causes a shift from owning to renting. Given the extreme value shocks at the dwelling step, the rental demand for both condos and houses rises. The condo rental price rises by 0.8 percent and condo price rises by 1.1 percent. The stocks of houses and condos also rise with the increased dwelling (rental) demand, by 0.21 percent and 0.09 percent, respectively. As there are no corporate-cost changes for condos, the increase in market prices for condos does not materially affect the homeownership rate or the mom-and-pop rental share for condos.

Along with the shift to renting, Table 6 shows that net worth declines. As households experience a decrease in rental expenses and thus shift towards renting, they do not build up more net worth but slightly increase their consumption of nondurables. This decline in total net worth can be explained by weakened motive to save for down payments due to higher house prices and lower rental rates.

Households respond to the corporate-cost reduction in houses by shifting from living with their parents to renting due to the lower house rental price, and from owning to renting

Description	Pre-2008 Data	Post-2008 Data	Baseline ($\mu_{mh} = 0.115$)	Lower costs ($\mu_{mh} = 0.081$)
Housing market				
Total homeownership rate	0.69	0.64	0.71	0.66
Homeownership rate houses	0.78	0.77	0.83	0.77
Homeownership rate condos	0.12	0.12	0.16	0.16
Young living with old (fraction)	0.40	0.46	0.40	0.39
Mom&pop rental houses stock share	0.83	0.72	0.88	0.43
Mom&pop rental condos stock share	0.24	0.12	0.09	0.08
Dwelling value/income, owners, p50	3.09	2.67	2.70	2.74
Average premium corp. house costs	$1,345	$940	$1,355	$965
Wealth distribution				
Net worth/income, p50	1.13	1.00	1.41	1.37
Median net worth of ages 66-81 to 40-55	1.78	2.20	0.75	0.77
Net worth/income, p10	0.00	0.00	0.05	0.03
Net worth/income, p90	7.47	7.16	7.49	7.37
Homeownership rate, age ≥ 70	0.80	0.83	0.66	0.62
Homeownership rate, age ≤ 35	0.51	0.44	0.23	0.18

Table 6: Annualized moments calibration vs. cost-reduced steady state. The pre-2008 column uses the targeted and untargeted moments for 2007 in Section 5. The post-2008 column uses the values for 2018. Data sources: FRED, SCF (2019), ACS, RFS, RHFS, and the operating costs found in Section 3.1.

due to the lower house rental price and higher house price. This shift can be seen in the (liquid) wealth thresholds at which non-owners switch their tenure choice, in Figure 7. In the top panels the net worth threshold is shown for all income levels, for the initial steady state (left) and for the steady state with lower corporate costs (right). The asset levels at which non-owners switch from living with their parents to renting falls. The bottom two panels show the net worth at which agents switch from renting to owning. Comparing the baseline case (left) with the corporate-cost reduction case (right), one can see that households switch from renting to owning only at higher wealth levels, for all ages and income levels. In sum, responding to the house rental price drop, agents choose to switch from living with their parents to renting at lower asset levels, and choose to remain renters for higher asset levels instead of becoming owners. Both developments increase the rental demand, whereas only the former increases total housing demand (and causes the dwelling prices to rise).

Figure 8 compares the household ownership rates and investment ownership rates at different ages across the two steady states. The homeownership rate and the dwelling investment rate in the new steady state with a lower μ_{mh} are uniformly below the baseline.

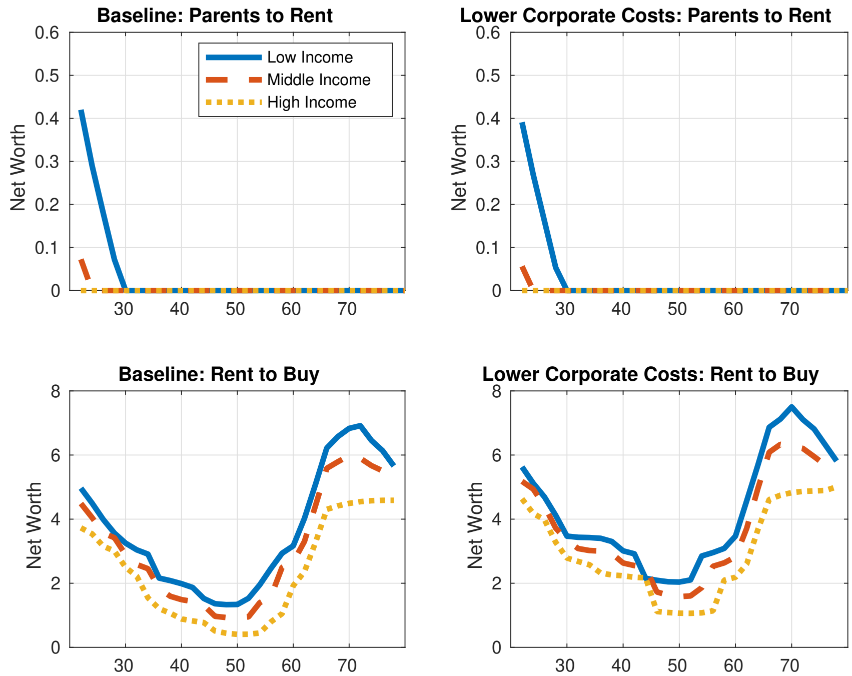
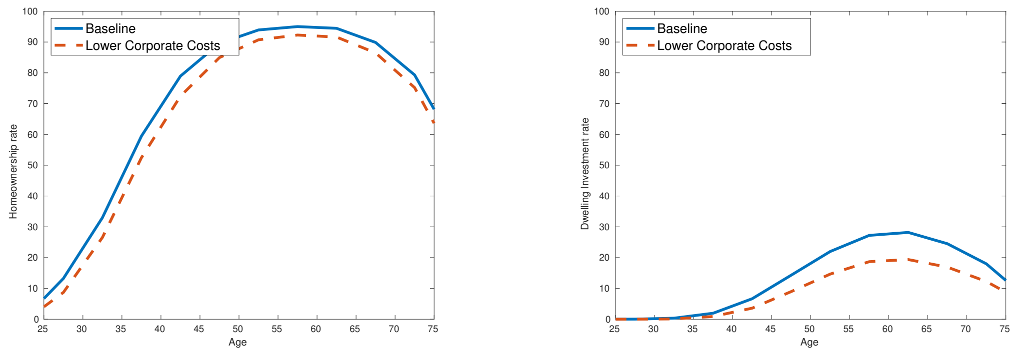


Figure 7: Asset thresholds for optimal tenure choice switching. The top panels show the asset levels at which agents optimally switch from living with their parents to renting for the baseline steady state and the lower corporate-cost steady state. The bottom panels show the asset levels at which agents optimally switch from renting to owning for the baseline steady state and the lower corporate-cost steady state. The threshold at which agents optimally switch is defined as the point at which the ratio of probabilities of the new tenure choice relative to the old tenure choice is at least 0.7.

The lower corporate costs for houses lower the house rental rate, which in turn weakens the motive for households to buy a house during the life-cycle. The lower homeownership rate in turn lowers the investment rate directly, as only homeowners can buy a second dwelling. Moreover, the corporate-cost reduction also indirectly lowers the dwelling investment rate by increasing the house price and lowering the house rental rate.

Figure 9 shows the fall in the distribution of corporate costs for houses. Note that the corporate costs for houses are bounded from below at \$3,800, which is the maintenance cost for mom-and-pop investors. With the shift in the distribution of the corporate costs, the rental rate is determined by the marginal entrant. In the initial steady state, the maximum maintenance cost draw for entry m_h^{*enter} is below the maximum cost draw to stay m_h^{*stay} (\$5,414 vs. \$8,494) due to the buying costs. After the corporate-cost reduction, the maximum marginal maintenance costs to enter and stay fall to \$4,876 and \$7,920, respectively. This fall in the highest corporate cost is reflected in a 3.6 percent drop in the rental price. The



(a) Homeownership over age

(b) Mom-and-pop ownership over age

Figure 8: Steady-state ownership rates over age and net worth. Data moments computed from the SCF 2007. Moments by wealth are median values within each decile of the net worth distribution.

corporate-cost reduction is thus expected to cause relatively efficient corporate investors to enter, partially replacing less efficient corporate investors and equally efficient mom-and-pop investors.

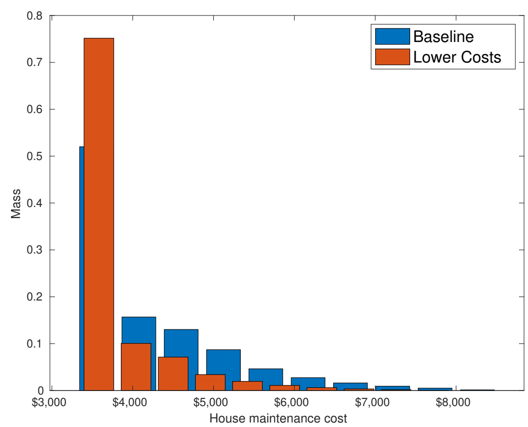


Figure 9: Distribution of corporate costs for houses

6.2 Great Recession with and without cost reduction

In order to use the model to study the role that institutional investors played during the Great Recession and its aftermath, the steady state is perturbed by a set of unexpected shocks to aggregate income and mortgage credit, which are believed to last forever. After six years, the economy is hit with a second set of unexpected shocks that revert aggregate income and mortgage credit to their original levels. The goal is to compare the equilibrium responses of the economy with and without the house cost reduction. More specifically, in the lower-costs experiment the unconditional mean of corporate costs for houses μ_{mh} falls from 0.115 to 0.081 (as in Section 6.1) while in the baseline experiment it remains constant.

Table 7 summarizes the components of the set of unexpected Great Recession shocks. I model the Great Recession to run for six years (three model periods) from 2008–2013 with the steady state in 2007. After that, the economy is hit with a second set of unexpected shocks that revert the Great Recession shocks. The Great Recession shocks have five parts. First, I lower aggregate income by 7 percent.[27] Second, I lower the maximum LTV ratio from 0.90 to 0.80, matching the drop of the 75th percentile of LTV ratios for newly originated Fannie Mae purchase loans during the Great Recession (Greenwald, 2018).[28] Third, I lower the maximum PTI ratio from 0.50 to 0.25 to capture the drop in maximum PTI ratios over the Great Recession as reported by Greenwald (2018).[29] Fourth, the fixed mortgage origination costs increase from \$1,200 to \$2,000 (0.0207 to 0.0345) in accordance with Kaplan et al. (2020) for boom and bust values. Fifth, I lower the housing taste parameter $(1 - \alpha_u)$ by 20 percent (from 0.1628 to 0.1302) to target a 20 percent house price drop in the baseline case of the Great Recession.

Description	Parameter	Boom Value	Bust Value	Source/Target
Aggregate income	Θ	1	0.93	FRED (1964–2014)
Maximum LTV ratio	λ_{LTV}	0.90	0.80	Greenwald (2018)
Maximum PTI ratio	λ_{PTI}	0.50	0.25	Greenwald (2018)
Fixed origination cost	F_o	0.0207	0.0345	Kaplan et al. (2020)
Housing taste	$1 - \alpha$	0.1628	0.1302	20% house price drop

Table 7: Changes to parameter values for a negative mortgage credit shock. The shock unexpectedly switches the parameters from the boom to the bust state for six years and then unexpectedly reverts.

To capture the delayed timing of the entrance of institutional investors since 2010–2011, the lower-costs experiment includes the permanent reduction of corporate costs from $t = 4$

[27] This is the decline in real GDP per capita from 2006–2007 to mid 2008–2013, after GDP per capita is linearly detrended between 1964 to 2014 (U.S. Bureau of Economic Analysis: A939RX0Q048SBEA, 2022). This estimate is also chosen by Kaplan et al. (2020) and Krueger et al. (2016).

[28] This percentage point reduction of the maximum LTV ratio is chosen in accordance with the size of reductions used in other papers that model boom or bust episodes, such as the 15 percentage point reduction used by Kaplan et al. (2020) and the 10 percentage point reduction used by Iacoviello and Pavan (2013).

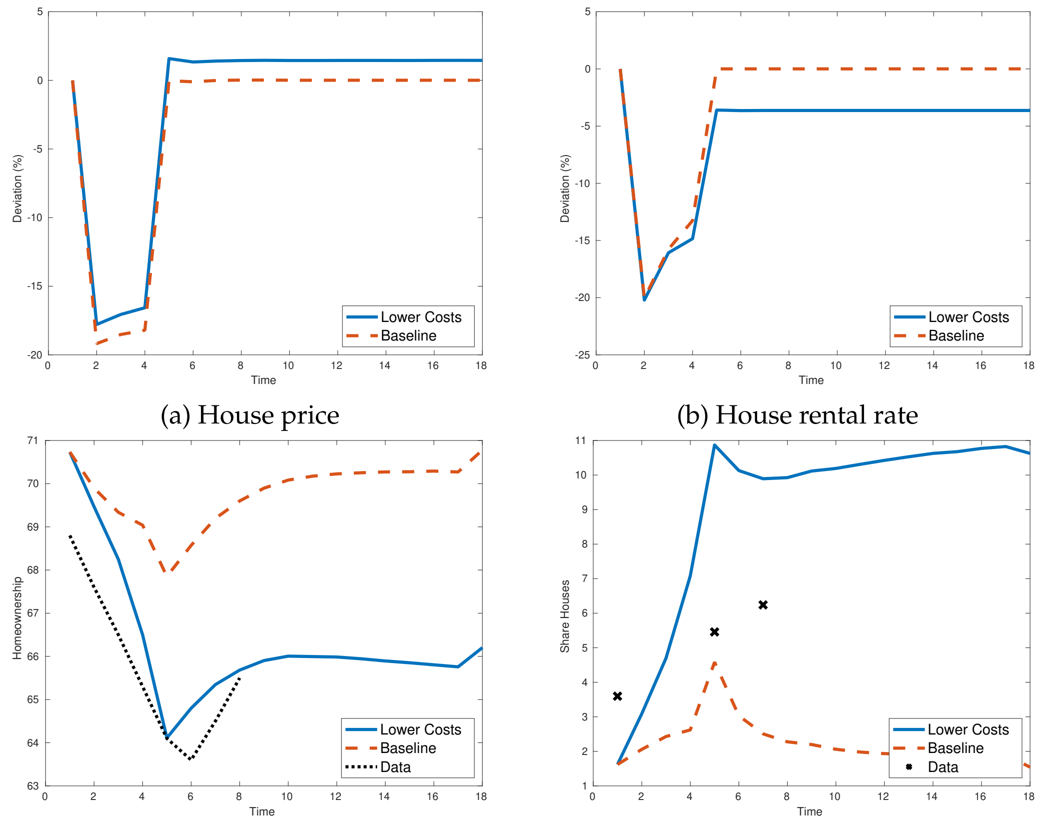
[29] The drop in maximum PTI ratio is larger than the one reported by Greenwald (2018) for front-end PTI limits to account for the fact that the amortization period in this model (remaining lifetime after purchase) is longer than in the data (typically 30 years). This adjustment is also made by Kaplan et al. (2020).

onwards, and this is expected when the first set of unexpected shocks hit at $t = 2$.[30]

Figure 10 compares the transitional dynamics triggered by the Great Recession shocks across the baseline and lower-costs experiments. Panel (a) shows that the housing market bust is less severe in the lower-costs experiment with the corporate-cost reduction: the house price falls by 1.64 percentage points less. Moreover, in panel (b) the rental rate for houses is lower in all but the first period of the Great Recession. As the corporate sector expects a maintenance cost drop at $t = 4$, entry is higher in the first period, which raises the highest marginal cost of the last entrants. In addition, with higher housing prices, the required rental rate is higher. Panel (c) shows that the homeownership rate falls by 6.6 percentage points in the lower-costs case, which is close to the fall of 5.4 percentage points in the data (68.8 percent in 2006 to 63.4 percent in 2016). In contrast, the homeownership rate only falls by 2.9 percent in the baseline case. Panel (d) shows the share of houses owned by the corporate rental sector, combining the rental share with the corporate rental ownership share of houses. While the corporate house share rises more quickly in the lower-costs case than in the data, the model matches the persistently higher share of corporate house ownership in the data.

