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Eirik Eylands Brandsaas, Jens Kvaerner

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Partial Homeownership: A Quantitative Analysis

Eirik Eylands Brandsaas and Jens Soerlie Kvaerner*

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Abstract

A convex combination of renting and traditional homeownership—Partial Ownership (PO)—is increasingly popular in many countries. We incorporate an existing for-profit PO contract into a life-cycle model to quantify its impact on investment in housing, households' welfare, and financial stability. We have the following results: 1) PO makes more households invest in (some) housing. 2) Willingness to pay for PO increases with housing unaffordability and is highest among low-income and renting households. 3) PO may reduce systemic risk despite raising aggregate debt because the most indebted traditional homeowners become partial owners.

Partial Homeownership, Housing Affordability, Financial Innovation, Financial Stability

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1 Introduction

One of the most important financial choices we make is whether to rent or buy a home.[1] House prices have doubled over the last 10 to 15 years in many cities, raising concerns about housing affordability and economic growth (Favilukis et al., 2022, Hsieh and Moretti, 2019). Without financial innovations to promote homeownership, many young individuals will have few housing choices, which may reduce economic growth and perpetuate wealth inequality.

While there is much work on housing affordability (see, e.g., Favilukis and Nieuwerburgh, 2021, Garriga et al., 2023, Molloy et al., 2022) and an increasing interest in optimal mortgage design (Campbell et al., 2021, Guren et al., 2021), the effects of alternatives ownership structures to traditional homeownership on housing demand and financial stability remain an open question. In this paper, we introduce an existing for-profit partial homeownership contract (PO) into a standard life cycle model of housing. The PO contract allows households to convexify their housing choice; that is, to buy a fraction of a home and rent the rest. PO thus differs fundamentally from timeshare agreements, especially popular in vacation locales.[2] Variations of PO are now in use in Norway, Sweden, England, Australia, and China.

Our study is the first to incorporate a for-profit PO contract in a life-cycle model standard in the housing literature (see, e.g., Cocco, 2005, Attanasio et al., 2012, Davis and Van Nieuwerburgh, 2015). In Norway, for-profit homebuilders, financial intermediaries, and public-private partnerships have all begun to offer PO.[3] It has received substantial attention in the popular press since its introduction a few years ago. A survey revealed that 37% of all households and 70% of renters would consider PO in their next housing transaction.[4]

In our model, households choose between renting, homeownership, and PO. The PO option includes buying between 50% and 90% of a house and renting the rest. Partial owners can increase their ownership share at any time. Homeowners and partial owners can sell their entire house, with partial owners receiving their share but not a fraction. Households differ in

[1] Sodini et al. (2023) document several positive causal effects of homeownership on a set of key household outcomes. Bach et al. (2020) find that housing and mortgage choices early in life are strong predictors of a household's location in the wealth distribution at retirement.

[2] With PO, households retain full ownership rights and have the option to become traditional owners later. In contrast, timeshare grants users the right to occupy a property for a fraction of a year.

[3] For example, coo.no, a fintech company, offers PO contracts for new and existing homes. OsloBolig, a joint venture between Oslo Municipality and private companies, buys new apartments on the open market and offers PO contracts. Many large builders, such as OBOS, Selvaag, and JM, also offer PO.

[4] Opinion: Morgendagens Boformer (en: Ownership Options in the Future).

wealth and education and face uninsurable idiosyncratic income risk and uncertainty about future house prices. We estimate the model using the simulated method of moments (SMM) on the administrative data from Norway and proprietary partial ownership data.

Our first application is to understand how PO affects aggregate homeownership rates. In the short run, PO leads to a reduction of households that rent as they switch to PO. Among households between 25 to 45 years—the primary users—, about 25% rents, which drops in half shortly after PO becomes available. After one year, PO has little impact on traditional homeownership. In the long run, PO also decreases traditional homeownership. In the model, 20% of young households are partial homeowners, matching the previously mentioned survey evidence on the hypothetical demand for PO.

We quantify the willingness-to-pay (WTP) for PO. The mean welfare gain from having access to PO for households between 25 to 45 years is between 19% and 4% of disposable income. The estimated welfare gains exceed that of reverse mortgages (see Nakajima and Telyukova, 2017). The model allows us to understand the heterogeneous demand for PO. As expected, renters have a higher WTP for PO than owners. On average, a 35-year-old renter is willing to pay 33% of disposable income to have access to PO, compared to 4% for owners. There are two main reasons for the difference in WTP. First, PO allows current renters to obtain some of the utility benefits associated with traditional homeownership. Second, PO relaxes borrowing constraints that are more binding for renters than owners.

Past crises show that real estate markets are essential for financial stability (Mian et al., 2017). As a result, we expect policymakers and regulators to be skeptical of PO and, therefore, study how PO affects household debt-to-income (DTI) ratios and downsizing.[5] As expected, as many renters borrow to become partial owners, the DTI ratio in the population rises. More interestingly, many households just wealthy enough to satisfy the regulatory constraints for traditional homeownership prefer PO and borrow less. Regarding downsizing, we find that PO has little impact on downsizing along the extensive margin but leads to a 50% decrease in the housing value lost among downsizers. PO reduces the right tail of the DTI distribution and lowers the value of downsizing after adverse shocks.

Apart from being necessary to answer our research questions, introducing PO in a life cy-

[5]For example, the concerns of the Norwegian Financial Stability Authority and the Central Bank became evident in their reluctance to a recent policy proposal to relax regulations that allow builders to offer more PO contracts.

cle model of housing forces us to introduce a new utility parameter, which we label ownership-elasticity. It measures how much of the homeownership utility premium partial owners get relative to their ownership share. To estimate the ownership-elasticity, we develop an identification strategy that relies on the ownership share PO users choose at contract origination. The average initial PO share in our data is 57%, with 72% of households choosing to own 50% (the lower limit). To match this, households must receive a relatively large share of the homeownership utility with a low ownership share. Our estimate suggests that a household owning 50% of a house receives 85% of the utility premium associated with homeownership.

Our analysis of the demand for PO has several broad implications. First, the high take-up rates among young households suggest that PO could reverse the decline in young homeownership after the Great Recession documented by Mabille (2022). D'Acunto and Rossi (2021) show that mortgage lending to low-income households declined in the U.S. immediately following the stricter regulation in 2010. Partial ownership offers an alternative homeownership method requiring less initial equity and borrowing. Second, Cocco (2005) shows that due to investment in housing, younger and less fortunate households have limited financial wealth to invest in stocks, meaning that house price risk crowds out stockholdings. We show that many who would become homeowners without PO instead become partial owners with PO, hinting that PO may reduce some of the crowding-out effects housing investment can have on equities. Third, PO reduces the equity investment and the size of the mortgage necessary to own some housing. That has several potential implications for measures linked to financial stability: the distribution of "hand-to-mouth" households (Kaplan and Violante, 2022) and debt-to-income ratios, the supply of housing during economic downturns, and the impact of house price fluctuations on consumption (Aladangady, 2017).

The perhaps best-known alternative to PO is a shared equity loan (SEM), in which the lender funds part of the buyer's downpayment in exchange for an equity share (see Benetton et al., 2021). Instead of interest payments, lenders receive their share of the home's sales price. The main difference between SEM and PO lies in the ownership and financing arrangements. SEM users cover all expenses and cannot change ownership shares. PO involves joint ownership, where the ownership rights and responsibilities are divided among the co-owners according to a pre-specified agreement. A shared appreciation mortgage (SAM) is another related product. It refers to a type of mortgage arrangement where the lender provides funds to a homeowner in exchange for a share of the future home price appreciation (see, e.g., Greenwald et al., 2021).

From a practical viewpoint, PO or similar equity-type instruments may have some advantages compared to the corresponding mortgage products, for example, regarding institutional barriers. In the US, government-sponsored enterprises such as Fannie Mae may impede the implementation of new mortgage products. In contrast, PO can arise endogenously in competitive markets without policy interventions, as in Norway and Sweden. In the US, the Fintech company Quarter Inc. has offered partial ownership contracts since 2023. As earlier mentioned, England, Australia, and China all have experience with some form of PO.

To our knowledge, we are the first to incorporate a traded for-profit PO contract into a life cycle model, calibrated and estimated using comprehensive microdata on wealth, homeownership, and unique data on partial ownership. The paper closest to ours—developed coincidentally—is Koch (2023). While some of the analysis and results overlap with ours, the main focus of the papers are different: We use our data to estimate preferences for for-profit partial ownership and use the model to make predictions about long-run developments of the PO market and assess its implications for financial stability. She studies portfolio choices and entry and exit in the housing market over the life cycle. Barras and Betermier (2020) study a theoretical asset allocation problem with safe assets, equity, and housing but do not consider borrowing constraints. Their central insight is that households end up with smaller houses and relatively more of their wealth in housing than what they would if they could buy a fraction of a home. Partial ownership thus improves welfare in their model by allowing households to hold a better-diversified portfolio while living in a house that better matches their desired housing consumption.

Our paper is related to the extensive literature that uses structural models to understand life cycle patterns and quantify the cost of suboptimal choices, financial frictions, or asymmetric information and the benefits of new financial products resolving these issues, especially in the context of homeownership (see e.g., Ameriks et al., 2011, Nakajima and Telyukova, 2017, Kovacs and Moran, 2021, Karlman et al., 2021, Liu, 2022, Indarte, 2023) Our contribution to this literature is to extend the standard housing model with PO. We find that PO shifts who bears the burden of financial constraints and have the potential to reduce asymmetric information and align incentives between landlords and households. Because PO reduces the size of the house investment, it can mitigate adverse effects of traditional homeownership that follow from the indivisibility of housing and illiquidity of homeownership (see e.g., Kaplan and Violante, 2022, Kermani and Wong, 2021, Bond and Eriksen, 2021, Diamond et al., 2020, Campbell and Cocco, 2007), with potentially large impacts on location, migration and remote work (see e.g., Oswald, 2019, Davis et al., 2024)

2 Institutional Setting and Data

2.1 The Norwegian Housing Market

We begin with a brief overview of the Norwegian housing market.[6] Norway is characterized by high homeownership. Approximately 80% of households own their home and 20% rent. The homeownership rate is between China (> 90%) and the US and Australia (each at 66%) and above average in the European Union (70%).

Households, corporations, and the government own these properties. Private landlords (e.g., households with two housing units) dominate the rental market with a market share of about 80%. Corporations own about 75% of the remaining units, and the government owns the rest (Sandlie and Sørvoll, 2017, Stamsø, 2023). The two forms of owner-occupation (traditional or housing association) have stayed the same since the 1980s.

Public policy encourages homeownership, and owner-occupied housing is treated favorably in the tax code. Households can deduct mortgage interest payments from income taxes, and capital gains on the primary residence are tax-exempt. Only 25% of the market value of the primary residence is subject to progressive wealth taxation. The residential property tax is low, and the average housing unit had a tax bill of only 3,713NOK (≈$370) in 2023.

Most households that buy a house acquire a pre-qualification letter ("finansieringsbevis") from a lender. The letter verifies the borrower's income and ensures compliance with mortgage regulations. Mortgages are generally floating rates with a 20-30-year payment plan. Existing (used) houses are sold anonymously at an ascending English auction. New homes sell at a fixed price set by the builder.

The Norwegian rental market is well-functioning with little government intervention. Unlike the neighboring counties, Sweden and Denmark, Norwegian landlords set the initial rent without restrictions (e.g., Sodini et al., 2023). Regulations provide tenant protection,

[6] We discuss the ownership structure in the Norwegian housing market in A.2 of the Online Appendix. For a discussion of financial regulation, we refer to Aastveit et al. (2022) and for more details on the rental market, we refer to Bø (2021).

contracts are largely standardized, and landlords have limited rights to terminate leases. Renters and landlords can annually re-adjust the rent in line with the inflation index.

There have been two main constraints on mortgage debt since 2016 (see Aastveit et al., 2022, for details): A loan-to-value (LTV) limit of 0.85 and a debt-to-income (DTI) limit of 5.0. Mortgage lenders are also required to verify that borrowers can handle a mortgage rate increase of 5 percentage points (3 percentage points from 2022). Default and forced liquidation remain rare.

2.2 Facts, Myths, and Predictions about Partial Ownership

Various forms of PO exist in the US, England, Australia, China, and Scandinavia. For data availability reasons, our focus is on the most common for-profit PO contract available in Norway and Sweden. We focus on Norway for three reasons. First, we have population-wide microdata on income and wealth. Second, Norway has a competitive for-profit PO market. Third, we have data on PO from the largest PO provider in the marketplace.

2.2.1 Partial Ownership in Norway

We use in our model the most common for-profit PO contract ("deleie") offered by OBOS, one of the biggest residential builders in Scandinavia. Households must buy a minimum ownership share of 50%, which they can later increase in 10 percentage point increments. When buying larger shares, the price equals the maximum of the initial and current market price, where the current market price equals the initial price times a local house price index. Both LTV and LTI requirements apply to PO. For example, if purchasing a 50 percent share of a home valued at 4 million NOK, the minimum downpayment would be 300,000 NOK, representing 15 percent (1-LTV) of the purchase price of the household's share. The household pays rent on the share not owned, with rent indexed to inflation just as for standard rental contracts. The household can list and sell the apartment at any time. In the case of a sale, proceeds after transaction costs are shared according to the ownership shares. The household is responsible for in-unit maintenance (e.g., painting walls and maintaining appliances) while "shared fees" (e.g., maintenance of common areas and property taxes) are split according to the ownership share. OBOS guarantees the contract for ten years, after which they can list the property for sale.[7] We refer to Appendix A.3 for further details.

The contract appears transparent and easy to understand. The only choice the buyer makes is the ownership share, and there are no hidden fees or cross-subsidies across consumers. All PO providers have websites with contact details and frequently asked questions. Moreover, in all OBOS sale listings that allow PO, households can adjust their desired ownership share and see how it adjusts the purchase amount, adjustment costs, maintenance costs, and rent payments (see Figure A1 for an illustration). This allows potential users to visualize all expenses associated with PO, which improves contract transparency.

Households are increasingly aware of partial ownership. A recent survey of adults in Oslo quantified the high interest in the PO contract among consumers: 37% of all households and 70% of renters consider PO in their next housing transaction, and interest for PO was highest among low-income households.[8] The strong demand for these properties prompted other builders (e.g., JM, Selvaag, and USBL) to offer PO contracts, motivated public-private joint partnerships (e.g., Oslo Bolig), and led financial intermediaries to offer PO contracts (e.g., Coo and Finit) on both new and existing homes.

2.2.2 Who Use Partial Ownership?

Figure 1 presents basic statistics of our PO data. The left panel in Figure 1 shows high growth in PO contract sales as a share of total sales. In communication with OBOS, they shared that the share of homes sold with PO would be larger without legal barriers limiting the number of PO contracts per building. Under current regulations, a building can have PO on up to 20% of the units.[9]

The center panel in Figure 1 shows that the average buyer is about 35. The low age suggests that PO is most attractive to first-time homebuyers. One reason why the contract is unappealing for older households is the embedded put option that allows OBOS to put the house out for sale if the partial owner has not become a full owner after ten years. This

[7]Because the contract is so new, no one has used it for ten years, and we do not know how often OBOS will exercise its option to list the property after ten years.

[8]Opinion: Morgendagens Boformer (en: Ownership Options in the Future).

[9]For example, take a five-unit building and sell one unit with PO, where the household owns 90%. In this case, OBOS is counted as owning 20% of the building, though they only own 2%. A recent government proposal suggests changing the limit to 50% and counting the ownership share accurately, gathering broad support from builders, regional governments, and the financial industry. That said, the Central Bank and the Financial Supervisory Authority objected due to financial stability concerns.