Next, consider the stock of houses. Panel (a) of Figure 11 shows that the stock of houses falls during the Great Recession shocks because construction falls due to lower prices. Notably, as the house price falls less in the lower-costs case than in the baseline, the housing stock falls less with the reduction in corporate costs. After the Great Recession shocks are gone, with a lower housing stock than before, the house price overshoots its initial price, as panel (a) of Figure 10 shows. The smaller house mass requires more of the population to choose to live with their parents, i.e. free-ride. The smaller fall in house prices in the lower-costs case relative to the baseline case translates into a reduced fall in house mass, which allows more households to rent/buy a dwelling rather than live with their parents. More specifically, while the fraction of young living with old peaks at 52.5 percent in the baseline, it peaks at only 51.4 percent in the lower-costs case. In addition, the new steady-state level in

[30] The crisis gave the corporate sector for houses the possibility to increase scale to lower maintenance costs. As corporate sector investors purchase more rental houses, they realize the future costs fall if they continue to do so. This assumption allows the corporate sector to remain rational instead of being surprised each period by a reduction in costs (myopic).



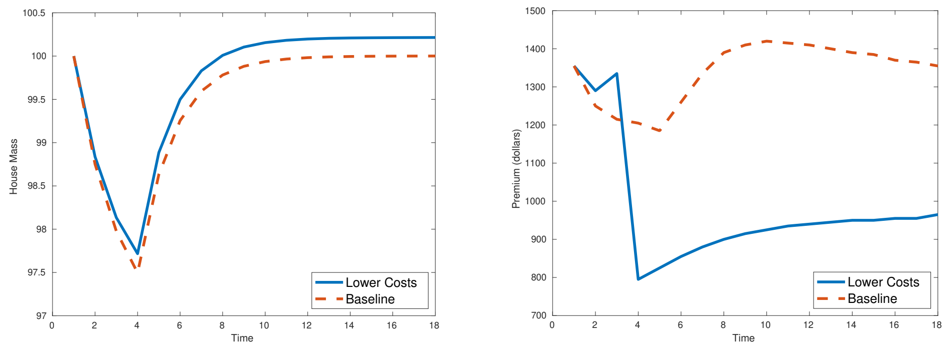
(a) House price (b) House rental rate

(c) Homeownership rate (d) Corporate house ownership

Figure 10: Transitional dynamics of Great Recession shocks lasting six years. Data sources: ACS, RFS, and RHFS.

the lower-costs case falls from 40 percent to 38.9 percent of the young choosing to free-ride. The increase of 12.5 percentage points (40 percent to 52.5 percent) overshoots the increase of 6 percent in the data (see Section 4).

The average corporate maintenance costs for houses during the transition path are shown in Panel (b) of Figure 11. As discussed before, the corporate maintenance distribution is lowered at $t = 4$ in the lower-costs case with a new steady-state average maintenance cost of \$965. The baseline case shows an initial decrease but then an increase in average costs. As entrants have a lower average cost than incumbents, the average maintenance cost falls when the corporate sector purchases increase. After the corporate rental share peaks at $t = 5$, the corporate maintenance cost slowly increases to converge back to its steady-state value. The lower-costs experiment instead shows a small rise in the average corporate cost at $t = 3$, which reflects a large spike in purchases by corporations who anticipate the fall in corporate costs at $t = 4$. Then the average corporate cost falls after $t = 4$ due to the downward shift in the corporate-costs distribution. As the corporate rental sector converges to its new steady-state level, the average corporate cost increases.



(a) House mass

(b) Average corporate maintenance costs for houses

Figure 11: Transitional dynamics of Great Recession shocks lasting six years.

Figure 12 shows the international asset position over time. The international asset position remains positive but falls more in the lower-costs case than in the baseline case due to the rise in value of the corporate-owned stock of dwellings. This observation aligns with the post-crisis decline in the U.S. net international investment position (U.S. Bureau of Economic Analysis: IIPUSNETIQ, 2022).

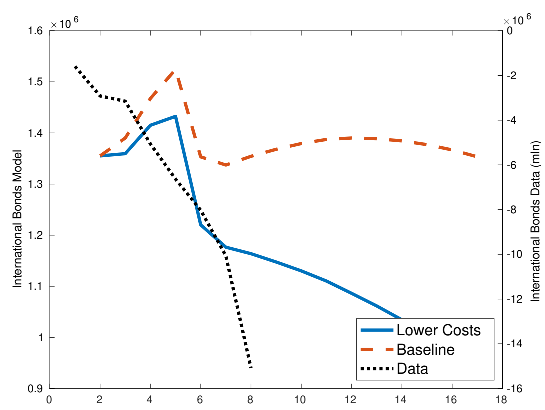
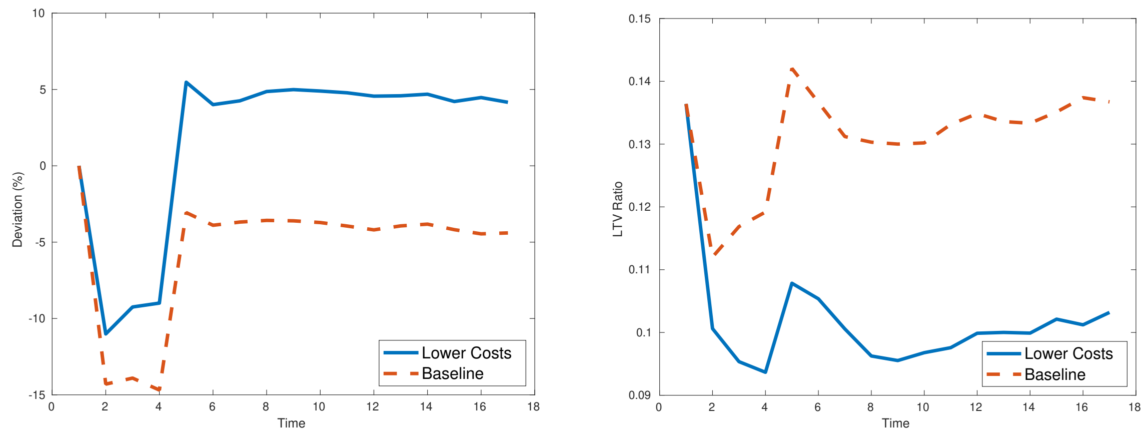


Figure 12: Transitional dynamics of Great Recession shocks lasting six years. Data from BEA.

Without the corporate-cost reduction for houses, mom-and-pop investors provide more rental houses. Figure 13 shows that the characteristics of new housing investors change markedly over the course of the shock. New mom-and-pop investors have lower net worth and a lower LTV ratio during the Great Recession, which reverts after the Great Recession shocks are over. In the case with a corporate-cost reduction, as there are fewer mom-and-pop investors due to the rise in house price and the fall in house rental rates, the average net worth of new investors falls less and converges to a higher level than before. Moreover, the average LTV ratio falls permanently for new investors as they become richer.



(a) Net Worth

(b) LTV Ratio

Figure 13: Wealth and indebtedness of the average new mom-and-pop investor

In sum, the Great Recession would have been worse without the observed cost reduction of the corporate sector. House prices would have fallen by 1.64 percentage points more and the population would have had to live in fewer dwellings. The corporate-cost reduction for houses stabilized the housing market during the Great Recession shocks. As the future corporate costs for houses fall, the corporate purchases increase. The increased demand for houses by the corporate sector, in combination with the lower equilibrium house rental price which increases rental demand, increases total house demand and thus increases the equilibrium house price. The homeownership rate, however, falls by more than it would without the fall in corporate costs.

6.3 Welfare effects

As the corporate-cost reduction moderates the house price fall but lowers the homeownership rate during the Great Recession shocks, the next step is to compute the welfare effects of the corporate-cost reduction. Welfare effects comparing steady states are solved first, followed by an analysis of welfare effects including the transition path to the new steady state.

Household welfare is measured by the consumption equivalent variation (CEV). To compare welfare with non-homothetic preferences, I closely follow the approach by Kindermann and Krueger (2022). For each agent currently alive, I calculate the amount of initial wealth transfers needed to make an individual indifferent between the baseline steady state and their new situation: the lower-costs steady state in Section 6.3.1 and the first transition period after the Great Recession shocks in Section 6.3.2. This is an ex-post transfer for the currently living generation. The transfers $\Psi_0(j, a, \epsilon, \phi, b, h^o, h^{mp}, \gamma)$ satisfy:

$$v_1(j, a + \Psi_0(j, a, \epsilon, \phi, b, h^o, h^{mp}, \gamma), \epsilon, \phi, b, h^o, h^{mp}, \gamma) = v_0(j, a, \epsilon, \phi, b, h^o, h^{mp}, \gamma), \tag{22}$$

where v_0 denotes the value function for the initial steady state, and v_1 denotes the value function in the new situation (i.e. the low-costs steady state or the first transition period). This transfer is then discounted to the present value, and converted in an annuity C that pays out for the whole remaining lifetime of the agent:[31]

$$C(j, a, \epsilon, \phi, b, h^o, h^{mp}, \gamma) = -\frac{\left(\Psi_0(j, a, \epsilon, \phi, b, h^o, h^{mp}, \gamma)/(1 + r^*)\right)}{\left(\frac{1-(\frac{1}{1+r^*})^{J-j+1}}{(1-\frac{1}{1+r^*})}\right)}. \tag{23}$$

I divide this annuity by average total consumption C_0 in the initial steady state to compute the CEV on a household level for agents who are currently alive:

$$CEV(j, a, \epsilon, \phi, b, h^o, h^{mp}, \gamma) = 100 * (C(j, a, \epsilon, \phi, b, h^o, h^{mp}, \gamma)/C_0). \tag{24}$$

These household-level welfare gains are weighted by the initial steady-state distribution to compute welfare gains for the lower-costs steady state and during the Great Recession shocks. I discuss the welfare gains for each household group over age and net worth: non-owners, owners, and mom-and-pop investors.

6.3.1 Steady-state comparison

Table 8 reports the steady-state welfare gains of a lower corporate house maintenance cost, weighted by the distribution of the initial steady state.

[31] I divide by the remaining lifetime of households so welfare effects for the latter age-groups are higher.

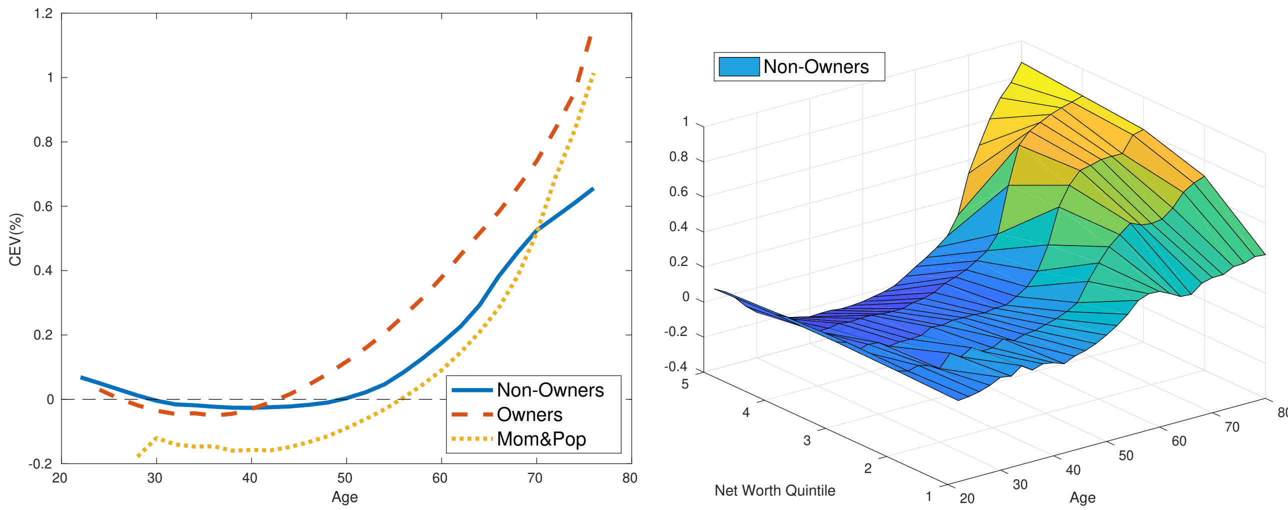
Overall, households enjoy a 0.322 percent CEV gain due to the reduction in corporate costs for houses. This gain is spread unequally, however, as only 68 percent of households are better off. Homeowners gain the most from the corporate-cost reduction, followed by mom-and-pop investors and non-owners. Non-owners benefit from the lower equilibrium house rental rate but obtain a small welfare gain due to the rise in house prices, making it more costly for them to buy. Homeowners experience a capital gain in their wealth holdings and thus are better off. While it is true that mom-and-pop households experience a capital gain on both their primary and secondary dwelling, their house rental income falls. Depending on the investors' age, this fall in rental income dominates the initial welfare gains.

	CEV (%)	Fraction $\geq$0
All	0.322	0.681
Non-owners	0.120	0.681
Owners	0.454	0.714
Mom&Pop	0.346	0.545

Table 8: Steady-state welfare effects. Welfare comparisons are made for the new steady state with the corporate-cost reduction relative to the initial steady state.

As only a fraction of households are better off, I split the welfare gains over age and net worth. Figure 14 shows the welfare gains for non-owners, owners, and mom-and-pop investors of different ages and splits the welfare gains for non-owners by age and net worth. Non-owners have the highest welfare gain for ages below 30 and above 50: they experience a fall in the house rental rate and, given life-cycle motives, are less likely to buy a house. In contrast, non-owners of ages 30 to 50 experience lower welfare gains: they experience a fall in house rental cost but also have to pay a higher house price in case they purchase a house. Owners and mom-and-pop investors have a similar shape in welfare gains but have relatively low mass in the first age groups. Homeowners and mom-and-pop investors experience a capital gain on their dwellings but face a lower equilibrium house rental rate, making becoming an investor less profitable. These lower rental returns become less relevant with age, but they dominate for younger mom-and-pop investors: they experience a welfare *loss* due to the decline in rental income dominating the increase in dwelling prices.

Appendix J discusses the steady-state welfare changes of eliminating tax advantages of



(a) Welfare gains by homeownership

(b) Welfare gains non-owners

Figure 14: Steady-state welfare effects. Welfare comparisons are made for the new steady state with the corporate-cost reduction relative to the initial steady state.

owning a home by taxing the imputed rental income of homeowners. With the shift from owning to renting after the corporate-cost reduction, the optimality of existing tax advantages for owners can be questioned.

6.3.2 Transition comparison

Consider next the welfare effects of the corporate-cost reduction for houses during the transition path. Welfare calculations are provided for the lower-costs case relative to the steady state and the baseline. Welfare gains or losses are computed using the value functions at the first period of the Great Recession shock. Hence, these welfare changes capture the Great Recession transition path to a new steady state, assuming that the set of Great Recession shocks are permanent.[32]

Table 9 reports the welfare gains of the lower-costs case during the Great Recession shocks for households alive during the first period of the transition, relative to the initial (baseline) steady state and the baseline case of the Great Recession. The welfare losses of the Great Recession shocks are concentrated among owners and mom-and-pop investors as

[32] While the CEV losses are large for the lower-costs case relative to the initial steady state, the CEV gains of the lower-costs case relative to the baseline case capture the effect of the reduction in corporate costs on the severity of the Great Recession.

they experience capital losses.[33] Table 9 shows that, in total, households are 13.46 percent worse off. With the corporate-cost reduction, in total households are 0.289 percent better off than without the corporate-cost reduction. The welfare gains of the corporate-cost reduction are concentrated among homeowners and mom-and-pop investors, primarily due to the capital gain they experience. Homeowners gain 0.420 percent CEV, corresponding to a $159 rise in annual consumption, while mom-and-pop investors gain 0.606 percent CEV, corresponding to a $231 rise in annual consumption. Non-owners suffer a welfare loss of the corporate-cost reduction. They benefit from the lower future house rental rates but lose due to higher house prices that make it more costly to buy a dwelling.

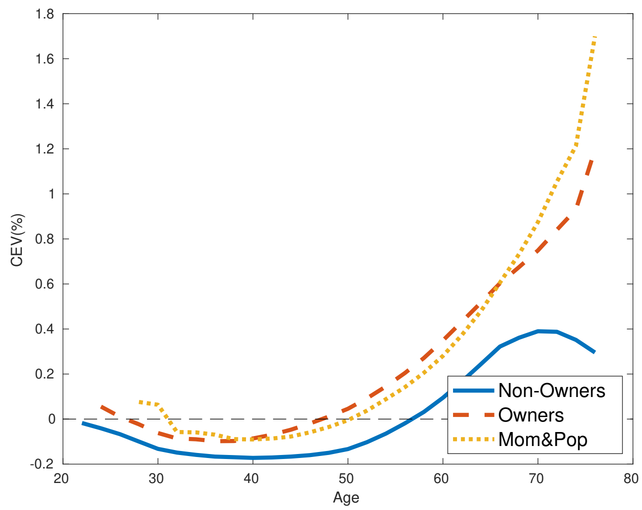
	vs. Baseline Steady State		*vs. Baseline Case Great Recession*	
	CEV (%)	Fraction ≥0	CEV (%)	Fraction ≥0
All	-13.456	0	0.289	0.596
Non-owners	-7.158	0	-0.016	0.382
Owners	-15.299	0	0.420	0.691
Mom&Pop	-23.658	0	0.606	0.811

Table 9: Welfare effects during the Great Recession shock. First, welfare comparisons are made for the lower-costs case of the Great Recession relative to the initial (baseline) steady state. Second, welfare comparisons are made for the lower-costs case of the Great Recession relative to the baseline case of the Great Recession (with vs. without corporate-cost reduction for houses).

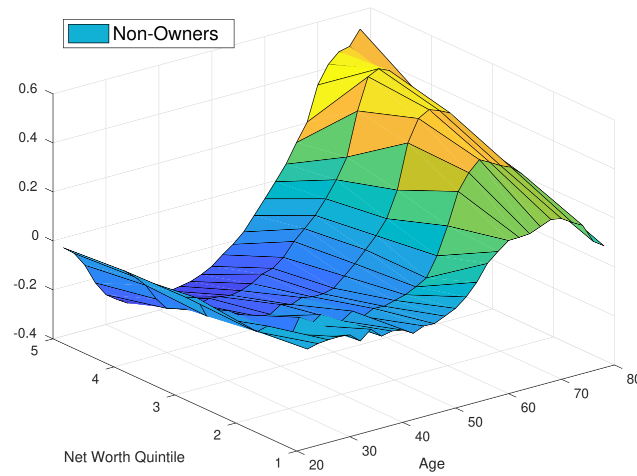
Figure 15 shows the welfare gains of the lower-costs case of the Great Recession relative to the baseline case of the Great Recession, aiming to measure the welfare gains of the reduction in corporate costs. Panel (a) shows the welfare gains for non-owners, owners, and mom-and-pop investors of different ages. Panel (b) splits the welfare gains for non-owners by age and net worth. Panel (a) shows that non-owners experience the largest welfare loss for ages 30-50, when they would consider buying a dwelling due to the life-cycle profile of income. While non-owners face a fall in future house rental costs, the immediate rental expenses and house price rise at the start of the Great Recession, making them worse off. Non-owners at higher ages benefit due to the drop in future house rental rates. Owners and mom-and-pop investors have a similar shape in welfare gains but have relatively low mass in the first age groups. Homeowners and mom-and-pop investors experience a capital gain on their dwellings but face a lower equilibrium house rental rate, making investment

[33]Note: the welfare losses are computed with the expectation that the Great Recession shocks last forever.

less profitable. These lower rental returns become less relevant with age but dominate for younger mom-and-pop investors: they experience a welfare loss due to the decline in rental income dominating the increase in dwelling prices.



(a) Welfare gains by homeownership



(b) Welfare gains non-owners

Figure 15: Welfare effects during the Great Recession shock. Welfare comparisons are made for the lower-costs case of the Great Recession relative to the baseline case of the Great Recession.

When the steady-state welfare gains of the corporate-cost reduction in Table 8 are compared to the Great Recession welfare gains of the corporate-cost reduction in Table 9, there are notable differences. Non-owners are relatively worse off in the Great Recession case for two reasons. First, they are constrained to buy a dwelling while the house price increases. Second, the fall in the house rental rate is delayed due to the delayed fall in the corporate costs for houses. While owners experience an approximately equal welfare gain, mom-and-pop investors are worse off in the steady-state comparison than in the Great Recession case. While mom-and-pop investors experience about the same capital gain in both the steady-state comparison and the Great Recession case, the house rental rate falls immediately in the steady-state case and only later in the Great Recession case, which lowers their welfare gains in the steady-state comparison.

6.4 Home-buying credit

Next, I evaluate the effect of a home-buying credit during the Great Recession. This credit could alleviate the welfare losses for non-owners caused by the corporate-cost reduction.

More specifically, this home-buying credit could compensate non-owners who were about to buy a home given their life-cycle profile of income.[34]

To motivate the policy intervention, the Obama administration enacted the federal first-time homebuyer tax credit in 2008 as a response to the Great Recession. This tax credit was part of the Housing and Economic Recovery Act (HERA) and allowed new homebuyers to get a tax credit of up to $7,500 during the first year of the initiative. The home-buying credit is modeled as a temporary subsidy to buy a dwelling for households who do not currently own a home. To replicate the size of the subsidy, I give buying households a subsidy of $7,500 (0.129 in model terms) during the first three periods of the unexpected shocks.

While the homeownership rate rises during the Great Recession shock, the homeownership rate falls after the second set of unexpected shocks hit and converges to its (lower) new steady-state level. Table 10 shows the welfare changes for the lower-costs case of the Great Recession with and without a home-buying subsidy. While households who buy a first home are better off, households owning a dwelling are worse off. The subsidy increases demand for houses and lowers demand for condos, resulting in a moderated fall in house prices (0.23 percentage points) but an amplified drop in condo prices (0.48 percentage points). Rental rates show a larger drop due to the fall in total rental demand. Homeowners are affected by a lower lump-sum transfer and face lower rental rates once they invest. In total, the net effect of a buying subsidy is a 0.08 percent welfare loss. In sum, a home-buying subsidy does not substantially mitigate the severity of the Great Recession shock, but, if financed by distortionary financing, involves costly redistribution.

7 Conclusions

This paper studies the causes and implications of the rise in the corporate housing rental share during the Great Recession. Homeownership cannot be understood without considering the second best choice: renting. The desirability of each depends on the cost difference between owning versus renting. I developed a new framework to evaluate this tradeoff, and

[34] This intervention satisfies the government budget constraint: the changes in total tax revenues directly affect the lump sum transfers to households. The welfare gains might be sensitive to the choice of financing. Debt financing in the distant future might increase the welfare of currently alive cohorts, but distortionary financing would lower it.

	vs. Lower costs	
	CEV (%)	Fraction $\geq$0
All	-0.082	0.234
Non-owners	0.096	0.548
Owners	-0.167	0.074
Mom&Pop	-0.232	0.000

Table 10: Welfare effects during the Great Recession shock. Welfare comparisons are made for the lower-costs case of the Great Recession with versus without a home-buying subsidy.

I argue that the costs of renting fell due to an improvement in (digital) management technology. This fall in corporate costs can explain the structural shift from owning to renting post-crisis. Without this fall, the Great Recession would have been deeper, and the welfare of owners and investors would have been lower. Financial regulations to curb the size of institutional investors might thus be suboptimal, conditional on competitive rental markets. Policies to promote homeownership could be re-evaluated given the (welfare increasing) rise of the corporate rental sector in rental houses during the Great Recession.

In the first half of the paper, I document a fall in corporate operating costs for houses during the Great Recession. Survey data show that operating costs for corporate-owned rental houses fell relative to owner-occupiers. To rationalize this fall in operating costs, the paper argues that institutional investors needed to have a minimum scale to achieve lower operating costs, and the Great Recession provided an opportunity to expand their portfolios. Housing transaction data show that the average corporate housing firm is larger post-crisis, which is consistent with firms increasing their portfolio sizes.

The second half of the paper presents a heterogeneous-agents life-cycle model with a housing market to evaluate the effect of the reduction in corporate costs for houses. The model features mom-and-pop investors and a corporate rental sector, and two types of dwellings: condos and houses. Dwellings can be owned by homeowners, mom-and-pop investors, or the corporate sector, and these owners differ in the maintenance costs. The corporate sector exhibits two key features: constant returns to scale and free entry. The constant returns to scale aspect allows me to focus on the observed cost reduction in the data, while the free entry condition provides an expected zero-profit condition to set the rental rate.

The model is used to study housing market equilibrium responses to the observed reduction in corporate operating costs during a crisis episode. The economy is perturbed with a set of unexpected shocks to mortgage credit and income, which are expected to last forever but then revert after six years. The exogenous crisis shock lowers the demand for both houses and condos, lowering both dwellings' prices and rental rates, and lowering homeownership rates. The reduction in corporate costs for houses increases rental demand, which moderates the fall in house prices by 1.6 percentage points but lowers the homeownership rate by an additional 3.7 percentage points. During the transition the welfare gains of the corporate-cost reduction are concentrated among homeowners as they experience capital gains, whereas renters benefit from a lower house rental rate only at the end of the crisis.

There are several possible extensions for future research. First, the model of this paper features a competitive corporate rental sector with an expected zero-profit condition. While the model captures a higher ex-post capital gain when the Great Recession shocks revert, it does not capture higher expected capital gains during the Great Recession. Even though higher expected capital gains could partially explain the sudden rise in the corporate rental share for houses, they cannot explain the persistent rise in corporate rental share post-crisis. Second, the competitive corporate rental sector rules out any consideration of market power. If the corporate sector can set a higher rental rate, the welfare changes for renters due to the increase in the corporate ownership of rental houses could be negative. Third, the reduction in operating costs was calibrated based on the operating costs estimation in survey data. Alternatively, one could make the operating costs dependent on the mass of corporate rental houses. This would capture the dependence of the corporate costs on the size of the corporate rental stock.

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Appendices

A Rental Housing Shares and Stocks

This Appendix provides details for the calculations in Section 2. In particular, I first describe the data selections I make. Second, I provide two alternative estimates of rental houses and condos owned by non-individuals. These alternatives show that the increase in rental houses owned by non-individuals is robust to 1) a stricter definition of non-individual investors, and 2) the use of other surveys to determine total stocks of houses and flats. Third, I segment the rental house stocks by year of construction to show that non-individuals increased ownership of both older and newer houses, with a larger increase in the latter.

A.1 Data selection

A key aspect of the Residential Finance Survey in 2001 and of the Rental Housing Finance Survey in 2015 and 2018 is that the unit of reference is the property itself, not the housing unit as in other surveys.

For the Residential Finance Survey in 2001, I make the following choices. First, I construct four groups of dwelling types. I use the variables *numunits* (number of housing units on property) and *rproptype* (property type). First, a 1-unit dwelling must have *numunits* equal to 1 and must have the property type *rproptype* either as a mobile home, a condominium or one with 1 to 4 housing units on less than 10 acres. Second, a 2-4 unit dwelling must have *numunits* above 1 but below 5 and must have a property type *rproptype* to be one with 1 to 4 housing units on less than 10 acres. Third, a 5-49 unit dwelling type must have *numunits* above 4 but below 50. At last, a 50+ unit dwelling type must have *numunits* above 50. I distinguish between two types of owners: individual and non-individual owners. I use the variable *ownertyp* (property owner type). I define individuals as *ownertyp == 1*: "individual investor(s) (includes joint ownership by two or more individuals, such as husband and wife, or by estate)." All other owner types are defined as non-individuals.

For the Rental Finance Housing Survey in 2015 and 2018, I also construct four groups of dwelling types, this time using only the variable *numunits_r* (number of units in property, recode) in the same way as before. The two types of owners are based on the variable *ownent* (current ownership entity), defining individual owners as *ownent ==1*: "individual investor, including joint ownership by two or more individuals, such as a married couple."

The next step is to aggregate the rental ownership shares for dwellings with 1-4 units (houses) and 5+ units (condos) in structure separately. I combine these shares with the housing information as found in the American Community Survey in 2001, 2015 and 2018 to construct housing stock estimates. I use the variable *unitsstr* (units in structure) to distinguish two types of dwellings: dwellings with 1-4 units in its structure and dwellings with 5+ units in its structure. More specifically, for the dwelling type with 1-4 units in structure, I include "1-family house, detached," "1-family house, attached," "2-family building," and "3-4 family building." For the the dwelling type with 5+ units in structure, I include "5-9 family building," "10-19 family building," "20-49 family building," and "50+ family building." Then, using the rental share information for houses from the American Community Survey and the rental ownership shares from the Residential Finance Survey and of the Rental Housing Finance Survey, I finally arrive at the rental stock of houses held by non-individual investors as discussed in Section 2.

A.2 Alternative stock estimates

Next, I provide two alternative estimates relative to the house rental stock estimates presented in Section 2. The first alternative is to use more restrictive criteria for the definition of non-individual investors in the Residential Finance Survey and of the Rental Housing Finance Survey. The second alternative is to not use total stocks of houses or condos from the American Community Survey and instead use only the information from the Residential Finance Survey and of the Rental Housing Finance Survey.[35]

[35]Using the American Community Survey gives more precise rental stock ownership estimates, especially when compared to the American Housing Survey. For instance, the American Housing Survey in 2017 reports a total of 94,154,000 dwellings with 1-4 units in the same structure, while there are only 20,605,000 dwellings with 5+ units in the same structure. In sum, dwellings with 1-4 units in structure make up 82.0 percent of the total dwelling stock. In addition, the American Community Survey in 2018 estimates that dwellings with 1-4 units in structure make up 80.6 percent of the total dwelling stock. In comparison, when the rental stock ownership information in the Rental Housing Finance Survey for 2018 is combined with the American Community Survey rental shares to induce total stocks by dwelling type, dwellings with 1-4 units in structure make up 78.4 percent of the total dwelling stock. Another key difference between these three methods is also that the American Housing Survey and the American Community Survey estimate that there are more rental dwellings with

The first alternative estimate uses a more stringent definition of non-individual investors: in the Residential Finance Survey 2001, I now exclude "Non-profit or church-related institution" and "Fraternal organization" as non-individual owners (*ownertyp == 11 & ownertyp == 13*). Similarly, in the Rental Housing Finance Survey 2015 & 2018, I exclude "Nonprofit organization (including religious institution, labor union, or fraternal organization)" (*ownent == 9*). As can be seen in Table 11, the more stringent definition of non-individuals does lower the estimated non-individual rental share primarily in the year 2001, and to a lesser extent in 2015 and 2018. Hence, the alternative definition would imply only a larger increase in the non-individual rental ownership share and stock of houses.