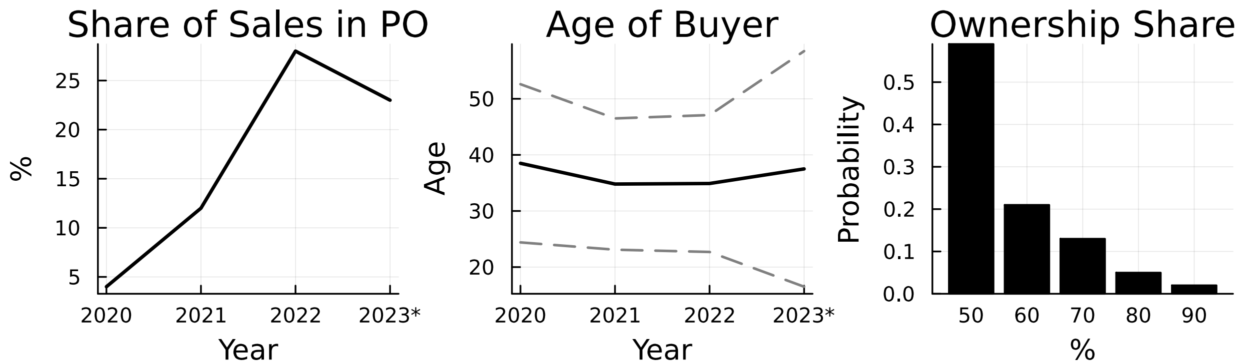


Figure 1 Summary Statistics from PO Contracts. The left panel plots the share of sales in PO, in regions where PO is offered, with data through February 2023. The middle panel plots the mean and standard deviation of the buyer's age. The right panel plots the initial ownership share. Source: OBOS.

prevents the contract to work as a substitute for a reverse mortgage. The right panel of Figure 1 shows that 59% of households start with the smallest possible ownership share of 50%. As of September 2023, 31% of partial owners have increased their ownership shares at least once. According to OBOS, a change in ownership share tends to exceed the minimum of 10%. We also have some information about the housing units sold with PO. The average unit has 2.67 rooms (in addition to a kitchen and bathroom), is 59 square meters, and is in a multifamily building with 117 units.

In sum, the typical PO buyers are relatively young, use PO on small apartments in apartment buildings in (expensive) urban areas, and many choose an initial ownership share of 50%. We reproduce a standard PO unit for sale listing in Figure A1.

2.2.3 Partial Ownership and Housing Frictions

As we now explain, PO reduces four frictions in residential contracts, which, in itself, suggests that PO adds value to both households and housing suppliers. Together with the fact that competitive rental and housing markets have existed for hundreds of years, we expect the use of a simple convex combination of owning and renting—PO—to increase.

First, PO mitigates the moral hazard problem in the rental market, which drives up the maintenance costs as tenants have fewer incentives to take good care of the house (see, e.g., Henderson and Ioannides, 1983, Shilling et al., 1991). With PO, households have some ownership, which aligns incentives better. In the Norwegian contract, the household is responsible for all in-unit maintenance.

Second, PO reduces costs associated with adverse selection of tenants (e.g., households with volatile incomes are more likely to have problems paying rent). Landlords often use security deposits, credit reports, or other screening mechanisms to learn about the quality of tenants (see, e.g., Miceli, 1989). PO owners have, prior to the purchase, often been through similar screening by the mortgage provider, and hence, less effort is necessary from the owner of the remaining share of the house.

Third, vacancies are expensive for landlords. For example, in the U.S., the rental vacancy rate averages 7.6% compared to the owner-occupied vacancy rate of 1.7%.[10] With PO, there is no vacancy: The partial owner becomes a traditional homeowner, or the unit is sold.

Fourth, PO aligns builder incentives with the buyers. A common concern with new homes is that builders have private information about the quality and take shortcuts to save costs, leading to higher maintenance that the households must bear. With PO, the builder owns parts of the house and is responsible for their share of maintenance (e.g., leaking roof or warping concrete) and thus has less incentive to take shortcuts.

While mitigating frictions can help to make a PO market sustainable, it does not answer why developers—such as OBOS in Norway and Sweden—have begun to offer PO in addition to traditional homeownership. For developers, one motivation is to sell a higher quantity of houses in a world with tight mortgage regulations and increasing development costs without lowering prices. For financial intermediaries, such as "Coo.no," the most obvious motivation is that households' high willingness to pay for PO is large enough to make PO a positive NPV project. In the end, for-profit companies offer rental contracts while others build and sell houses. Partial ownership is a combination of these two activities, and so intuitively, a combination of the two should also be viable.[11]

2.3 Other Data Sources

We use multiple additional data sources to estimate our life cycle model. Information on wealth, homeownership, income, and education comes from the Norwegian Tax Registry (NTR) and Statistics Norway (SSB). We have data on PO contracts from OBOS, the largest

[10]Source: Table 1 of the Housing Vacancy Survey of the Current Population Survey (CPS/HVS).

[11]In our model simulations, we find that the expected return of offering PO for a provider is in between that of selling a house and renting it out.

homebuilder in Scandinavia and the largest supplier of PO. The data we use to calculate the distribution of housing size comes from Eiendomsverdi AS. Section A.1 of the Appendix explains how we construct our sample and calculate the statistics we use to estimate the model. Section D.1 of the Online Appendix describes how we estimate the parameters for the income process. Together, these statistics are sufficient to replicate our results.

3 Model

We now present the model, which nests a standard life-cycle homeownership model. Our innovation is the introduction of the PO contract.

3.1 Setup

The unit of analysis is a household i of age a. Each period t corresponds to one year. The household enters the model at age 24, works for K years, and spends $T - K$ years in retirement. During this period, the household maximizes utility by choosing consumption, $C_{i,a}$ and housing services $H_{i,a}$, including the ownership share S.

3.1.1 Preferences, Choices, and the Life Cycle

Omitting subscript i, households choose consumption, housing, and ownership to maximize the discounted sum of lifetime utility:

$$\max_{C_a, H_a, S_a} E_{24} \sum_{a=24}^{T} \beta^{a-24} \frac{\left(C_a^{1-\eta} H_a^{\eta} \chi(S_a)\right)^{1-\gamma}}{1-\gamma}, \tag{1}$$

where $\beta < 1$ is the discount factor, γ is the coefficient of relative risk aversion, and η measures the relative importance of housing services.[12]

The utility from housing services depends on ownership status $S_{i,a}$ through a premium capturing any enjoyment agents derive from owning rather than renting their home, $\chi(S) = 1 + \chi S^{\alpha}$, where α is the ownership-elasticity. Without PO, we have $S = 0$ for renters

[12] Since the average PO user is 35 years, we abstract from features important to older households, such as stochastic mortality, bequest motives (Ameriks et al., 2011, Lockwood, 2018, Kvaerner, 2022) and "aging-at-home" preferences (Cocco and Lopes, 2019).

and $S = 1$ for owners, and α is redundant. With PO, households with ownership status $S \in (0, 1)$ are partial owners. As $\alpha \to 0$, households receive the full premium regardless of the ownership share. As $\alpha \to \infty$, sole ownership is necessary to receive the full premium. If $\alpha = 1$, the utility shift is linear in the ownership share.

3.1.2 The Labor Income Process

Households enter the model at age a with an education level e, which affects their income stream. Before retirement, the labor income, Y_a, is exogenously given by:

$$\ln(Y_{a,e}) = f(a, e) + \nu_{a,e} + \epsilon_{a,e}, \tag{2}$$

where $f(a, e)$ is a deterministic function of age and education. The stochastic component governs the sum of a transitory shock $\epsilon_{a,e} \sim N(0, \sigma_\epsilon^2)$ and a persistent shock:

$$\nu_{e,a} = \rho_e \nu_{e,a-1} + u_{e,a}, \tag{3}$$

where $u_{a,e} \sim N(0, \sigma_u^2)$. Following Fagereng et al. (2017), the parameters $\rho_e, \sigma_u, \sigma_\epsilon$ depend on education. After retirement $(a > K)$, income is a constant proportion ϕ of income at retirement age K. We provide variable definitions and explain the estimation procedure for the income process in Appendix D.1.

3.1.3 Housing

To model demand for PO, we need a realistic representation of house price levels and house price growth and volatility. These factors drive the demand for both housing and PO. Consequently, we follow the standard practice in the literature and include stochastic house prices modeled as a random walk with drift (see, e.g., Cocco and Lopes, 2019, Vestman, 2019, Campbell et al., 2021, Catherine, 2021).[13] Let P_t^H denote the date t real housing price, and

[13] As a consequence of how we model house prices, we cannot speak to the impacts of PO on house prices, aggregate wealth, or inequality. Widespread use of PO in the long term will likely affect the cross-sectional distributions of both house and rental prices and, thus, indirectly impact ownership choices. We leave such a general equilibrium analysis for future research. As PO is primarily offered in densely populated areas where the supply of housing stock is restricted, we omit an endogenous construction sector as in, for example, Murphy (2018).

let $p_t^H \equiv \ln(P_t^H)$. The log real house price is given by

$$\Delta p_t^H = \mu + \sigma_h Z, \tag{4}$$

where Z is i.i.d. $N(0,1)$.