The second alternative estimate uses only the Residential Finance Survey and the Rental Housing Finance Survey to impute the rental dwelling stocks for both houses and condos owned by non-individuals (jointly with the rental share by structure size from the American Community Survey). As can be seen in Table 11, there is still a large increase in both the houses and condos owned by non-individuals for rental purposes. The only difference compared to the baseline used in Section 2 is that now the condo rental stock owned by non-individuals increased by an estimated 5 million.

Statistics & Year	Baseline	Alternative owner criteria	RFS & RHFS only
Non-individual house (condo) rental share			
2001	16.6% (75.6%)	15.0% (74.3%)	16.6% (75.6%)
2015	22.8% (82.1%)	22.2% (81.1%)	22.8% (82.1%)
2018	27.5% (88.1%)	27.0% (87.5%)	27.5% (88.1%)
Non-individual house (condo) rental stock			
2001	2.86 (11.83)	2.58 (11.63)	2.46 (12.66)
2015	4.84 (15.13)	4.70 (14.95)	5.57 (18.83)
2018	5.68 (17.02)	5.56 (16.91)	6.43 (22.00)

Table 11: Alternative estimates of rental share and rental stock for houses by non-individuals in Section 2. Rental stock is in millions. Data sources: ACS, RFS, and RHFS.

1-4 unit than 5+ units in the same building in 2018: respectively 23.9 million vs. 18.3 million and 20.6 million vs. 19.3 million, while the Rental Housing Finance Survey estimates the opposite: 23.4 million vs. 25.0 million.

A.3 Dwelling age

I segment the rental stock of houses by year built using only information from the Residential Finance Survey and the Rental Housing Finance Survey. For the Residential Finance Survey of 2001, I use the variable *YRBUILT*, while for the Rental Housing Finance Survey of 2015 and 2018, I use the variable *YRNEWBLG_R*.[36] For the Residential Finance Survey of 2001, I allocated the category "1999 and beyond" to the 1990–1999 group. Table 12 shows that non-individuals increased their rental house stock among all the segments of year built from 2001 to 2015, except for the category 1990–1999.

Yr & Yr built	2016–2018	2010–2015	2000–2009	1990–1999	1980–1989	1970–1979	1960–1969	<1959
Non-individual house construction year								
2001	-	-	-	438,946	240,933	291,294	330,135	1,161,591
2015	-	88,000	373,000	139,000	391,000	933,000	559,000	2,898,000
2018	18,000	140,000	762,000	618,000	1,225,000	885,000	339,000	2,218,000
Individual house construction year								
2001	-	-	-	1,126,513	1,214,380	1,651,429	1,474,032	6,880,169
2015	-	72,000	1,323,000	1,303,000	2,080,000	2,179,000	2,273,000	8,990,000
2018	30,000	351,000	1,938,000	1,416,000	1,703,000	2,084,000	1,840,000	7,241,000

Table 12: Rental houses by investor type split by construction year. The number of houses for non-individuals is 2,462,899 in 2001, 5,567,000 in 2015, and 6,426,000 in 2018. The number of houses for individuals is 12,346,523 in 2001, 18,843,000 in 2015, and 16,931,000 in 2018. Note: not all dwellings have their construction year reported. Data sources: RFS and RHFS.

B ZTRAX Data Selection

In this Appendix, I describe the data used in Section 3, the cleaning steps, how I identify institutional investors, and how I identify individual firms to construct size distributions.

B.1 Housing transaction data cleaning

The housing transaction data come from the Zillow Transaction and Assessment Dataset (ZTRAX), a large dataset containing deeds for the United States. Each record contains the date of transfer, the address of the property, the type of property, the sale price, and the

[36] While the variable *YROLDBLG_R* is the correct variable, the online data tables show that the counts by year built are almost identical between the two variables. The variable *YROLDBLG_R* is available only in the internal use file, not in the public use file.

names of the buyers and sellers. I use the transaction data for the time period from January 1st, 2000, to December 31st, 2019. As I am interested in housing stocks, I use only transactions with a nonmissing parcel identifier (*importparcelid*). This is a unique identifier used to identify parcels across different years. I start with 387 million observations.

I use the following criteria to clean the data. First, I restrict the data to ownership transfers, dropping observations that exclusively refer to mortgages or foreclosures.[37] Second, I drop all rerecorded documents.[38] Third, I drop transactions with the deed type "Life Estate" or "Cancellation."[39] Fourth, I select only transactions with a non-missing purchase price (*salespriceamount*) of at least $10,000. Fifth, I drop intrafamily transfers (where *intrafamily-transferflag == "Y"*). This selection step leaves me with 102 million observations.

Next, I select only residential property transfers, I use the property land use standard codes for the latest available tax year for each parcel identifier.[40] I split the residential property transfers in single-family and multi-family properties using the property land use standard codes. Table 13 summarizes this classification.[41] This leaves 93.1 million transactions.

B.2 Identify institutional investors

To identify institutional investors, I follow the approach taken by Garriga et al. (2023) and Graham (2020). This Section both categorizes institutional purchases and identifies specific institutional purchasers by name and address. I use the ZTRAX buyer classification to split buyer names into individual and non-individual names. Before I categorize non-individual

[37] I base the selection on *dataclassstndcode*, where I drop "Mortgage, " "Affidavit Death of Trustee/Successor Trustee," "Affidavit of Trust," "Stand Alone Purchase Money Mortgage," "Declaration of Easement," "Documents to correct Map Reference/Parking Space/Easements," "Assessment Historical Sales," "Hawaii - Standalone Mortgage," "Deeds that consumate a lot line adjustment," and "Foreclosure."

[38] More specifically, all observations where *rerecordedcorrectionstndcode* is nonmissing.

[39] I require that the document types are not one of the following: "Cancellation of Agreement of Sale," "Cancellation of Contract of Sale," "Cancellation of Land Contract," "Cancellation of Notice of Sale," "Cancellation of Trustee's Deed," "Life Estate Deed/Deed Reserving/Confirming Life Estate," "Life Estate Quitclaim Deed," or "Life Estate Warranty Deed (Reserving/Confirming Life Estate)."

[40] The results are robust to the case where I use the tax assessment data from the tax-year following the sale.

[41] In this step, I drop any property land use standard code starting with Agricultural ("AG"), Commercial and Industrial ("CI"), Communication ("CM"), Exempt ("EX"), Government ("GV"), Improved land ("IM"), Industrial ("IN"), Mixed Use ("MX"), Recreational ("RC"), Unimproved land ("UL"), Vacant Land/Lot ("VL"), Commercial Office ("CO"), Commercial Retail ("CR"), Exempt & Institutional ("EI"), Historical & Cultural ("HI"), Industrial-Heavy ("IH"), Miscellaneous ("MS"), Personal Property ("PP"), and Transportation ("TR"). I also drop observations which have a missing property land use standard code. At last, I also drop any of the following land use codes: miscellaneous improvement ("RR118"), residential parking garage ("RR117"), residential common area ("RR110"), and timeshare ("RR111").

Single-family: single family residential (RR101); townhouse (RR104); row house (RR108); mobile home (RR103); cluster home (RR105); seasonal, cabin, vacation residence (RR112); bungalow (RR113); zero lot line (RR114); garden home (RR119); patio home (RR116); manufactured, modular, prefabricated homes (RR115); rural residence (RR102); planned unit development (RR109); residential general (RR000); inferred single family residential (RR999).
Multi-family: condominium (RR106); cooperative (RR107); landominium (RR120); duplex (2 units, any combination) (RI101); triplex (3 units, any combination) (RI102); quadruplex (4 units, any combination) (RI103); apartment building (5+ units) (RI104); apartment building (100+ units) (RI105); high-rise apartment (RI107); garden apartment, court apartment (5+ units) (RI106); mobile home park, trailer park (RI109); dormitory, group quarters (residential) (RI113); fraternity house, sorority house (RI111); apartment (generic) (RI112); multifamily dwelling (generic any combination 2+) (RI110); boarding house rooming house apt hotel transient lodging (RI108); residential condominium development (association assessment) (RI114); residential income general (multi family) (RI000).

Table 13: Classification based on property land use standard codes from ZTRAX (Zillow, 2022).

purchases in institutional purchases and non-institutional purchases, I first identify the non-individual buyers which make multiple purchases over time (i.e. identical companies). This intermediate step allows me to construct a size distribution of institutional investors.

To identify companies with misspellings in either the name or the address, I use a fuzzy matching algorithm to match non-individual buyers based on the street address. More specifically, I append the buyermailfullstreetaddress with the buyermailaddressunitdesignatorco and the buyermailaddressunitnumber, if the last two fields are available.[42] The fuzzy match algorithm over zip codes requires that the city, the zip code, the house number, and the unit number are the same. The threshold rule for the fuzzy matching algorithm for addresses is set to the default value of 0.8.[43] Then, I group non-individual buyers by name. To avoid coincidental name matches, I group non-individual buyers only if their buyernonindividualname_1 are the same, conditional of having a name of at least 8 characters long.[44] At last, I drop all observations that have a missing individual name and a missing nonindi-

[42]The unit designator code has values such as apt, bsmt, bldg, unit. The buyermailaddressunitnumber identifies units with an identical street address and number, for instance with alphabetical identifiers.

[43]This choice does not materially affect the results. As a robustness check, I set the value to 1.

[44]Given that this step could still bundle coincidentially identical firm names from firms out of different states, I also provide the firm size distribution calculations when I match only based on address.

vidual name (both buyerlastname_1 and buyernonindividualname_1 are missing).

To categorize institutional purchases, I make use of the buyer description codes that are provided in the raw data. All missing buyer description codes for observations with a nonempty non-individual name are set to Company ("CO"), while all missing buyer description codes for observations with an empty non-individual name are set to Individual ("ID"). I define institutional investors as Legal Partnerships ("PT"), Private Companies ("CO"), and Trusts ("TR"). I exclude builders/developers, government agencies, national and regional authorities, nonprofit organizations, homeowner associations, hospitals, universities, churches, airports, banks, thrifts, credit unions, relocation companies, living trusts and family trusts.[45] To filter out these non-individual buyers, the buyer description codes are adjusted based on the buyer name.

Then, following Garriga et al. (2023), I drop the transactions for five states: Mississippi, Missouri, Montana, Utah and Wyoming, as these states or counties do not require that the sale price is submitted to the county office.

B.3 Calculate market share

To make the distinction between dwellings with 1-4 units in structure and dwellings with 5+ units in structure, I use the variable *noofunits*, following Garriga et al. (2023). I make the following adjustments for dwellings if the number of units is missing. First, I set the number of units to 2 if propertylandusestndcode is "RI101." Second, I set the number of units to 2 if propertylandusestndcode is "RI110." Third, I set the number of units to 3 if propertylandusestndcode is "RI102." Fourth, I set the number of units to 4 if propertylandusestndcode is "RI103." Fifth, I set the number of units to 5 if propertylandusestndcode is "RI104." Sixth, I set the number of units to 5 if propertylandusestndcode is "RI106." Seventh, I set the number of units to 100 if propertylandusestndcode is "RI105." For the rest of the multi-family property types and all the single-family types that do not specify number of units, I assign 1 unit.

For both dwellings with 1-4 units in structure and dwellings with 5+ units in structure,

[45] Living trusts and family trusts are identified based on name and based on the following raw buyer description codes: Family Irrevocable Trust ("FI"), Family Living Trust ("FL"), Family Revocable Trust ("FR"), Family Trust ("FT"), Irrevocable Living Trust ("IL"), and Living Trust ("LV").

I calculate the market share of institutional investors by purchase price and by number of units. For both calculations I divide the total institutional purchases by the total purchases, i.e. purchases by institutional and individual buyers.

C ZTRAX Robustness Exercises

In this Appendix, I present robustness checks for the results presented in Section 2. First, I show the purchase share (by number of units and price-weighted) for single-family dwellings. Figure 16 shows that the increase in institutional investors' market share is also present in the market for single-family dwellings.

Figure 16: Institutional investors' purchase share by number of units and price-weighted. This purchase share includes only single family dwellings. Data from ZTRAX (Zillow, 2022).

Next, I summarize the firm size distributions by matching firms only on address (and not names). Table 14 confirms that the firm distributions for both existing firms and new firms have shifted towards larger firms post-crisis.

At last, I perform a robustness check on the choice of threshold for the fuzzy matching on address. More specifically, even when I require an exact match (setting the threshold at 1), the results are mostly unaffected. Tables 15 and 16 show the resulting firm size distributions with and without matching on names.

D Operating Costs Data

This Appendix provides additional information regarding data selection and summary statistics for Section 3.1.

		Firms existing in 2007 & 2015		New firms
		2007	2015	2015
1 unit	Share of operating firms (%)	86.7	86.9	78.5
	Market share (%)	53.4	46.1	40.2
	Average size	1.00	1.00	1.00
2-9 units	Share of operating firms (%)	12.0	11.5	19.8
	Market share (%)	22.5	19.3	31.3
	Average size	3.04	3.16	3.09
10+ units	Share of operating firms (%)	1.2	1.6	1.7
	Market share (%)	24.1	34.6	28.6
	Average size	31.41	41.73	32.88
Total	**Average size**	**1.62**	**1.89**	**1.95**

Table 14: Distribution of non-individual buyers over total unit categories 1, 2-9 and 10+ units, for dwellings with 1-4 units in structure. Only use fuzzy matching algorithm on address to match firms, not names. Data from ZTRAX (Zillow, 2022).

		Firms existing in 2007 & 2015		New firms
		2007	2015	2015
1 unit	Share of operating firms (%)	81.4	78.7	73.5
	Market share (%)	44.9	37.2	33.2
	Average size	1.00	1.00	1.00
2-9 units	Share of operating firms (%)	17.1	19.3	24.2
	Market share (%)	28.4	28.1	34.6
	Average size	3.01	3.08	3.16
10+ units	Share of operating firms (%)	1.5	2.0	2.3
	Market share (%)	26.7	34.7	32.2
	Average size	31.51	35.96	31.51
Total	**Average size**	**1.81**	**2.11**	**2.21**

Table 15: Distribution of non-individual buyers over total unit categories 1, 2-9 and 10+ units, for dwellings with 1-4 units in structure. Matching on names and exact address. Data from ZTRAX (Zillow, 2022).

To get to the operating costs of an owner-occupier, I use the American Housing Survey for 2001, 2015 and 2019. I split the sample into owner-occupied dwellings with 1-4 units in structure (houses) and 5+ units in structure (condos). I use the variable ”BLD” for the years 2015 and 2019, and I use the variable ”nunits” for the year 2001. To construct the operating costs for owner-occupiers, I use the maintenance cost variable ”MAINTAMT” for the years

		Firms existing in 2007 & 2015		New firms
		2007	2015	2015
1 unit	Share of operating firms (%)	86.8	86.9	78.5
	Market share (%)	53.5	46.2	40.2
	Average size	1.00	1.00	1.00
2-9 units	Share of operating firms (%)	12.0	11.5	19.8
	Market share (%)	22.5	19.3	31.3
	Average size	3.04	3.16	3.08
10+ units	Share of operating firms (%)	1.2	1.6	1.7
	Market share (%)	24.0	34.4	28.5
	Average size	31.32	41.60	32.89
Total	**Average size**	**1.62**	**1.88**	**1.95**

Table 16: Distribution of non-individual buyers over total unit categories 1, 2-9 and 10+ units, for dwellings with 1-4 units in structure. Matching only on exact address. Data from ZTRAX (Zillow, 2022).