The rent-to-price ratio, denoted by κ, is constant. Following Kaplan et al. (2020), one subset of the housing sizes is available for rent, and one subset is available for owner-occupation. We denote the housing choice sets by $\mathcal{H}(S)$. Homeowners pay depreciation proportional to the market value, which is the sum of property maintenance δ and interior house maintenance τ. For owners, depreciation and capital gains are due for in the following year: $S_{a+1}(P_{t+1}H_{a+1}(1-\tau-\delta))$, where H_{a+1} is the house the household live in this period. In contrast, rent $\kappa P_t H_{a+1}$ is due in the current year. The household pays adjustment costs m_b (m_s) proportional to the market value to buy (sell) an owner-occupied unit.

Since house prices follow a random walk and the rent-to-price ratio is constant while income is stationary, prices can reach a level where households cannot afford to rent the smallest unit. We include a welfare system that provides a price-dependent minimum wage ($y(P)$), indexed to the market rent of the smallest unit plus a consumption floor $\underline{c}$.

3.1.4 Wealth

Household wealth, W, equals a cash account plus housing wealth. The cash account pays an interest rate of r_f. The household can take out a mortgage. Mortgages are available at the interest rate $r_f + \theta$, where θ denotes the mortgage premium.

All mortgages are one-period instruments rolled over every year. Households can costlessly adjust the size of the mortgage. As a result, households with mortgages do not have cash. Depending on context, we refer to the net position as liquid wealth, LW, or debt D. The return on liquid wealth is:

$$r(LW) = \begin{cases} r_f + \theta, & \text{if } LW < 0 \\ r_f, & \text{otherwise.} \end{cases} \tag{5}$$

Borrowing is subject to a loan-to-value (LTV) and a debt-to-income (DTI) constraint.

3.1.5 Partial Ownership

We now discuss how we model the PO contract described in Section 2.2. We follow the contract in only allowing partial ownership in 10 percentage point increments, starting at 50% i.e., $S \in \{0.0, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0\}$. Once a household achieves 100% ownership, the contract is converted to traditional ownership. A partial owner can increase ownership but not decrease it without selling the entire share.

Buying, selling, and changing ownership shares entail fixed costs: l_b, l_s, l_c.[14] When increasing ownership shares, the price is the larger of the contract's starting (P_0^H) and current (P_t^H) prices. The cost of increasing the ownership from S_a to S_{a+1} is therefore:

$$\bar{P}_t H_a \Delta S_{a+1}(1 + m_b) + l_c, \tag{6}$$

where $\bar{P}_t = \max\{P_t^H, P_0^H\}$ is the price. We find, somewhat surprisingly, that this option element is not important for our analysis; removing it increases WTP by only three percentage points. The main reason is that households can, if prices fall, "reset" the contract by selling the unit, receiving their share, and entering into a new PO contract. Once the price level falls substantially below P_0 this becomes cheaper. As a result, the initial price is only relevant when households experience a slight decline in prices (see Appendix B.2 for an example). In addition, house prices and labor income are uncorrelated in the model, so few households experience a large simultaneous drop in labor income and housing wealth.

There are two recurring costs associated with PO. First, the partial owner pays market rent on the share of the property not owned (i.e., $P_t H_{a+1} \kappa (1 - S_{a+1})$). Second, the household pays all interior house maintenance (τ) but shares exterior maintenance costs (δ), such as outdoor painting, according to ownership shares.

Without bequest motives and risks relevant for old households, PO will be in high demand among seniors who use it to decumulate wealth, which is inconsistent with the data. To prevent retirees from dominating the PO market in the model, we impose a cost that is gradually rising after age 55:

$$c(a) = \max\{0, a - 55\}. \tag{7}$$

[14]For example, a household that owns 80% of its home and wants to own 50% must sell its home, receive 50% of the value, then buy a new home with an 80% share, and pay its share of the sales cost m_s (80%), its share of the buying cost m_b (50%), and 100% of associated legal fees l_b and l_s.

The function is no more than a thrifty way of modeling details in the actual PO contract, which makes it unattractive for senior households, such as a 10-year contract length (see Appendix A.3 for further details). The function does not impact the choices of young households.

3.2 Recursive Formulation and Decision Problems

We now state the recursive formulation and explain the decision problem. We omit subscripts and use prime superscripts for next-period values. The timing is as follows: The house price and income shocks appear at the start of a period. The household makes its decisions after observing these values. The utility of today's choices is realized in the current period. For example, a household that rented in the previous period and bought a house in this period would receive the ownership utility (χ) right after the housing transaction.

3.2.1 Budget Equations

Households choose consumption (C), housing (H'), ownership status (S'), and liquid wealth (LW'). Renters pay rent, while homeowners keep the house on their balance sheet. We introduce the function $ac(P, S, H, S', H')$ that calculates the adjustment costs as a function of house price, choices, and size. The budget equation for a household with wealth W and income Y is:

$$W + Y = C + LW' + ac(P, S, H, S', H') + (1 - S')\kappa PH' + S'PH'. \tag{8}$$

A partial homeowner faces the same budget equation, with the additional possibility of changing the ownership share:

$$\begin{aligned} W + Y = C + LW' + ac(P, S, H, S', H') + (1 - S')\kappa PH' + S'PH' \\ + \mathbf{1}_{\Delta S' \neq 0, \Delta H' = 0} \Delta S' \bar{P}_t H', \end{aligned} \tag{9}$$

where the last term is the price of increasing ownership.

The evolution of wealth is determined by liquid wealth (LW') and the market value of the owned housing net of depreciation:

$$W' = LW'(1 + r(LW')) + \mathbf{1}_{S'>0} P'H'(S'(1-\delta) - \tau) \tag{10}$$

3.2.2 Decision Problems

All households make the same choices regardless of homeownership. The state variables for renters and homeowners are: $\Xi \equiv \{W, H, S, \nu, P, a\}$ while partial owners have one extra variable: The house price level when they first became partial owners, P_0^H, which can affect the price of increasing ownership.

Because retired households have the same decision problems without income shocks, we only discuss working-age households. The decision problem for renters and homeowners is:

$$V(\Xi) = \max_{C,H',LW',S'} \{u(C,H') + \beta E[V(\Xi)]\}, \tag{11}$$

subject to

$$C > 0, \tag{12}$$
$$S' \in \{0.0, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0\}, \tag{13}$$
$$H' \in \mathcal{H}(S'), \tag{14}$$
$$D' \geq LTV \times PH'S', \tag{15}$$
$$D' \geq DTI \times YS', \tag{16}$$

the age constraint (Eq. 7), the budget equation (Eq. 10), and the law of motion (Eq. 8). The constraints have simple interpretations: Eq. 13 shows that a household must choose to rent, partially own, or own. Eq. 14 shows that the housing choice set depends on ownership status. Eqs. 15 and 16 show that borrowing is only available for home purchases and must satisfy both LTV and DTI requirements.

The analog decision problem of a partial owner is identical, except that the initial price becomes an additional state variable:

$$V(\Xi; P_0^H) = \max_{C,H',B',S'} \left\{u(C,H') + \beta E\left[V(\Xi'; P_0^H)\right]\right\}, \tag{17}$$

subject to Eqs.: 7, 9, 10, and the regular constraints in 12-16.

4 Parameterization

We solve the model using standard methods (see Section E.2 of the Online Appendix). The model parameterization contains three stages. First, we use parameters from the literature or estimate them with our data outside the model. Second, we use simulated methods of moments (SMM) to estimate the discount factor β and the utility shifter for homeownership χ. The identifying moments are wealth levels and homeownership rates by age. Third, we estimate the ownership-share elasticity α also via SMM by matching the average ownership share of new partial owners. Table 1 summarizes all parameters.