2015 and 2018, and the variable ”cstmnt” for the year 2001. Then, to construct operating costs for owner-occupiers, I add the average improvement cost for the AHS 2005–2019. The average annual improvement costs are calculated using the variable ”REMODAMT” (total cost of home improvement jobs in last two years) for the years 2015-2019, and the variable ”rac” for 2005–2013 (cost of replacements or additions to unit). I truncate the annual improvement costs at $20,000 in 2018 dollars. The average annual improvement costs for houses are $2,406 and for condos are $1,245, in 2018 dollars. The home value variable is ”value” in the year 2001 and ”MARKETVAL” in the years 2015 and 2019. In addition, I save the sizes of the structures, which I split in seven categories, using the variable ”nunits” for 2001 and ”BLD” for 2015 & 2018. Then, I construct categories of real estate property taxes. To remain consistent with the Residential Finance Survey and the Rental Housing Finance Survey, I construct the same categories as provided in the Rental Housing Finance Survey for 1 unit in structure. I compute year purchased using the year in which the householder moved in: the variable ”hhmove” for 2001, 2015 & 2019.

For operating costs of rental dwellings, I use property-level data from the Residential Finance Survey in 2001 and the Rental Housing Finance Survey in 2015 and 2018. I construct rental operating costs by investor type (individual vs. non-individual) and dwelling type (houses and condos), with the same selection steps as explained in Appendix A. Given that operating costs could differ by non-individual owner type, I apply several filters to construct the data sample for the regressions. For the Residential Finance Survey in 2001, I select rental properties only if 1) there are no rent receipts for business or office units, 2) there are positive rent receipts for residential units, and 3) the property is not owned by a non-profit or church-related institution or by a fraternal organization. For the Rental Housing Finance Survey in 2015 and 2018, I select rental properties if 1) there are no positive total receipts from commercial rent, 2) there are positive monthly rental receipts per housing unit, and 3) the current ownership entity is not a nonprofit organization (including religious institution, labor union, or fraternal organization). For the year 2001, the maintenance and management costs variables are ”annmaint” (annual maintenance and repair expenses) and ”annadmin” (annual project management and administration). For the years 2015 and 2018, the maintenance and management variables are ”oprep” (maintenance and repair expenses) and ”opmng.” I drop all observations with a strictly negative value per unit value for the combined maintenance and management costs.

Next, I provide more detail for the rental dwelling control variables used in the operating costs regressions in Section 3.1. For housing values, in 2001 I use the variable ”r_value_per_hu” (value per housing unit) and ”mrktvalpu_r” (value per unit, recode). In addition, I save the sizes of the structures, which I compute using ”numunits” in 2001 and ”numunits_r” in 2015 & 2018. Then, I save the real estate property taxes as described in Section 3.1, using ”annretax” in 2001 and ”optax_r” in 2015 & 2018. At last, I save whether the property has a property manager using the variable ”usemangr” in 2001 and ”mngmnt” in 2015 & 2018. To capture the purchase year, I use the variable ”YRACQ” in 2001 (year owner acquired the property), and the variable ”YRPROPACQ_R” in 2015 & 2018 (year property acquired by owner, recode).

The summary statistics for the resulting sample for houses (1-4 units) from the American Housing Survey and the Residential Finance Survey and the Rental Housing Finance Survey are displayed in Table 17.

		Owner-occupiers			Ind. investors			Non-ind. investors		
		2001	2015	2018	2001	2015	2018	2001	2015	2018
Maintenance	Mean	$682	$965	$950	$1,379	$1,479	$1,917	$1,698	$1,558	$1,734
	Pr(> 0)	0.70	0.89	0.87	0.74	0.96	0.94	0.80	0.76	0.91
Management	Mean	-	-	-	$147	$288	$414	$910	$256	$586
	Pr(> 0)	-	-	-	0.13	0.19	0.21	0.35	0.33	0.33
Units in structure	1 unit	0.98	0.98	0.98	0.60	0.60	0.55	0.58	0.48	0.61
	2 units	0.01	0.01	0.01	0.23	0.20	0.18	0.25	0.15	0.12
	3-4 units	0.01	0.01	0.01	0.17	0.20	0.27	0.17	0.37	0.27
Unit value ($1000s)	Mean	236	286	331	131	230	250	152	198	235
Management	Pr(> 0)	-	-	-	0.12	0.17	0.20	0.34	0.28	0.42
Observations		27,948	31,990	29,881	1,335	238	309	167	76	103

Table 17: Summary statistics for house operating costs. Averages are survey weighted, and in 2018 dollars. The maintenance and management costs are truncated at $20,000 in 2018 dollars. Owner-occupier data is from the American Housing Survey. Investor information is from the Residential Finance Survey and the Rental Housing Finance Survey.

E Operating Costs Robustness Exercises

In this Appendix, I first provide robustness exercises for the regression results presented in Section 3.1. Then, I redo all the regressions for condos (dwelling with 5+ units in structure).

E.1 Robustness

I perform two robustness exercises. First, I include the survey year 2018 in the regression; second, I make use of respective survey weights in the combined survey data.

Extended survey time

Next, I include the data for the Rental Housing Finance Survey in year 2018. Given that the American Housing Survey has waves only in 2017 and 2019, I make the decision to include the 2019 wave of the American Housing Survey. Running the same regression specifications as in Section 3.1, using Equation (1), Table 18 shows that the results of 2015 extend to 2018: the operating costs for institutions remain lower in 2018 than in 2001. The operating-cost premium for institutional investors does slightly rise in 2018 relative to 2015. Note that, especially when adding more controls such as in regression specifications (9) and (10), the difference between the estimated interaction effects for the years 2015 and 2018 becomes insignificant.

Dependent variable: ln*Costs*	*Extended Survey time by including 2018*				
	(6)	(7)	(8)	(9)	(10)
Mom&pop	0.228***	0.229***	0.261***	0.224***	0.217***
	(0.008)	(0.009)	(0.010)	(0.010)	(0.010)
Mom&pop x 2015	0.016	0.016	0.010	-0.015	- 0.010
	(0.021)	(0.021)	(0.022)	(0.022)	(0.022)
Mom&pop x 2018	0.053***	0.055***	0.058***	0.023	0.027
	(0.019)	(0.019)	(0.020)	(0.020)	(0.020)
Institution	0.438***	0.439***	0.468***	0.373***	0.368***
	(0.023)	(0.023)	(0.024)	(0.024)	(0.024)
Institution x 2015	-0.159***	-0.158***	-0.160***	-0.144***	-0.134***
	(0.041)	(0.041)	(0.042)	(0.041)	(0.041)
Institution x 2018	-0.109***	-0.104***	-0.096***	-0.137***	-0.130***
	(0.037)	(0.037)	(0.038)	(0.038)	(0.038)
House value controls	Y	Y	Y	Y	Y
Structure size controls	N	Y	Y	Y	Y
Property tax controls	N	N	Y	Y	Y
Property manager control	N	N	N	Y	Y
Year purchased controls	N	N	N	N	Y
N	84,535	84,535	84,535	84,535	83,714
R^2	0.0885	0.0887	0.0954	0.0989	0.1038

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{***}p < 0.01$.
Standard errors are in parentheses.

Table 18: Regression of ln*Costs* on owner type: owner-occupier, individual investor and non-individual investor, including interaction effects with time. Data sources: AHS, RFS, and RHFS. Use years 2001, 2015 and 2018.

Weighted regression results

Next, I perform a robustness exercise where I use the weights of the two surveys. I first perform the regressions without the year 2018, after which I also perform the regressions with year 2018. Tables 19 and 20 summarize the results from the ten regression specifications. Running the regression Equation (1) with survey weights shows that the fall in house operating-cost premium estimates does not change significantly compared to the unweighted regression. The only effect of including weights is a reduction in the confidence bands around the operating-cost premium estimates.

Dependent variable: ln*Costs*	*Use survey weights from data sets*				
	(11)	(12)	(13)	(14)	(15)
Mom&pop	0.219***	0.231***	0.256***	0.206***	0.200***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Mom&pop x 2015	-0.012	-0.010	0.000	-0.030***	- 0.015
	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)
Institution	0.405***	0.418***	0.438***	0.307***	0.301***
	(0.015)	(0.015)	(0.015)	(0.016)	(0.016)
Institution x 2015	-0.182***	-0.171***	-0.135***	-0.118***	-0.100***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
House value controls	Y	Y	Y	Y	Y
Structure size controls	N	Y	Y	Y	Y
Property tax controls	N	N	Y	Y	Y
Property manager control	N	N	N	Y	Y
Year purchased controls	N	N	N	N	Y
N	57,806	57,806	57,806	57,806	57,806
R^2	0.1041	0.1050	0.1152	0.1347	0.1401

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{***}p < 0.01$.
Standard errors are in parentheses.

Table 19: Regression of ln*Costs* on owner type: owner-occupier, individual investor and non-individual investor, including interaction effects with time. Data sources: AHS, RFS, and RHFS. Use years 2001 & 2015. Use survey weights.

Dependent variable: ln*Costs*	*Extended survey time and survey weights*				
	(16)	(17)	(18)	(19)	(20)
Mom&pop	0.219***	0.238***	0.266***	0.222***	0.216***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Mom&pop x 2015	-0.012	-0.009	-0.020**	-0.043***	- 0.031***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Mom&pop x 2018	0.080***	0.089***	0.079***	0.046***	0.054***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Institution	0.405***	0.425***	0.448***	0.338***	0.331***
	(0.015)	(0.016)	(0.016)	(0.016)	(0.016)
Institution x 2015	-0.182***	-0.165***	-0.154***	-0.141***	-0.128***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Institution x 2018	-0.101***	-0.094***	-0.089***	-0.121***	-0.110***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
House value controls	Y	Y	Y	Y	Y
Structure size controls	N	Y	Y	Y	Y
Property tax controls	N	N	Y	Y	Y
Property manager control	N	N	N	Y	Y
Year purchased controls	N	N	N	N	Y
N	84,535	84,535	84,535	84,535	83,714
R^2	0.1139	0.1160	0.1254	0.1396	0.1452

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{***}p < 0.01$.
Standard errors are in parentheses.

Table 20: Regression of ln*Costs* on owner type: owner-occupier, individual investor and non-individual investor, including interaction effects with time. Data sources: AHS, RFS, and RHFS. Use years 2001, 2015 and 2018. Use survey weights.

E.2 Regressions for condos

I run the same regressions as in Section 3.1 in this Appendix for condos (dwellings with 5+ units in structure). I use this information to calibrate the model in Section 5. In terms of operating costs, I include only the management costs for rental units and not the maintenance cost, as typically HOA fees are charged to cover regular maintenance for condos, and these are equal for both homeowners and rental investors.

From Table 21 it is clear that institutions and mom-and-pop investors over time also saw a smaller operating-cost premium relative to homeowners for condos. However, as the mean operating cost of condos in 2001 is only \$1,622 in 2018 dollars, rising slightly to \$1,783 in 2015, the changes over time in terms of dollar cost are significantly smaller.

Dependent variable: ln*Costs*	(1)	(2)	(3)	(4)	(5)
Mom&pop	0.235***	0.226***	0.303***	0.191***	0.181***
	(0.015)	(0.015)	(0.037)	(0.037)	(0.037)
Mom&pop x 2015	-0.179***	-0.171***	-0.188***	-0.200***	-0.203***
	(0.051)	(0.052)	(0.052)	(0.051)	(0.051)
Institution	0.415***	0.380***	0.438***	0.311***	0.305***
	(0.014)	(0.014)	(0.037)	(0.037)	(0.037)
Institution x 2015	-0.229***	-0.213***	-0.213***	-0.227***	-0.241***
	(0.024)	(0.024)	(0.024)	(0.024)	(0.025)
House value controls	Y	Y	Y	Y	Y
Structure size controls	N	Y	Y	Y	Y
Property tax controls	N	N	Y	Y	Y
Property manager control	N	N	N	Y	Y
Year purchased controls	N	N	N	N	Y
N	16,360	16,360	16,360	16,360	16,360
R^2	0.1035	0.1078	0.1176	0.1351	0.1473

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{***}p < 0.01$.
Standard errors are in parentheses.

Table 21: Regression of ln*Costs* on owner type: owner-occupier, individual investor and non-individual investor, for dwellings with 5+ units in structure: condos. Including interaction effects with time. Data sources: AHS, RFS, and RHFS. Use only the years 2001 & 2015.

Dependent variable: ln*Costs*	*Extended Survey time by including 2018*				
	(6)	(7)	(8)	(9)	(10)
Mom&pop	0.235***	0.229***	0.317***	0.204***	0.202***
	(0.015)	(0.015)	(0.034)	(0.034)	(0.034)
Mom&pop x 2015	-0.179***	-0.174***	-0.201***	-0.212***	- 0.218***
	(0.051)	(0.051)	(0.051)	(0.051)	(0.050)
Mom&pop x 2018	-0.181***	-0.168***	-0.182***	-0.184***	-0.199***
	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)
Institution	0.415***	0.391***	0.455***	0.325***	0.327***
	(0.014)	(0.015)	(0.033)	(0.034)	(0.034)
Institution x 2015	-0.229***	-0.218***	-0.226***	-0.240***	-0.254***
	(0.023)	(0.023)	(0.024)	(0.023)	(0.024)
Institution x 2018	-0.251***	-0.243***	-0.241***	-0.253***	-0.269***
	(0.024)	(0.024)	(0.024)	(0.024)	(0.025)
House value controls	Y	Y	Y	Y	Y
Structure size controls	N	Y	Y	Y	Y
Property tax controls	N	N	Y	Y	Y
Property manager control	N	N	N	Y	Y
Year purchased controls	N	N	N	N	Y
N	18,171	18,171	18,171	18,171	18,121
R^2	0.1107	0.1132	0.1238	0.1413	0.1531

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{***}p < 0.01$.
Standard errors are in parentheses.

Table 22: Regression of ln*Costs* on owner type: owner-occupier, individual investor and non-individual investor, including interaction effects with time. For dwellings with 5+ units in structure: condos. Data sources: AHS, RFS, and RHFS. Use years 2001, 2015 and 2018.

Dependent variable: ln*Costs*	*Use survey weights from data sets*				
	(11)	(12)	(13)	(14)	(15)
Mom&pop	0.167***	0.172***	0.260***	0.135***	0.117***
	(0.012)	(0.012)	(0.034)	(0.034)	(0.033)
Mom&pop x 2015	-0.103***	-0.112***	-0.145***	-0.186***	- 0.169***
	(0.021)	(0.021)	(0.021)	(0.021)	(0.022)
Institution	0.389***	0.385***	0.446***	0.285***	0.263***
	(0.011)	(0.011)	(0.033)	(0.033)	(0.033)
Institution x 2015	-0.268***	-0.267***	-0.264***	-0.271***	-0.241***
	(0.015)	(0.015)	(0.016)	(0.016)	(0.016)
House value controls	Y	Y	Y	Y	Y
Structure size controls	N	Y	Y	Y	Y
Property tax controls	N	N	Y	Y	Y
Property manager control	N	N	N	Y	Y
Year purchased controls	N	N	N	N	Y
N	16,359	16,359	16,359	16,359	16,359
R^2	0.1116	0.1141	0.1282	0.1557	0.1819

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{***}p < 0.01$.
Standard errors are in parentheses.

Table 23: Regression of ln*Costs* on owner type: owner-occupier, individual investor and non-individual investor, including interaction effects with time. For dwellings with 5+ units in structure: condos. Data sources: AHS, RFS, and RHFS. Use years 2001 & 2015. Use survey weights.

Dependent variable: ln*Costs*	*Extended survey time and survey weights*				
	(16)	(17)	(18)	(19)	(20)
Mom&pop	0.167***	0.170***	0.244***	0.126***	0.121***
	(0.013)	(0.013)	(0.030)	(0.030)	(0.030)
Mom&pop x 2015	-0.103***	-0.111***	-0.154***	-0.197***	-0.184***
	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)
Mom&pop x 2018	-0.090***	-0.096***	-0.116***	-0.112***	-0.133***
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
Institution	0.389***	0.395***	0.433***	0.276***	0.269***
	(0.011)	(0.012)	(0.030)	(0.030)	(0.030)
Institution x 2015	-0.268***	-0.272***	-0.279***	-0.286***	-0.264***
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Institution x 2018	-0.213***	-0.218***	-0.214***	-0.228***	-0.242***
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
House value controls	Y	Y	Y	Y	Y
Structure size controls	N	Y	Y	Y	Y
Property tax controls	N	N	Y	Y	Y
Property manager control	N	N	N	Y	Y
Year purchased controls	N	N	N	N	Y
N	18,170	18,170	18,170	18,170	18,170
R^2	0.1152	0.1177	0.1337	0.1650	0.1864

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{***}p < 0.01$.
Standard errors are in parentheses.

Table 24: Regression of ln*Costs* on owner type: owner-occupier, individual investor and non-individual investor, including interaction effects with time. For dwellings with 5+ units in structure: condos. Data sources: AHS, RFS, and RHFS. Use years 2001, 2015 and 2018. Use survey weights.

F Household Decision Problems

F.1 Owner

First, the owner decides whether to sell its primary dwelling or not.

$$\bar{\boldsymbol{V}}_j^o(a,\epsilon,\phi,b,h^o,0,\gamma) = \max \begin{cases} \bar{V}_j^{o-stay}(a,\epsilon,\phi,b,h^o,0,\gamma), \\ \bar{V}_j^{o-sell}(a,\epsilon,\phi,b,h^o,0,\gamma). \end{cases} \tag{25}$$

If the owner keeps its primary dwelling, it decides whether to not adjust, refinance or buy a second dwelling.

$$\bar{V}_j^{o-stay}(a,\epsilon,\phi,b,h^o,0,\gamma) = \max \begin{cases} V_j^{o-stay-n}(a,\epsilon,\phi,b,h^o,0,\gamma), \\ V_j^{o-stay-r}(a,\epsilon,\phi,b,h^o,0,\gamma), \\ \bar{V}_j^{o-stay-b}(a,\epsilon,\phi,b,h^o,0,\gamma). \end{cases} \tag{26}$$

If the owner sells its primary dwelling, it decides whether to live with its parents, rent or buy a new primary dwelling.

$$\bar{V}_j^{o-sell}(a,\epsilon,\phi,b,h^o,0,\gamma) = \max \begin{cases} V_j^{o-sell-p}(a,\epsilon,\phi,b,h^o,0,\gamma), \\ \bar{V}_j^{o-sell-r}(a,\epsilon,\phi,b,h^o,0,\gamma), \\ \bar{V}_j^{o-sell-b}(a,\epsilon,\phi,b,h^o,0,\gamma). \end{cases} \tag{27}$$

I discuss each of the six cases below, starting with own-stay.

1. If the owner stays and does not adjust, it solves the following problem:

$$V_j^{o-stay-n}(a,\epsilon,\phi,b,h_i^o,0,\gamma) = \max_{c,a'} u(c,s) + \beta E[\bar{\boldsymbol{V}}_{j+1}^o(a',\epsilon',\phi',b',h_i^o,0,\gamma')] \tag{28}$$

$$s.t. \quad c + a' + h_i^o(\delta + \tau_p P_i) + \pi_j(b,r_b) \leq a(1+r) + y(\epsilon) + T,$$

$$s = \gamma h_{par} + (1-\gamma)\omega h_i^o,$$

$$b' = (1+r_b)b - \pi_j(b,r_b),$$

$$i \in \{c,h\}.$$

2. If the owner stays and refinances, it solves the following problem:

$$V_j^{o-stay-r}(a,\epsilon,\phi,b,h_i^o,0,\gamma) = \max_{c,b^n,a'} u(c,s) + \beta E[\bar{\boldsymbol{V}}_{j+1}^o(a',\epsilon',\phi',b',h_i^o,0,\gamma')] \tag{29}$$

$$s.t. \quad c + a' + b + h_i^o(\delta + \tau_p P_i) + \pi_j(b^n, r_b) \leq a(1+r) + y(\epsilon) + b^n - F_o - F_{refi} + T,$$

$$s = \gamma h_{par} + (1-\gamma)\omega h_i^o,$$

$$b' = (1+r_b)b^n - \pi_j(b^n, r_b),$$

$$\pi_j(b^n, r_b) \leq \lambda_{DTI} y(\epsilon),$$

$$b^n \leq \lambda_{LTV}[P_i h_i^o],$$

$$i \in \{c,h\}.$$

3. If the owner stays and buys a second dwelling, it solves:

$$\bar{V}_j^{o-stay-b}(a,\epsilon,\phi,b,h_i^o,0,\gamma) = \max_{k\in\{c,h\}} V_{j,k}^{o-stay-b}(a,\epsilon,\phi,b,h_i^o,0,\gamma), \tag{30}$$

$$V_{j,k}^{o-stay-b}(a,\epsilon,\phi,b,h_i^o,0,\gamma) = \max_{c,b^n} u(c,s) + \beta E[\bar{\boldsymbol{V}}_{j+1}^{m\&p}(a',\epsilon',\phi',b',h_i^o,h_k^{mp},\gamma')] \tag{31}$$

$$s.t. \quad c + a' + \pi_j(b^n, r_b) + h_i^o(\delta + \tau_p P_i) + (1+f_b)P_k h_k^{mp} \leq a(1+r) + y(\epsilon) + r_k^{net} + b^{net} + T,$$

$$s = \gamma h_{par} + (1-\gamma)\omega h_i^o,$$

$$r_k^{net} = (r_k - \phi_k - \tau_p P_k)h_k^{mp}(1-\tau_{hi}) + \tau_{hi} m_\tau P_k h_k^{mp},$$

$$b^{net} = b^n - F_o - b,$$

$$b^n \leq \lambda_{LTV}[P_i h_i^o + P_k h_k^{mp}],$$

$$\pi_j(b^n, r_b) \leq \lambda_{DTI} y(\epsilon),$$

$$b' = (1+r_b)b^n - \pi_j(b^n, r_b),$$

$$i \in \{c,h\}.$$

4. If the owner sells and chooses to live with their parents, it solves:

$$V_j^{o-sell-p}(a,\epsilon,\phi,b,h_i^o,0,\gamma) = \max_{c,a'} u(c,s) + \beta E[\bar{\boldsymbol{V}}_{j+1}^{no}(a',\epsilon')] \tag{32}$$

$$s.t. \quad c + a' \leq a(1+r) + y(\epsilon) + (1-f_s)P_i h_i^o - F_s - b + T,$$

$$s = h_{parents},$$

$$i \in \{c,h\}.$$

5. If the owner sells and chooses to rent, it has to decide the primary dwelling type:

$$\bar{V}_j^{o-sell-r}(a,\epsilon,\phi,b,h_i^o,0,\gamma) = \max_{k\in\{c,h\}} V_{j,k}^{o-sell-r}(a,\epsilon,\phi,b,h_i^o,0,\gamma), \tag{33}$$

$$V_{j,k}^{o-sell-r}(a,\epsilon,\phi,b,h_i^o,0,\gamma) = \max_{c,a'} u(c,s) + \beta E[\bar{\boldsymbol{V}}_{j+1}^{no}(a',\epsilon')] \tag{34}$$

$$s.t. \quad c + r_k s + a' \leq a(1+r) + y(\epsilon) + (1-f_s)P_i h_i^o - F_s - b + T,$$

$$s = h_k,$$

$$i \in \{c,h\}.$$

6. If the owner sells and chooses to buy, it has to decide the primary dwelling type:

$$\bar{V}_j^{o-sell-b}(a,\epsilon,\phi,b,h_i^o,0,\gamma) = \max_{k\in\{c,h\}} V_{j,k}^{o-sell-b}(a,\epsilon,\phi,b,h_i^o,0,\gamma), \tag{35}$$

$$V_{j,k}^{o-sell-b}(a,\epsilon,\phi,b,h_i^o,0,\gamma) = \max_{c,a',b^n} u(c,s) + \beta E[\bar{\boldsymbol{V}}_{j+1}^{o}(a',\epsilon',\phi',b',h_k^o,0,\gamma')] \tag{36}$$

$$s.t. \quad c + h_k^o[(1+f_b)P_k + \delta + \tau_p P_k] + a' + \pi_j(b^n,r_b)$$

$$\leq a(1+r) + y(\epsilon) + (1-f_s)P_i h_i^o - F_s + b^{net} + T,$$

$$b^{net} = b^n - F_o - b,$$

$$b' = (1+r_b)b^n - \pi_j(b^n,r_b),$$

$$s = \omega h_k^o,$$

$$b^n \leq \lambda_{LTV} P_k h_k^o,$$

$$\pi_j(b^n,r_b) \leq \lambda_{DTI} y(\epsilon),$$

$$i \in \{c,h\},$$

$$\gamma = 0,\ \phi = \overline{\phi}.$$

F.2 Mom&Pop

The mom&pop first decides whether to sell its second dwelling or not:

$$\bar{\boldsymbol{V}}_j^{m\&p}(a,\epsilon,\phi,b,h^o,h^{mp},\gamma) = \max \begin{cases} \bar{V}_j^{m\&p-stay}(a,\epsilon,\phi,b,h^o,h^{mp},\gamma), \\ \bar{V}_j^{m\&p-sell}(a,\epsilon,\phi,b,h^o,h^{mp},\gamma). \end{cases} \tag{37}$$

If the mom&pop keeps its second dwelling, it decides whether to not adjust, to refinance or to move its primary dwelling.

$$\bar{V}_j^{m\&p-stay}(a,\epsilon,\phi,b,h^o,h^{mp},\gamma) = \max \begin{cases} V_j^{m\&p-stay-n}(a,\epsilon,\phi,b,h^o,h^{mp},\gamma), \\ V_j^{m\&p-stay-r}(a,\epsilon,\phi,b,h^o,h^{mp},\gamma), \\ \bar{V}_j^{m\&p-stay-m}(a,\epsilon,\phi,b,h^o,h^{mp},\gamma). \end{cases} \tag{38}$$

If the mom&pop sells its second dwelling, it can decide to not adjust, move, or to buy a new second dwelling.

$$\bar{V}_j^{m\&p-sell}(a,\epsilon,\phi,b,h^o,h^{mp},\gamma) = \max \begin{cases} V_j^{m\&p-sell-n}(a,\epsilon,\phi,b,h^o,h^{mp},\gamma), \\ \bar{V}_j^{m\&p-sell-m}(a,\epsilon,\phi,b,h^o,h^{mp},\gamma), \\ \bar{V}_j^{m\&p-sell-b}(a,\epsilon,\phi,b,h^o,h^{mp},\gamma). \end{cases} \tag{39}$$

I discuss each of these six cases below, starting with mom&pop-stay.

1. If the mom&pop decides to stay and not adjust, it solves:

$$V_j^{m\&p-stay-n}(a,\epsilon,\phi,b,h_i^o,h_k^{mp},\gamma) = \max_{c,a'} u(c,s) + \beta E[\bar{\boldsymbol{V}}_{j+1}^{m\&p}(a',\epsilon',\phi',b',h_i^o,h_k^{mp},\gamma')] \tag{40}$$

$$\begin{aligned}
s.t. \quad & c + a' + \pi_j(b,r_b) + h_i^o(\delta + \tau_p P_i) + \leq a(1+r) + y(\epsilon) + r_k^{net} + T, \\
& s = \gamma h_{par} + (1-\gamma)\omega h_i^o, \\
& r_k^{net} = (r_k - \phi_k - \tau_p P_k)h_k^{mp}(1-\tau_{hi}) + \tau_{hi} m_\tau P_k h_k^{mp}, \\
& b' = (1+r_b)b - \pi_j(b,r_b), \\
& i \in \{c,h\},\ k \in \{c,h\}.
\end{aligned}$$

2. If the mom&pop stays and refinances, it solves:

$$V_j^{m\&p-stay-r}(a,\epsilon,\phi,b,h_i^o,h_k^{mp},\gamma) = \max_{c,b^n,a'} u(c,s) + \beta E[\bar{\boldsymbol{V}}_{j+1}^o(a',\epsilon',\phi',b',h_i^o,h_k^{mp},\gamma')] \tag{41}$$

$$s.t. \quad c + a' + b + h_i^o(\delta + \tau_p P_i) + \pi_j(b^n, r_b) \leq a(1+r) + y(\epsilon) + b^n - F_o - F_{refi} + r_k^{net} + T,$$

$$s = \gamma h_{par} + (1-\gamma)\omega h_i^o,$$

$$r_k^{net} = (r_k - \phi_k - \tau_p P_k)h_k^{mp}(1-\tau_{hi}) + \tau_{hi} m_\tau P_k h_k^{mp},$$

$$b' = (1+r_b)b^n - \pi_j(b^n, r_b),$$

$$b^n \leq \lambda_{LTV}[P_i h_i^o + P_k h_k^{mp}],$$

$$\pi_j(b^n, r_b) \leq \lambda_{DTI} y(\epsilon),$$

$$i \in \{c,h\},\ k \in \{c,h\}.$$

3. If the mom&pop keeps the second dwelling but moves its primary dwelling, it solves:

$$\bar{V}_j^{m\&p-stay-m}(a,\epsilon,\phi,b,h_i^o,h_k^{mp},\gamma) = \max_{l\in\{c,h\}} V_{j,l}^{m\&p-stay-m}(a,\epsilon,\phi,b,h_i^o,h_k^{mp},0), \tag{42}$$

$$V_{j,l}^{m\&p-stay-m}(a,\epsilon,\phi,b,h_i^o,h_k^{mp},0) = \max_{c,b^n,a'} u(c,s) + \beta E[\bar{\boldsymbol{V}}_{j+1}^{m\&p}(a',\epsilon',\phi',b',h_l^o,h_k^{mp},\gamma')] \tag{43}$$

$$s.t. \quad c + a' + b + \pi_j(b^n, r_b) + h_l[(1+f_b)P_l + \delta + \tau_p P_l]$$

$$\leq a(1+r) + y(\epsilon) + b^n - F_o + (1-f_s)P_i h_i^o - F_s + r_k^{net} + T,$$

$$s = \omega h_l,$$

$$r_k^{net} = (r_k - \phi_k - \tau_p P_k)h_k^{mp}(1-\tau_{hi}) + \tau_{hi} m_\tau P_k h_k^{mp},$$

$$b' = (1+r_b)b^n - \pi_j(b^n, r_b),$$

$$b^n \leq \lambda_{LTV}[P_l h_l^o + P_k h_k^{mp}],$$

$$\pi_j(b^n, r_b) \leq \lambda_{DTI} y(\epsilon),$$

$$\gamma = 0,$$

$$i \in \{c,h\},\ k \in \{c,h\}.$$

4. If the mom&pop sells its second dwelling and decides to not adjust, it solves:

$$
\begin{aligned}
&V_j^{m\&p-sell-n}(a,\epsilon,\phi,b,h_i^o,h_k^{mp},\gamma) = \max_{c,b^n} u(c,s) + \beta E[\bar{\boldsymbol{V}}_{j+1}^o(a',\epsilon',\phi',b',h_i^o,0,\gamma')] && (44)\\
&s.t. \quad c + a' + \pi_j(b^n,r_b) + h_i^o(\delta + \tau_p P_i) + \leq a(1+r) + y(\epsilon) + (1-f_s)P_k h_k^{mp} - F_s + b^{net} + T,\\
&s = \gamma h_{par} + (1-\gamma)\omega h_i^o,\\
&b^{net} = b^n - F_o - b,\\
&b' = (1+r_b)b^n - \pi_j(b^n,r_b),\\
&b^n \leq \lambda_{LTV}[P_i h_i^o],\\
&\pi_j(b^n,r_b) \leq \lambda_{DTI} y(\epsilon),\\
&i \in \{c,h\},\ k \in \{c,h\}.
\end{aligned}
$$