4.1 First-stage Parameters

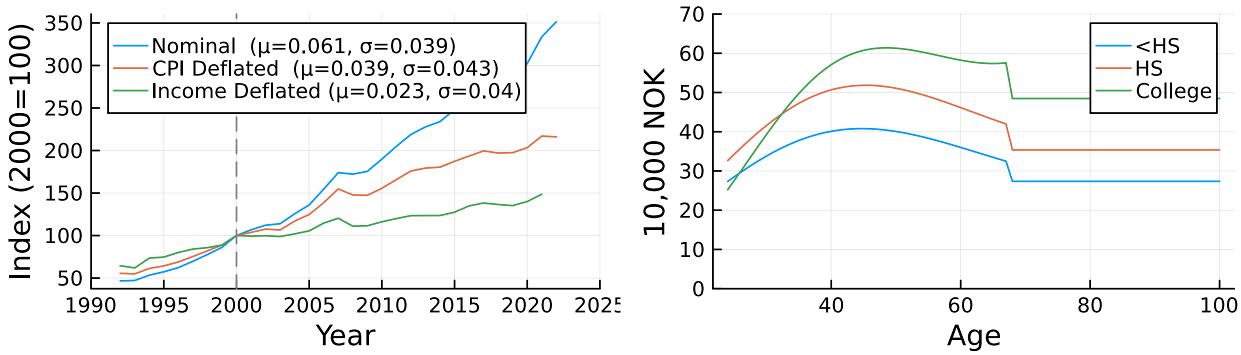
We first discuss the calibration of parameters common for the model with and without PO and then discuss parameters only relevant to PO.

4.1.1 Common Parameters

We set the coefficient of relative risk aversion γ to 2.0 following Campbell and Cocco (2015). We set the preference weight on housing η to 0.3, based on Yao et al. (2015).

We estimate the labor income process using administrative data for the Norwegian population from 1993 to 2018. As Campbell and Cocco (2015), we rely on a broad measure of household income, defined as the sum of gross salary income, pension, net capital income, and total government transfers minus taxes. Following Fagereng et al. (2017), we set the pension-to-income ratio $\phi = 0.842$. Figure 2b shows the life-cycle profile by education groups (all details about the estimation of the labor income process are in Appendix D.1).

We set the parameters governing house prices as follows. To estimate mean house price growth (μ) and its standard deviation (σ_h), we start with the nominal home price index. We then deflate this index by median after-tax household income, as income is stationary in the model. Figure 2a shows the evolution of nominal, real, and income-deflated house prices. Expected log house price growth equals the time-series mean, $\mu = 0.023$. Since prices of



(a) House Prices **(b)** Calibrated Income Process

Figure 2 Calibration. This figure presents the price index for existing homes in Norway in nominal and real terms, as well as the mean and standard deviation of the log growth rate.

individual homes are about twice as volatile as price indices (Landvoigt et al., 2015, Case and Shiller, 1989), we double the volatility and set $\sigma_h = 0.0564$.[15]

We include three house sizes: 44, 77, and 100 square meters. These sizes correspond to the 5th, 25th, and 50th percentiles of home sizes. We omit large houses because wealthy households generally prefer traditional homeownership. We use the smallest unit as a numeraire. The two smallest units are available for rent, and the two largest are for ownership.

We calculate the rent-to-price ratio κ as follows. We start with yearly rent statistics, which differ by size, number of rooms, and type (single-family, small multifamily, and multifamily). We divide the rent per square meter for five-room rentals by the single-family square meter price. Similarly, we divide the four-room rental price by the small multifamily price and the three and two-room prices by the multifamily price. The normalization ensures that the rent-to-price ratios are functions of both square meters and housing type. The ratios are relatively stable. Our rent-to-price ratio in the model is equal to the average ratio of these four series, $\kappa = 0.044$, which is close to the commonly used American estimate of 0.05 by Davis et al. (2008) (see Figure A5e for illustration).

We set the adjustment costs on housing to match the institutional setting. First, buyers pay a transaction tax of 2.5% of the purchase price, so we set $m_b = 0.025$. Second, real estate agents charge an average of 2% in sales commissions, and households often incur additional

[15] As a reference point, the ratio average arithmetic real house price growth to volatility is 0.44, comparable to a value-weighted Norwegian stock index over the same period.

costs such as staging (Yao et al., 2015), so we set $m_s = 0.025$.

We set the risk-free rate $r_f = 0.0143$ as in Fagereng et al. (2017) and the total depreciation on housing to $\tau + \delta = 2.5\%$ as in Yao et al. (2015). Following Norwegian law, the maximum LTV and DTI are 0.85 and 5.0.[16] Since 2000, the mortgage tax deduction has ranged from 22% to 28%, and the average mortgage premium has been 2.6%. Thus, we set the mortgage premium $\theta = 0.016$ to account for the tax deduction on the mortgage rate, given by the risk-free rate plus the mortgage premium. We set the consumption floor to $\underline{c} = 10$, comparable to the financial subsistence benefits of a single household. When simulating the households, we calibrate the joint distribution of the price level, wealth, and productivity as we explain in Section E.2 of the Online Appendix.

4.1.2 Partial Ownership Parameters

Filing fees to enter a PO contract are $l_b = 0.2128$ while canceling it is free $l_s = 0.0$. We set the cost of changing ownership shares to $l_c = 0.8701$, which matches the amount OBOS charges plus various government fees.[17] We introduce PO for medium-sized houses, which are the closest to the average size of units sold with PO. [18] The relative share of depreciation due to exterior δ and interior maintenance τ matter for PO because only exterior maintenance costs are shared between owners. Since the PO contract we model is currently offered only on new construction, which requires little maintenance, we set $\delta = 0.02$ and $\tau = 0.005$.

4.2 Second-Stage: Wealth and Homeownership over Age

We use SMM to estimate the discount factor β and the utility shifter for homeownership χ. The point is to match a set of stylized facts before we introduce PO. The empirical moments we target are the average net worth and the homeownership rate of households aged between 25 and 50 years. Each age contains two moments, resulting in an overidentified

[16]The maximum DTI ratio of 5 is on total pre-tax income. The typical income tax rate for 35-year-olds in our sample is around 20%, which implies a DTI of 6 on after-tax income. Moreover, current regulations also require that borrowers can manage a mortgage rate increase of 5 percentage points (3 percentage points from 2022). Hence, we set the after-tax DTI limit at 5.0.

[17]OBOS charges six times the standardized inflation-indexed legal fee ("rettsgebyr") set to 1,243 NOK in 2023. To include other small government fees, we set the cost to seven times the legal fee.

[18]In Appendix B.1, we show that our conclusions regarding the demand for PO and WTP are insensitive to reasonable changes to the size of the PO unit. As a result, only having PO on the empirically most common house size has a limited impact on the analysis while it speeds up the model considerably.

Panel A: Externally Calibrated Parameters			
Parameter		Value	Source
Risk aversion	γ	2.0	Campbell and Cocco (2015)
Exp. Share Housing	η	0.3	Yao et al. (2015)
Risk-free rate	r^f	0.0143	Fagereng et al. (2017)
Mortgage premium	θ	0.016	SN 08175
Wage profiles	$f(a, e)$	Fig. 2b†	Data
Permanent income shock	σ_v	Tab. A3	Data
Transitory shock var.	σ_ϵ	Tab. A3	Data
Retirement Income Drop	ϕ_{ret}	0.842	Fagereng et al. (2017)
Rent-to-price ratio	κ	0.044	SN 06035, 09895
Sales cost	m_s	0.025	Commission + Fees
Purchase cost	m_b	0.025	Tax code
Property maintenance	δ	0.02	Yao et al. (2015)
In-unit maintenance	τ	0.005	Yao et al. (2015)
Loan-to-Value	LTV	0.85	Law
Debt-to-Income	DTI	5.0	Law
Price growth	μ	0.023	SN 04751, 03014, 07230
Price volatility	σ^2	0.0564	SN 04751, 03014, 07230
Rental sizes	$\mathcal{H}(0)$	$[1.0, 1.75]$	Own calculation
Owner-occupied sizes	$\mathcal{H}(1)$	$[1.75, 2.27]$	Own calculation
PO sizes	$\mathcal{H}((0,1))$	$[1.75]$	Own calculation
PO purchase cost	l_b	0.2128†	Contract
PO change cost	l_c	0.8701†	Contract
PO sales cost	l_s	0.0†	Contract
Starting age	n/a	24	
Retirement age	K	67	
Final age	T	100	
Consumption Floor	$\underline{c}$	10†	Welfare system
Initial Distribution of wealth	n/a	Fig. A5a†	Data
Initial Distribution of prices	n/a	Fig. A5b†	Data
Panel B: Internally Estimated Parameters			
Parameter		Value	Standard Error
Discount Factor	β	0.965	0.001
Homeownership utility	χ	0.176	0.027
Ownership share Elasticity	α	0.214	0.027

Table 1 Model Parameters Superscript † denotes variables in NOK10,000. SN refer to publicly available tables produced by Statistics Norway.

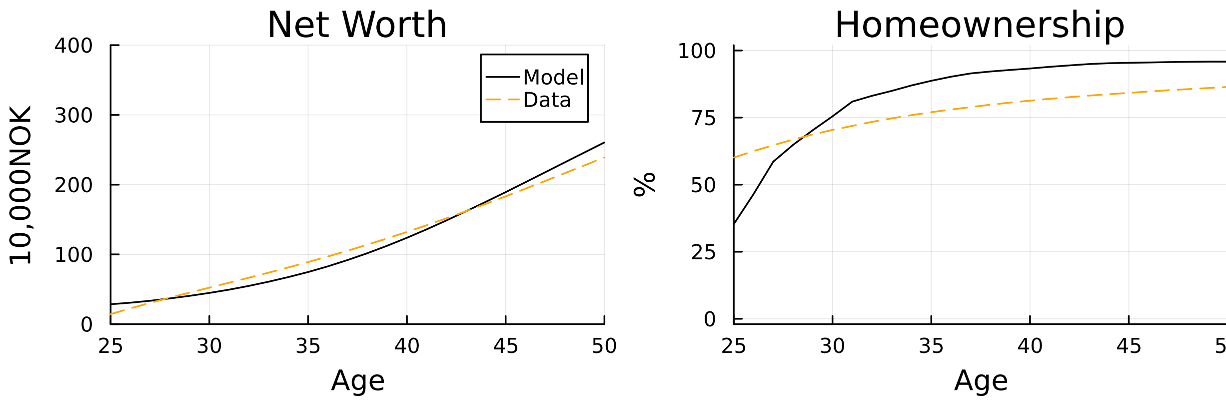


Figure 3 Model Fit. The figure compares the predicted average net worth and the homeownership rate of households aged between 30 and 50 years using the parameter vector that solves Eq. 18 with the empirical counterparts.

system with two parameters and 50 moments. The identification is straightforward. A higher discount factor (β) increases wealth accumulation. A higher ownership preference (χ) increases homeownership.

The SMM estimator is defined as follows. Let $\hat{m}$ denote the vector of empirical moments we target in the estimation. The parameter vector of interest is $\omega \equiv \{\beta, \chi\}$. Given a candidate parameter vector ω, we solve the model and calculate the equivalent simulated moments $\hat{m}(\omega)$. The estimated parameters are those that minimize the distance between the empirical and simulated moments:

$$\omega^{\star}(\Omega) = \arg\min_{\omega} \left\{ [\hat{m}(\omega) - \hat{m}]' \Omega [\hat{m}(\omega) - \hat{m}] \right\}. \tag{18}$$

Here, Ω is a diagonal weighting matrix with elements equal to the inverse of the squared empirical moments, $1/\hat{m}^2$. This normalization prevents some moment conditions from receiving a high weight because of their units, as they reflect percentage deviations from their targets. We obtain standard errors using a bootstrap procedure, as we explain in Section E.1.2 of the Online Appendix. As we chose our life-cycle model of housing due to its ability to match wealth and homeownership rates in a variety of countries (e.g., Vestman, 2019, Attanasio et al., 2012, Kovacs and Moran, 2021), it is unsurprising that also model fits our data, as Figure 3 shows. Our innovation is to extend the model to include PO and estimate the ownership elasticity, as we discuss in the next section.

4.3 Third-Stage: Introducing Partial Ownership

We use our data on PO users to identify one new housing preference parameter: the ownership elasticity. It tells how much of the homeownership utility premium a partial owner receives for a given ownership share.

We proceed as follows. First, we add the ownership-elasticity α to the ownership utility premium: $\chi(S) = 1 + \chi S^{\alpha}$. We start with the model without PO, as in the previous section, and then introduce PO as part of the households' choice set and simulate one year. In the simulation, some households switch to PO. Upon choosing a PO, the ownership share $S \in (0, 1)$ depends on the ownership-elasticity α. If α is small, households will choose a low initial ownership share to "harvest" most utility benefits from homeownership. As we increase α, partial owners will increase their ownership share because the utility value of low ownership now is closer to renting than owning.

Figure 4 shows the fit. As expected, the targeted moment, the initial ownership share, monotonically increases the ownership-elasticity α. The estimated α is 0.214 (standard error of 0.027).[19]

What does the value of α tell us? In Table 2, the average initial PO share is 57%, and 67% of households choose to own 50% (the lower limit). To match this, we need a low α so that households get a large share of the homeownership utility with a low ownership share. At first glance, the seemingly low α may hint that PO is mainly a cheap way to get the homeownership utility premium (χ). However, in the data, about 20% of households have, in the first three years of the contract, already increased their ownership share. Moreover, in both simulations and the data, relatively many households buy a larger share 50% (see Figure A6). Taken together, these observations imply that at least part of the benefit from PO comes via the possibility of convexifying the rent-own decision.

4.4 Policy Functions

To provide intuition, we now present the policy functions for homeownership with and without partial ownership, as well as how they depend on our estimated parameters.

[19]We calculate the standard error by bootstraping. We draw 100 bootstrapped samples of the initial ownership shares in the data and repeat the estimation to find the standard error.

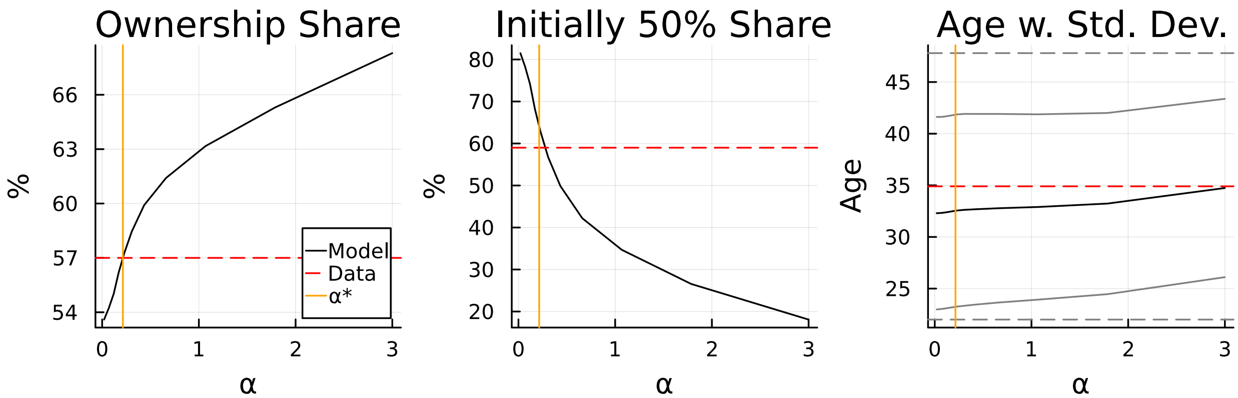


Figure 4 Moments from Third-Stage Estimation. The horizontal dashed red line is the empirical moment, while the orange solid vertical line is the estimated parameter value for α. The gray lines denote the mean plus/minus the standard deviation of age in the data (dashed) and the model (solid).

Moment	Model	Data	Target
Average new initial ownership share	57.0%	57%	Y
New owners owning 50%	64.1%	59%	N
Average Age	32.5	35.0	N
Std. Dev. Age	9.3	13.0	N

Table 2 Model Fit - Third Stage. the ownership-elasticity α is set to match the average new initial ownership share (first row). *Source:* OBOS.

4.4.1 The Decision To Become a Partial Owner

Figure 5 shows the ownership choices of current renters (left), homeowners (center), and partial owners (right). The key insight is that partial ownership smooths out the discrete ownership choice.

Without PO, renters follow a threshold rule, only becoming homeowners when they are sufficiently wealthy. With PO, renters become partial owners at lower wealth levels and gradually increase ownership as wealth rises. The threshold to own outright shifts to the right. The 50% minimum ownership requirement, combined with mortgage borrowing constraints, limits the poorest households from becoming partial owners. The first step—50% ownership—is large, because households who would have chosen lower shares "stretch" to buy 50%.