5. If the mom&pop sells its second dwelling and decides to move, it solves:

$$
\begin{aligned}
&\bar{V}_j^{m\&p-sell-m}(a,\epsilon,\phi,b,h_i^o,h_k^{mp},\gamma) = \max_{l\in\{c,h\}} V_{j,l}^{m\&p-sell-m}(a,\epsilon,\phi,b,h_i^o,h_k^{mp},0), && (45)\\
&V_{j,l}^{m\&p-sell-m}(a,\epsilon,\phi,b,h_i^o,h_k^{mp},0) = \max_{c,b^n} u(c,s) + \beta E[\bar{\boldsymbol{V}}_{j+1}^o(a',\epsilon',\phi',b',h_l^o,0,\gamma')] && (46)\\
&s.t. \quad c + a' + b + \pi_j(b^n,r_b) + h_l^o[(1+f_b)P_l + \delta + \tau_p P_l]\\
&\qquad \leq a(1+r) + y(\epsilon) + b^n - F_o + (1-f_s)(P_i h_i^o + P_k h_k^{mp}) - 2F_s + T,\\
&s = \omega h_l,\\
&b' = (1+r_b)b^n - \pi_j(b^n,r_b),\\
&b^n \leq \lambda_{LTV}[P_l h_l^o],\\
&\pi_j(b^n,r_b) \leq \lambda_{DTI} y(\epsilon),\\
&\gamma = 0, \phi = \overline{\phi},\\
&i \in \{c,h\},\ k \in \{c,h\}.
\end{aligned}
$$

6. If the mom&pop sells its second dwelling and decides to buy a new second dwelling,

it solves:[46]

$$\bar{V}_j^{m\&p-sell-b}(a,\epsilon,\phi,b,h_i^o,h_k^{mp},\gamma) = \max_{l\in\{c,h\}} V_{j,l}^{m\&p-sell-b}(a,\epsilon,\phi,b,h_i^o,h_k^{mp},\gamma), \tag{47}$$

$$V_{j,l}^{m\&p-sell-b}(a,\epsilon,\phi,b,h_i^o,h_k^{mp},\gamma) = \max_{c,b^n} u(c,s) + \beta E[\bar{\mathbf{V}}_{j+1}^o(a',\epsilon',\phi',b',h_i^o,h_l^{mp},\gamma')] \tag{48}$$

$$\begin{aligned}
s.t. \quad & c + a' + b + \pi_j(b^n,r_b) + h_i^o(\delta + \tau_p P_i) + h_l[(1+f_b)P_l] \\
& \leq a(1+r) + y(\epsilon) + b^n - F_o + (1-f_s)P_k h_k^{mp} - F_s + r_l^{net} + T, \\
& s = \gamma h_{par} + (1-\gamma)\omega h_i^o, \\
& r_l^{net} = (r_l - \phi_l - \tau_p P_l)h_l^{mp}(1-\tau_{hi}) + \tau_{hi} m_\tau P_l h_l^{mp}, \\
& b' = (1+r_b)b^n - \pi_j(b^n,r_b), \\
& b^n \leq \lambda_{LTV}[P_i h_i^o + P_l h_l^{mp}], \\
& \pi_j(b^n,r_b) \leq \lambda_{DTI} y(\epsilon), \\
& i \in \{c,h\}, k \in \{c,h\}.
\end{aligned}$$

[46] If a household moves from its primary dwelling, I set $\gamma = 0$. There is no reset of the maintenance technology unless both the first and second dwellings are sold during the period.

G Equilibrium Definition

In the definition of equilibrium I denote the vector of individual states for non-owners as $\boldsymbol{x}^n = \{a, \epsilon\}$ and for owners and mom&pop as $\boldsymbol{x}^o = \{a, \epsilon, \phi, b, h^o, h^{mp}, \gamma\}$. I drop the dependence of variables on the state vector. I summarize the measures of non-owners, owners and mom&pop households at age j in μ_j^{no}, μ_j^o and μ_j^{mp}, with $\sum_{j=1}^{J}(\mu_j^{no} + \mu_j^o + \mu_j^{mp}) = 1$. In the equilibrium definition the subscript i denotes the dwelling choice, $i \in \{c, h\}$. I use the decision (indicator) functions $\{g_j\}$ to describe the resulting choices of the households' decisions, closely following the problem setup in Appendix F and Figure 4.

A recursive competitive equilibrium consists of value functions $\Big\{ \bar{\boldsymbol{V}}_j^{no}, V_j^p, \bar{V}_j^r, \bar{V}_j^b, \{V_{j,i}^r\}, \{V_{j,i}^b\}$, $\bar{\boldsymbol{V}}_j^o, \bar{V}_j^{o-stay}, \bar{V}_j^{o-sell}, V_j^{o-stay-n}, V_j^{o-stay-r}, \bar{V}_j^{o-stay-b}, V_j^{o-sell-p}, \bar{V}_j^{o-sell-r}, \bar{V}_j^{o-sell-b}, \{V_{j,i}^{o-stay-b}\}$, $\{V_{j,i}^{o-sell-r}\}, \{V_{j,i}^{o-sell-b}\}, \bar{\boldsymbol{V}}_j^{m\&p}, \bar{V}_j^{m\&p-stay}, \bar{V}_j^{m\&p-sell}, V_j^{m\&p-stay-n}, V_j^{m\&p-stay-r}, \bar{V}_j^{m\&p-stay-m}$, $V_j^{m\&p-sell-n}, \bar{V}_j^{m\&p-sell-m}, \bar{V}_j^{m\&p-sell-b}, \{V_{j,i}^{m\&p-stay-m}\}, \{V_{j,i}^{m\&p-sell-m}\}, \{V_{j,i}^{m\&p-sell-b}\} \Big\}$, decision rules $\Big\{ g_j^{no-p}, g_{j,c}^{no-r}, g_{j,h}^{no-r}, g_{j,c}^{no-b}, g_{j,h}^{no-b}, c_j^{no-p}, \{c_{j,i}^{no-r}\}, \{c_{j,i}^{no-b}\}, a_j^{'no-p}, \{a_{j,i}^{'no-r}\}, \{a_{j,i}^{'no-b}\}$, $\{b_{j,i}^{no-b}\}, g_j^{o-stay-n}, g_j^{o-stay-r}, g_{j,c}^{o-stay-b}, g_{j,h}^{o-stay-b}, g_j^{o-sell-p}, g_{j,c}^{o-sell-r}, g_{j,h}^{o-sell-r}, g_{j,c}^{o-sell-b}, g_{j,h}^{o-sell-b}$, $c_j^{o-stay-n}, c_j^{o-stay-r}, \{c_{j,i}^{o-stay-b}\}, c_j^{o-sell-p}, \{c_{j,i}^{o-sell-r}\}, \{c_{j,i}^{o-sell-b}\}, a_j^{'o-stay-n}, a_j^{'o-stay-r}, \{a_{j,i}^{o-stay-b}\}$, $a_j^{'o-sell-p}, \{a_{j,i}^{'o-sell-r}\}, \{a_{j,i}^{'o-sell-b}\}, b_{j,i}^{o-stay-r}, \{b_{j,i}^{o-stay-b}\}, \{b_{j,i}^{o-sell-b}\}, g_j^{mp-stay-n}, g_j^{mp-stay-r}$, $g_{j,c}^{mp-stay-m}, g_{j,h}^{mp-stay-m}, g_j^{mp-sell-n}, g_{j,c}^{mp-sell-m}, g_{j,h}^{mp-sell-m}, g_{j,c}^{mp-sell-b}, g_{j,h}^{mp-sell-b}, c_j^{mp-stay-n}$, $c_j^{mp-stay-r}, \{c_{j,i}^{mp-stay-m}\}, c_j^{mp-sell-n}, \{c_{j,i}^{mp-sell-m}\}, \{c_{j,i}^{mp-sell-b}\}, a_j^{'mp-stay-n}, a_j^{'mp-stay-r}$, $\{a_{j,i}^{'mp-stay-m}\}, a_j^{'mp-sell-n}, \{a_{j,i}^{'mp-sell-m}\}, \{a_{j,i}^{'mp-sell-b}\}, b_j^{mp-stay-r}, \{b_{j,i}^{mp-stay-m}\}, \{b_{j,i}^{mp-sell-m}\}$, $\{b_{j,i}^{mp-sell-b}\} \Big\}$, rental prices r_c and r_h, house prices P_c and P_h, interest rate r from the mutual fund, corporate rental demand for condos and houses, functions for the stock of condos and stock of houses, dwelling investment, and government expenditures $\{X_{c,corp}, X_{h,corp}, H_c, H_h, I_c^s, I_h^s, T\}$, such that:

1. Given prices, households optimize by solving Equations (5)-(10) and (25)-(48) with the associated value functions and decision rules.

2. Firms in the construction sector for condos and houses maximize profits, by solving Equation (16), with associated dwelling investment functions $\{I_c^s, I_h^s\}$. In sum, $\delta H_c = I_c$

and $\delta H_h = I_h$.

3. The rental rates r_c and r_h are consistent with rental market clearing for condos and houses:

$$X_{c,corp} + \sum_{j=1}^{J} \Big[\int (g_{j,c}^{o-stay-b}) d\mu_j^o + \int (g_{j,c}^{mp-sell-b}) d\mu_j^{mp}$$
$$+ \int (g_j^{mp-stay-n} + g_j^{mp-stay-r} + g_{j,c}^{mp-stay-m} + g_{j,h}^{mp-stay-m}) d\mu_j^{mp} (h^{mp} = h_c^{mp}) \Big]$$
$$= \sum_{j=1}^{J} \Big[\int (g_{j,c}^{no-r}) d\mu_j^{no} + \int (g_{j,c}^{o-sell-r}) d\mu_j^o \Big],$$

$$X_{h,corp} + \sum_{j=1}^{J} \Big[\int (g_{j,h}^{o-stay-b}) d\mu_j^o + \int (g_{j,h}^{mp-sell-b}) d\mu_j^{mp}$$
$$+ \int (g_j^{mp-stay-n} + g_j^{mp-stay-r} + g_{j,c}^{mp-stay-m} + g_{j,h}^{mp-stay-m}) d\mu_j^{mp} (h^{mp} = h_h^{mp}) \Big]$$
$$= \sum_{j=1}^{J} \Big[\int (g_{j,h}^{no-r}) d\mu_j^{no} + \int (g_{j,h}^{o-sell-r}) d\mu_j^o \Big],$$

where for both market clearance equations, the left-hand side represents total supply of dwellings. The total supply is provided by the corporate sector, homeowners who buy a second dwelling and mom&pop investors who sell and buy a second dwelling in the same period. In addition, all mom&pop households owning the second dwelling and who stay and not adjust, stay and refinance, or stay and move primary dwelling still provide the second dwelling for rental. The right-hand side represents total rental demand, equal to the demand for rental dwellings from non-owners and from owners who sell and decide to rent.

4. The government budget constraint holds, with lump sum redistribution equal to the

total amount of property and rental tax income:

$$\sum_{i\in c,h}\left(\tau_p H_i P_i h_i + \tau_{ci}\int_{m_i}\left(r_i h_i - m_i h_i - \tau_p P_i h_i\right)d\mu([0,m_i^*])X_{i,corp} - m_\tau \tau_{ci} P_i h_i X_{i,corp}\right.$$

$$+((r_i h_i - \underline{\phi}_i h_i - \tau_p P_i h_i)\tau_{hi} - m_\tau \tau_{hi} P_i h_i)\sum_{j=1}^{J}\Bigg[\int(g_{j,i}^{o-stay-b})d\mu_j^o + \int(g_{j,i}^{mp-sell-b})d\mu_j^{mp}$$

$$\left.+\int(g_j^{mp-stay-n} + g_j^{mp-stay-r} + g_{j,c}^{mp-stay-m} + g_{j,h}^{mp-stay-m})d\mu_j^{mp}(h^{mp} = h_i^{mp})\Bigg]\right)$$

$$= \sum_{j=1}^{J}\left(\int T d\mu_j^n + \int T d\mu_j^o + \int T d\mu_j^{mp}\right).$$

5. Dwelling markets clear:

$$H_c = X_{c,corp} + \sum_{j=1}^{J}\Bigg[\int(g_{j,c}^{no-b})d\mu_j^{no} + \int(g_{j,c}^{o-sell-b})d\mu_j^o$$

$$+\int(g_j^{o-stay-n} + g_j^{o-stay-r} + g_{j,c}^{o-stay-b} + g_{j,h}^{o-stay-b})d\mu_j^o(h^o = h_c^o)$$

$$+\int(g_j^{mp-stay-n} + g_j^{mp-stay-r} + g_j^{mp-sell-n} + g_{j,c}^{mp-sell-b} + g_{j,h}^{mp-sell-b})d\mu_j^{mp}(h^o = h_c^o)$$

$$+\int(g_{j,c}^{mp-stay-m} + g_{j,c}^{mp-sell-m})d\mu_j^{mp}$$

$$+\int(g_{j,c}^{o-stay-b})d\mu_j^o + \int(g_{j,c}^{mp-sell-b})d\mu_j^{mp}$$

$$+\int(g_j^{mp-stay-n} + g_j^{mp-stay-r} + g_{j,c}^{mp-stay-m} + g_{j,h}^{mp-stay-m})d\mu_j^{mp}(h^{mp} = h_c^{mp})\Bigg],$$

$$H_h = X_{h,corp} + \sum_{j=1}^{J}\Bigg[\int(g_{j,h}^{no-b})d\mu_j^{no} + \int(g_{j,h}^{o-sell-b})d\mu_j^o$$

$$+\int(g_j^{o-stay-n} + g_j^{o-stay-r} + g_{j,c}^{o-stay-b} + g_{j,h}^{o-stay-b})d\mu_j^o(h^o = h_h^o)$$

$$+\int(g_j^{mp-stay-n} + g_j^{mp-stay-r} + g_j^{mp-sell-n} + g_{j,c}^{mp-sell-b} + g_{j,h}^{mp-sell-b})d\mu_j^{mp}(h^o = h_h^o)$$

$$+\int(g_{j,h}^{mp-stay-m} + g_{j,h}^{mp-sell-m})d\mu_j^{mp}$$

$$+\int(g_{j,h}^{o-stay-b})d\mu_j^o + \int(g_{j,h}^{mp-sell-b})d\mu_j^{mp}$$

$$+\int(g_j^{mp-stay-n} + g_j^{mp-stay-r} + g_{j,c}^{mp-stay-m} + g_{j,h}^{mp-stay-m})d\mu_j^{mp}(h^{mp} = h_c^{mp})\Bigg].$$

The left-hand side represents total dwelling supply. The right-hand side represents total dwelling demand. The first line represents total dwelling demand by the corporate sector, and then total dwelling demand by non-owners who buy a dwelling and by owners who sell and buy a dwelling in the same period. The second line represents total dwelling demand by owners who owned that dwelling before. The third line represents dwelling demand by mom&pop investors for their primary home, who already owned that dwelling before. The fourth line describes dwelling demand by any mom&pop investor who moves to that dwelling. The last two lines describe dwelling demand for a secondary (investment dwelling). The fifth line describes second dwelling demand by any homeowner or mom&pop investor who purchases that dwelling. The last line describes second dwelling demand for mom&pop investors who already owned that dwelling before.