Without PO, current homeowners also follow a threshold rule, with the threshold shifted

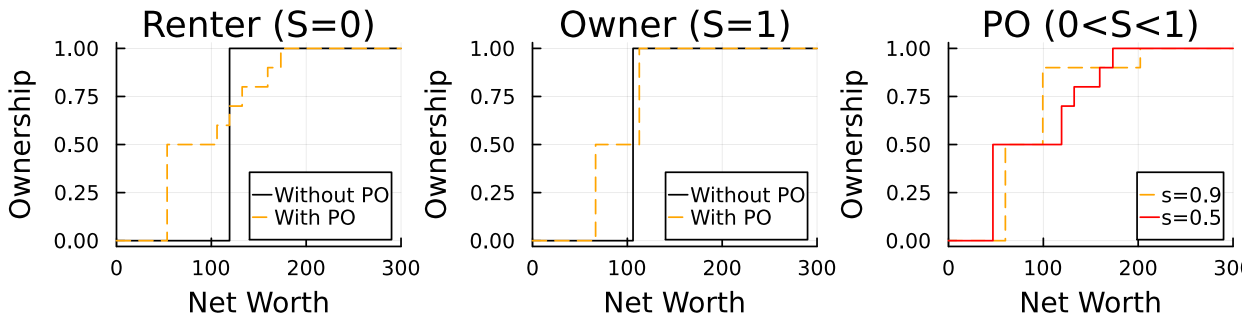


Figure 5 Housing Choice Over the Wealth Distribution. The figures illustrate how young households decide to rent ($S = 0$), partially own ($0 < S < 1$), or own traditional ($S = 1$), as a function of wealth. The policy functions represent a 25-year-old high school graduate with median productivity who faces medium house prices. A wealth of 100 on the x-axis refers to 1 million NOK.

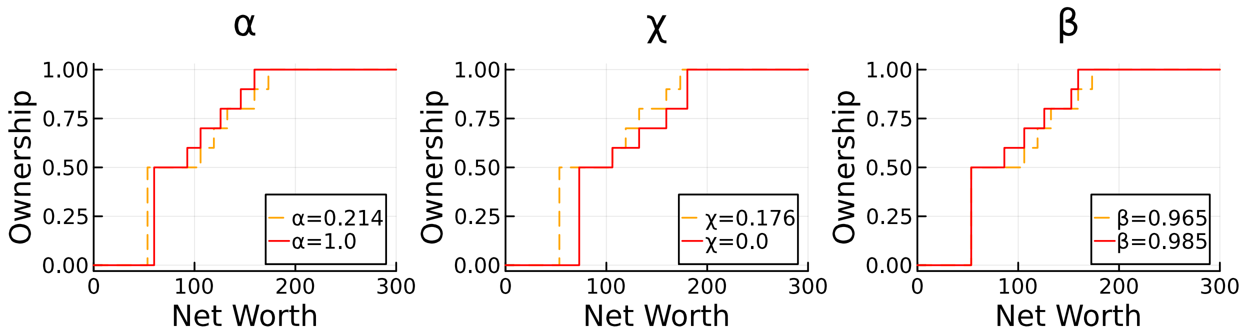
to the left compared to renters due to sales costs. With PO, homeowners choose PO at modest wealth levels and rent only at the lowest wealth levels. Unlike for renters, few combinations of state variables result in a step function for homeowners due to the considerable adjustment cost associated with going from, say, 100% to 80% ownership, which requires selling the home and buying 80% ownership. While introducing PO has less impact on owners than renters, it is crucial for marginal owners—those below or just above the threshold.

We plot the policy functions for two partial owners with different ownership shares. Without adjustment costs, these functions would overlap. With adjustment costs, households stick to their ownership share for longer. The slow adjustment to changes in wealth is most pronounced for reducing ownership shares, as the contract prohibits reductions. The transaction costs of selling and entering into a new contract are large enough to make partial owners reluctant to reduce ownership shares, just as for traditional owners.

4.4.2 Drivers of the Demand for PO

We investigate how demand for PO is affected by the three preference parameters estimated internally: ownership-elasticity α, the ownership-utility premium χ, and the discount factor β in a comparative statics exercise. Other preferences and state variables remain unchanged. The central finding is that preferences do not mainly drive the demand for PO.

Figure 6a shows how the housing choice of a renter depends on the ownership-elasticity α. The parameter is essential to understand the future ownership structure of partial home-



(a) Ownership-elasticity **(b)** Ownership Premium **(c)** Discount Factor

Figure 6 Comparative Statics on Housing Decisions for Current Renters. The figures illustrate how young households decide to rent, partially own, or own as a function of wealth. The policy functions represent the same households as in Figure 5.

ownership. The dashed orange line shows the policy function with the estimated α. The solid red line shows the case with an α of 1, corresponding to the standard ownership utility premium of $\chi(S) = 1 + \chi S$. The central insight is that the household ownership shares in homes with PO is an increasing function of α. With a high enough α, households will buy the largest ownership share they can afford. Conversely, with a lower α, households choose small ownership shares, and, as a result, the financial intermediaries must own a larger share of homes with partial ownership.

In Figure 6b, we remove the ownership-utility premium ($\chi = 0$). Without it, renting becomes, by definition, relatively more attractive, causing the demand function for home-ownership to shift to the right. At the same time, it leads to a parallel shift in the PO step ladder. Thus, in a world without an ownership utility premium, households still use PO.

In Figure 6c, we increase the subjective discount factor β. Small changes in β have little direct impact on housing choices. We present similar figures for other parameters in Appendix C, highlighting that part of the demand for PO comes through reducing frictions such as the indivisibility of housing and changing exposure to house price risk.

5 Results

Our results contain three parts: First, we introduce PO into the calibrated model. This allows us to study take-up rates over the life cycle in the short and long term. Then, we quantify the willingness-to-pay (WTP) for PO across social strata and housing market conditions. Finally, we use the model to understand the effect of PO on debt and debt-to-income (DTI) ratios and housing downsizing.

5.1 Take-Up of PO in the Short and Long-run

We present aggregate housing outcomes after the introduction of PO in Figure 7.[20] We separate take-up rates from long-run outcomes one year after the introduction of PO. The top left plot shows the take-up rate of PO over the life cycle. Take-up declines with age and is around 20% at age 35, the average age of PO users. The top right plot shows the percentage of households that rent. PO decreases rental rates, especially among the young, and this adjustment happens almost entirely within one year. In the model, households can freely exit the rental contract. This generates a small upward bias in one-year transitions from renting to PO. The plot at the bottom left shows that PO initially only marginally decreases traditional ownership. Over time, homeownership declines because households wait until they are wealthier before they own 100% of their home.

The bottom right plot shows that the average ownership share increases immediately after the introduction of PO. Over time, we see that the ownership shares fall slightly for young households but remain relatively unchanged for senior households. Thus, the increase in the number of households who own some of their housing (renters switching to PO) is roughly offset by fewer households owning all of their housing (owners switching to PO). One aggregate implication of PO is; therefore, that aggregate house price risk is shared among more households.

5.1.1 PO and Economic Outcomes Related to Homeownership

We now discuss how PO relates to the literature that studies how homeownership affects other economic outcomes (see, e.g., Sodini et al., 2023).

The high take-up rates of young households suggest that PO could reverse some of the fall

[20]The percentage of households aged 25 who are partial owners is defined as $\sum \frac{0<S_i'<1}{N}$, renters as $\sum \frac{S_i'=0}{N}$, traditional owners as $\sum S_i' = 1N$, and the share of housing owned by households as $\sum S_i' N$, where S_i' is how much household i chose to own this period and N is the number of households. By definition, the share of households who are traditional owners and the share of housing owned by households is the same without PO (black lines, bottom row in Figure 7).