6. The corporate sector for both condos and houses solve Equations (11)-(14), with associated total condos and houses purchases of $X_{c,corp}$ and $X_{h,corp}$. In addition, the optimality conditions generate m_i^{*stay} and m_i^{*enter}, for $i \in \{c, h\}$. Given the corporate sector setup with entry and buying costs, it holds that $m_i^{*stay} > m_i^{*enter}$. The free entry-condition Equation (14) holds and the law of motion for both industries is stationary:

$$\mu([0, m_i^{*stay}]) = \int_{m_i < m_i^{*stay}} \tilde{G}_i(m_i, [0, m_i^{*stay}])\mu(m_i)dm_i + M_{i,t+1}G\Big([0, m_i^{*enter}]\Big),$$

where in steady state $M_{i,t+1} = M_{i,t} = M_i$, $\forall t$.

7. The mutual fund solves Equation (21), which in steady state implies $r_t = r^*$, $\forall t$.

H Solution Method

To solve the steady-state equilibrium, I use the following procedure. At first, I initialize the prices P_i for each dwelling $i \in \{c, h\}$. Then, I iterate the following steps until convergence for both dwellings jointly:

1. For dwelling markets $i \in \{c, h\}$: given P_i, the corporate sector optimizes, which yields $\rightarrow r_i$ and m_i^{*stay} and m_i^{*enter}.

- To find m_i^{*stay}, we set $\Delta V(p) = V_{stay}(m_i; p) - V_{exit}(p) = 0$.
- To find r_i and m_i^{*enter}: $\int_0^{m_i^{*enter}(P_{r_i})} \Pi_i(m_i; P_i) - P_i h_i dG(m_i) \leq c_E$ (use m_i^{*stay} if $<$).

2. Given $\{P_i, r_i\}_{i \in \{c,h\}}$, households optimize.

3. Given decision rules and prices $\{P_i, r_i\}_{i \in \{c,h\}}$, solve stationary distribution: household total ownership demand $X_{i,hh}$, household rental demand $X^r_{i,hh}$, and household investment demand $X_{i,m\&p}$, for $i \in \{c, h\}$.

4. Compute corporate mass $X_{i,corp} = X^r_{i,hh} - X_{i,m\&p}$, for $i \in \{c, h\}$. Also compute $\mu_{t+1}(m_i)$.

5. Given dwelling ownership, compute government income and set lump sum rebate T. Note: in steady state, the return to financial assets always equals $r = r^*$.

6. Convergence for either dwelling market? Check $X_{i,hh} + X_{i,corp} + X_{i,m\&p} = H_i$. If excess demand, increase P_i.

I Model Fit Non-targeted Moments

Table 25 summarizes the model fit.

Description	Model	Data	Source
Non-Targeted Moments			
Average earnings owners/renters	1.05	2.24	SCF, 2007
Debt/income, owners w mortgage, p50	1.11	1.53	SCF, 2007
Debt/income, m&p w mortgage, p50	0.69	1.52	SCF, 2007
Fraction of owners with mortgage	0.41	0.74	SCF, 2007
Fraction of m&p w mortgage	0.34	0.73	SCF, 2007
Homeownership rate, age ≥ 70	0.66	0.80	SCF, 2007
Homeownership rate, age ≤ 35	0.23	0.51	SCF, 2007
Median net worth ratio, ages 66-81 to 40-55	0.75	1.78	SCF, 2007
Net worth/income, p10	0.05	0.00	SCF, 2007
Net worth/income, p90	7.49	7.47	SCF, 2007
Housing net worth/ net worth, owners, p10	0.49	0.49	SCF, 2007
Housing net worth/ net worth, owners, p50	0.82	0.95	SCF, 2007
Housing net worth/ net worth, owners, p90	2.24	1.06	SCF, 2007
Institutional share of purchases houses	0.05	0.08	ZTRAX, 2006 (Zillow, 2022)
Institutional share of purchases condos	0.91	0.55	ZTRAX, 2006 (Zillow, 2022)
Mortgage refinance rate	0.16	0.12	Bhutta and Keys (2016)
Fraction of dwellings sold	0.05	0.10	Ngai and Sheedy (2020)
Fraction of houses sold by inst. investors	0.203	0.205	ZTRAX, 01-19 (Zillow, 2022)

Table 25: Annualized moments relative to the data

J Homeownership Taxation

This Appendix discusses the policy intervention of eliminating the tax advantage of owning by taxing the imputed rental income of homeowners. With the shift from owning to renting after the corporate-cost reduction, the optimality of existing tax advantages of owning can be questioned. This policy is discussed only in a steady-state comparison. The policy taxes the imputed rental income after paying property taxes and maintenance costs for homeowners but does allow them to write off the depreciation expenses. The policy impacts on the housing market are compared for the lower-costs steady state and the baseline steady state. This intervention satisfies the government budget constraint: the changes in total tax revenues directly affect the lump sum transfers to households.[47]

Table 26 shows that the homeownership rate falls by 7 percentage points for both steady states. The house value to income ratios remain stable, which reflects constant total housing demand. While homeowners have to pay rental income tax, this negative effect on housing demand is offset by a higher lump sum redistribution to all households. In terms of dwelling prices and rental rates, the tax on imputed rental income increases the house (condo) price by -0.13 percent (4.34 percent) and rental house (condo) rate by -0.09 percent (3.36 percent) for the initial steady state. In the final steady state, the condo price and condo rental rate also rise, by 3.23 percent and 2.55 percent, respectively. The lump sum rebates are given to all agents, which incentivizes the marginal person to prefer renting a condo over living with their parents. This results in higher condo demand, which increases the equilibrium condo price.

Table 27 lists the welfare changes for non-owners, owners, and mom-and-pop investors. I compare the welfare effects of the tax change for the baseline steady state and the lower-costs steady state, where the household groups are weighted using the respective steady-state distributions before the tax change. The tax on imputed rental income for both the steady states increases welfare for non-owners and lowers welfare for owners and mom-and-pop investors. While the total welfare gain is positive for both steady states, the welfare gain doubles for the lower-costs steady state. The corporate-cost reduction for houses comes

[47] The welfare gains might be sensitive to the choice of financing. Debt financing in the distant future might increase the welfare of currently alive cohorts, but distortionary financing would lower it.

Description	Baseline	Baseline + tax	Lower costs	Lower costs + tax
Housing market				
Total homeownership rate	0.71	0.64	0.66	0.59
Homeownership rate houses	0.83	0.77	0.77	0.71
Homeownership rate condos	0.16	0.08	0.16	0.07
Fraction young live with old	0.40	0.40	0.39	0.38
Mom&pop rental houses stock share	0.88	0.52	0.43	0.25
Mom&pop rental condos stock share	0.09	0.06	0.08	0.05
Dwelling value/income, owners, p50	2.70	2.70	2.74	2.75
Average premium corp. house costs	$1,355	$1,355	$965	$965

Table 26: Steady-state comparison - evaluating taxation on imputed rental income

with a higher welfare gain of eliminating the tax advantages of owning a dwelling (0.12 vs. 0.05 percent). Abolishing the homeowners tax distortion allows the economy to better take advantage of the improved maintenance technology.

	vs. Baseline		*vs. Lower costs*	
	CEV (%)	Fraction ≥ 0	CEV (%)	Fraction ≥ 0
All	0.05	0.477	0.12	0.493
Non-owners	0.778	1	0.733	1
Owners	-0.273	0.202	-0.158	0.239
Mom&Pop	-0.672	0.135	-0.462	0.114

Table 27: Steady-state welfare effects - evaluating taxation on imputed rental income

K Robustness Exercise

In this Appendix, I set the standard deviation of the corporate maintenance cost distribution for houses to zero. Then, I re-calibrate the steady state, to match the moments described in Table 29. In this case, I set the initial premium at 0.0661. This average cost aligns with the operating-cost premium in the data of 44 percent, as $(0.0661/0.046) - 1 = 0.44$. I choose the following internally calibrated parameters:

Description	Parameter	Value
Preferences		
Discount factor	β	0.9615
Non-durable share in utility	α_u	0.8372
Bequest luxuriousness	$\bar{b}$	10.5925
Bequest desirability	ψ	70.9995
Housing		
Smallest dwelling size	h_{parents}	0.25
Owners		
Mismatch shock transition	$\{\gamma_{0,0}, \gamma_{0,1}, \gamma_{1,0}, \gamma_{1,1}\}$	$\{0.9, 0.1, 0, 1\}$
Dwellings mom&pop		
Costs m&p transition probabilities	$\{\Pi_{\underline{\phi},\underline{\phi}}, \Pi_{\underline{\phi},\bar{\phi}}, \Pi_{\bar{\phi},\underline{\phi}}, \Pi_{\bar{\phi},\bar{\phi}}\}$	$\{1, 0, 0.9, 0.1\}$
Dwellings institutions		
Uncond. mean corp. costs houses	μ_{mh}	0.0661
Corporate entry costs	c_E	0.0210

Table 28: Internally calibrated parameters, no standard deviation corporate costs

Description	Model	Data	Source
Targeted Moments			
Total homeownership rate	0.71	0.69	FRED, 2006
Homeownership rate houses	0.80	0.78	ACS, 2001
Homeownership rate condos	0.26	0.12	ACS, 2001
Mom&pop rental houses stock share	0.78	0.83	ACS & RFS, 2001
Mom&pop rental condos stock share	0.18	0.26	ACS & RFS, 2001
LTV ratio, owners with mortgage, p50	0.46	0.51	SCF, 2007
LTV ratio, m&p w mortgage, p50	0.23	0.39	SCF, 2007
Dwelling value/income, owners, p50	2.71	3.09	SCF, 2007
Net worth/income, p50	1.41	1.13	SCF, 2007
Mean size owned to rented dwelling	1.19	1.5	Chatterjee and Eyigungor (2015)
Average premium corporate house costs	$1,350	$1,345	Section 3.1

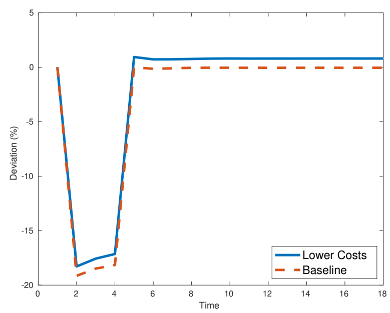
Table 29: Moments relative to the data, no standard deviation corporate costs

Then, I lower the average corporate cost from 0.0661 to 0.0600. The fall in average costs aligns with the drop in the data from \$1,346 to \$936. More specifically, the operating-cost premium in the model falls from \$1,350 to \$940 when the corporate cost mean falls from 0.0661 to 0.0600. I compare the initial and final steady states in Table 30. As in Table 6 in Section 6, the reduction of the corporate-cost premium lowers the homeownership rate. While in Section 6 the homeownership rate fell by 5 percentage points, here the homeownership rate falls by 3 percentage points. In addition, the homeownership rate of houses falls by 3 percentage points here but by 6 percentage points in Section 6. The moderated price responses cause these weakened ownership changes. In the steady state with the corporate-cost reduction, the house price is 0.8 percent higher, but the house rental price is 2.2 percent lower. This rise in house price and fall in house rental rate causes a shift from owning to renting. The shift to renting also causes an increase in demand for condos, increasing its rental price by 0.4 percent and its price by 0.5 percent. These price changes are smaller in magnitude than in Section 6.

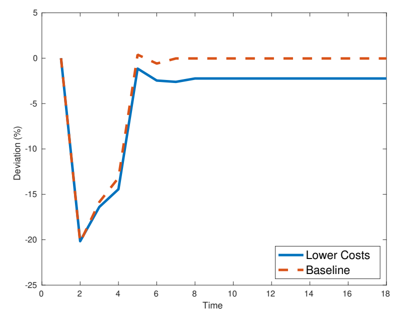
Description	Baseline ($\mu_{mh} = 0.0661$)	Lower costs ($\mu_{mh} = 0.0600$)
Housing market		
Total homeownership rate	0.71	0.68
Homeownership rate houses	0.80	0.77
Homeownership rate condos	0.26	0.26
Fraction young live with old	0.40	0.39
Mom&pop rental houses stock share	0.78	0.50
Mom&pop rental condos stock share	0.18	0.17
Dwelling value/income, owners, p50	2.71	2.73
Wealth distribution		
Net worth/income, p50	1.41	1.39
Median net worth ratio, ages 66-81 to 40-55	0.76	0.77
Net worth/income, p10	0.04	0.04
Net worth/income, p90	7.51	7.42
Homeownership rate, age ≥ 70	0.66	0.63
Homeownership rate, age ≤ 35	0.23	0.20

Table 30: Moments initial vs. final steady state, no standard deviation corporate costs.

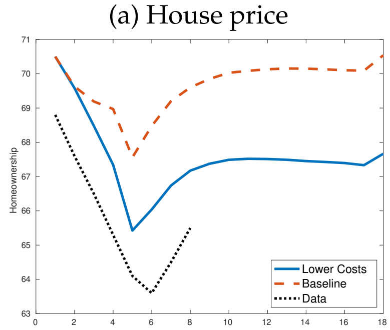
Last, the transitional dynamics of the transition experiment are shown in Figure 17. The results are generally unaffected by the choice of the standard deviation of the corporate costs for houses. Panel (a) shows that the house price fall with the lower corporate cost is moderated by 1.02 percent, instead of 1.64 percent as in Section 6. Panel (c) shows that the total homeownership rate falls by 5.1 percent with a corporate-cost reduction and by 2.9 percent without. In the data, the homeownership rate fell by 5.2 percent. Panel (d) shows that the corporate ownership rises in both experiments, but remains at a higher level in the lower-costs experiment (as in the data). Figure 18 shows in panel (a) that the house mass falls more in the baseline. Panel (b) shows that the average corporate house maintenance costs for the lower-costs experiment falls immediately to its new steady-state level at $t = 4$.



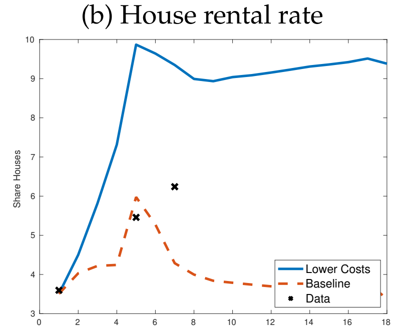
(a) House price



(b) House rental rate

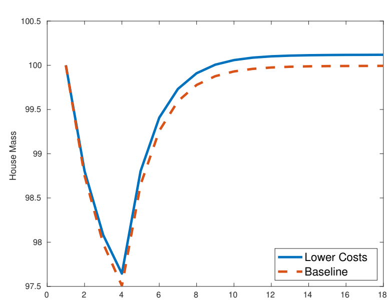


(c) Homeownership rate

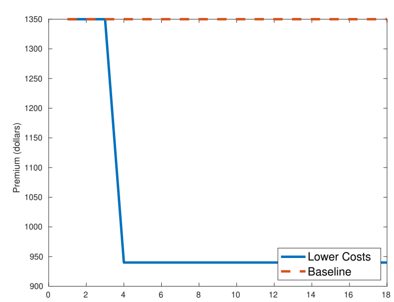


(d) Corporate house ownership

Figure 17: Robustness exercise for transitional dynamics of Great Recession shocks. Data sources: ACS, RFS, and RHFS.



(a) House mass



(b) Average corporate maintenance costs for houses

Figure 18: Robustness exercise for transitional dynamics of Great Recession shocks.