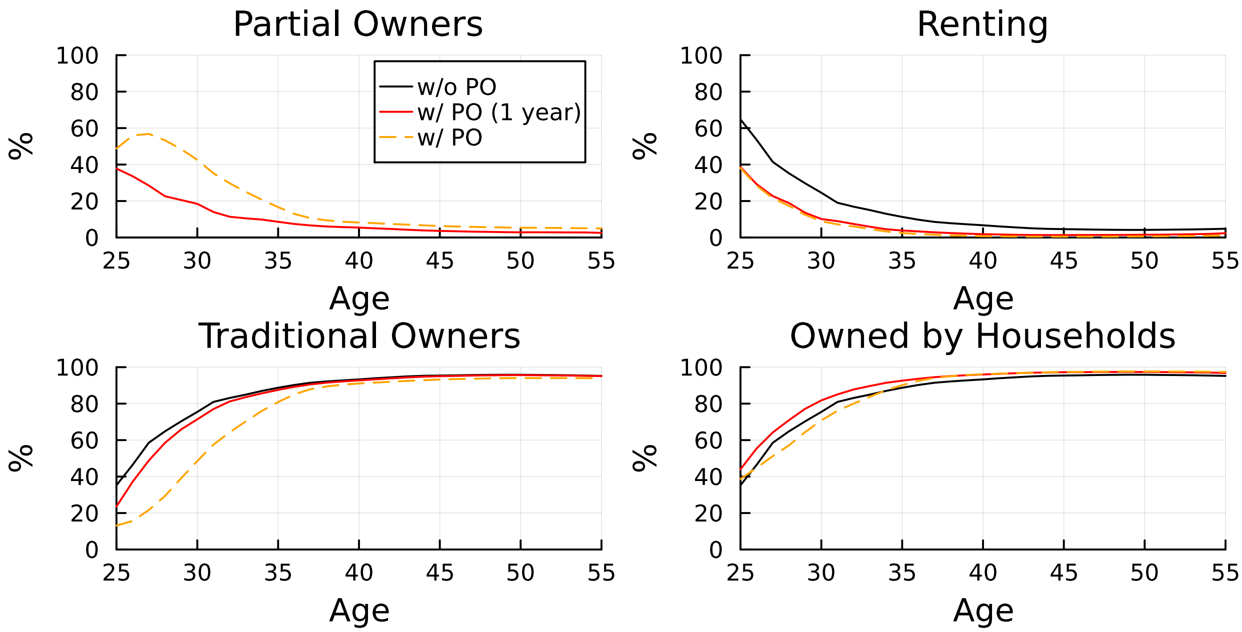


Figure 7 Aggregate Outcomes After PO Introduction. The solid black line shows the outcomes without PO. The solid red line shows the outcome of interest one year after the introduction of PO. The orange dashed line shows the long-term outcomes with PO.

in young homeownership after the Great Recession documented by Mabille (2022). He shows that a contraction of credit availability matches the fall in homeownership. We show that PO is most popular among young households, who are generally more credit-constrained.

Bach et al. (2020) document that housing and mortgage choices early in life are among the most important predictors of where households end up in the wealth distribution at retirement. We show that many young households that would be renters without PO become partial owners and would now benefit from house price appreciation.

PO makes it possible to increase housing investments gradually. One downside of housing is that it may crowd out stock investment (see e.g., Cocco, 2005, Catherine, 2021). Cocco (2005) concludes that housing crowds out stockholdings. We show that many households that would become homeowners without PO instead become partial owners with PO. This finding hints that PO may reduce some of the crowding-out effects of housing investment.

PO may also dampen other adverse effects of homeownership, such as lowering geographic mobility (Oswald, 2019) because it reduces lock-in effects and barriers to buying a home. Lock-in effects are smaller due to lower housing adjustment costs for partial homeowners.

Barriers to buying are smaller due to the lower initial investment one needs to become a partial homeowner.

5.2 Welfare Effects of Partial Ownership

We measure the economic importance of PO as a one-time payment that makes a household's indirect utility with PO the same as without PO. Specifically, we first calculate the value function without PO V. We define the WTP as the maximum one-time cost c a household is willing to pay to obtain PO:

$$WTP(\Xi) = \{c \in \mathbf{R} : E[V(\Xi)] = E[\tilde{V}(W - c, H, S, \nu, P, a)]\}, \tag{19}$$

where $\tilde{V}$ denotes the value function with PO. The expectation operator is taken with respect to a particular group of households (e.g., low-income households). The parameterization of the welfare cost calculations is from the benchmark case (see Table 1 for parameters). This idea is often used to quantify the importance of a particular choice or a financial product (see, e.g., Cocco et al., 2005, Calvet et al., 2007, Koijen et al., 2016, Nakajima and Telyukova, 2017, Gomes et al., 2022, among others).

5.2.1 Welfare Gains from PO

Figure 8 presents the mean WTP as well as the 5th and the 95th percentiles by age. The WTP for PO among households aged 25 to 45—the primary users—is between 4% to 19% of after-tax income. (15,000-52,000 NOK). The WTP ranges from roughly 35% of after-tax income to zero. The estimated welfare gains are high in absolute and relative terms. The most direct comparison is Nakajima and Telyukova (2017). They estimate that the WTP for a reverse mortgage option is between 0.84% and 5.13% of after-tax income at age 65. Thus, the WTP for PO exceeds that of reverse mortgages.[21]

[21] Many other studies calculate WTP for various choices and products. While a direct comparison of WTPs is difficult due to different approaches, economic environments, and so on, we note that the WTP for PO seems in the range of welfare losses associated with suboptimal portfolio choices over the life cycle. For example, Cocco et al. (2005) calculate the welfare loss due to suboptimal portfolio choices. The most considerable losses are equivalent to a reduction in annual consumption between 1.5% and 2.0%. Calvet et al. (2007) estimate that the welfare cost of under-diversification is 0.5% of disposable income for the median Swedish household.

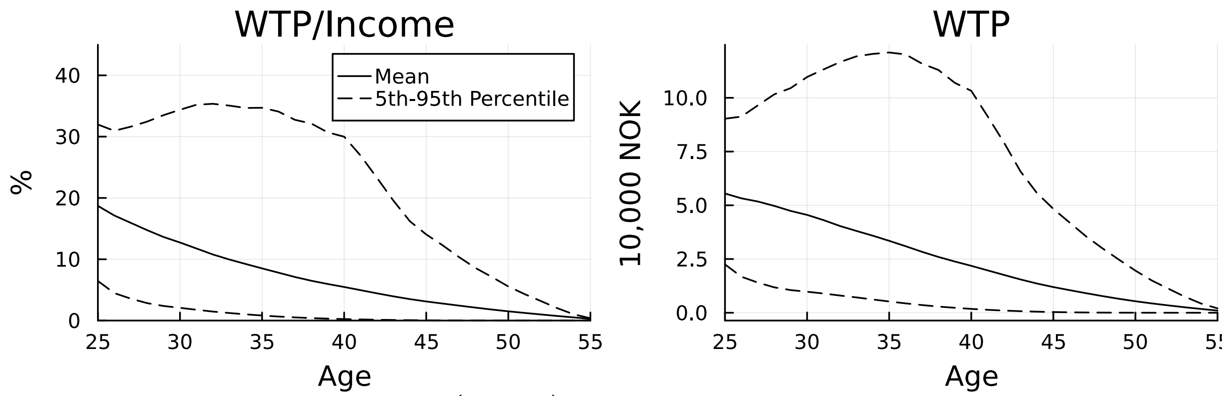


Figure 8 Willingness to Pay (WTP) for PO. The figure plots the one-time WTP for PO as defined by Equation 19. The left plot shows WTP as a percent of annual household income. The plot on the right shows WTP measured in 10,000 NOK.

5.2.2 Heterogeneity in WTP for PO

We use the model to understand the demand for PO. Our focus is on households that differ in terms of homeownership, income, wealth, and on the affordability of housing. Figure 9 presents the results.

We plot WTP by homeownership status before PO in the top left. The gains are greater for renters than for homeowners. One reason is that renters get much of the utility benefit from traditional homeownership with PO. Traditional homeowners benefit from gradual exposure to real estate over the life cycle and smoother downsizing after adverse shocks.

The top right plot shows that the PO WTP is highest for low-income households. For example, at age 30, the WTP of low-income households is approximately six times higher than that of high-income households. The bottom middle plot shows that the WTP is higher for richer households. The difference in WTP between high and low-wealth households is smaller than for high and low-income households. The reason is that low income is a more common source of exclusion from the mortgage market than low wealth for households over 30 years. These results suggest that the WTP for PO depends on how and for whom mortgage regulation binds.

The final plot at the bottom right shows how WTP changes with housing affordability. The higher the house prices are, the higher the WTP for PO at all ages. The impact of house price levels on WTP is particularly high for young households. This result indicates that PO may reverse some of the decline in young homeownership driven by worsening affordability

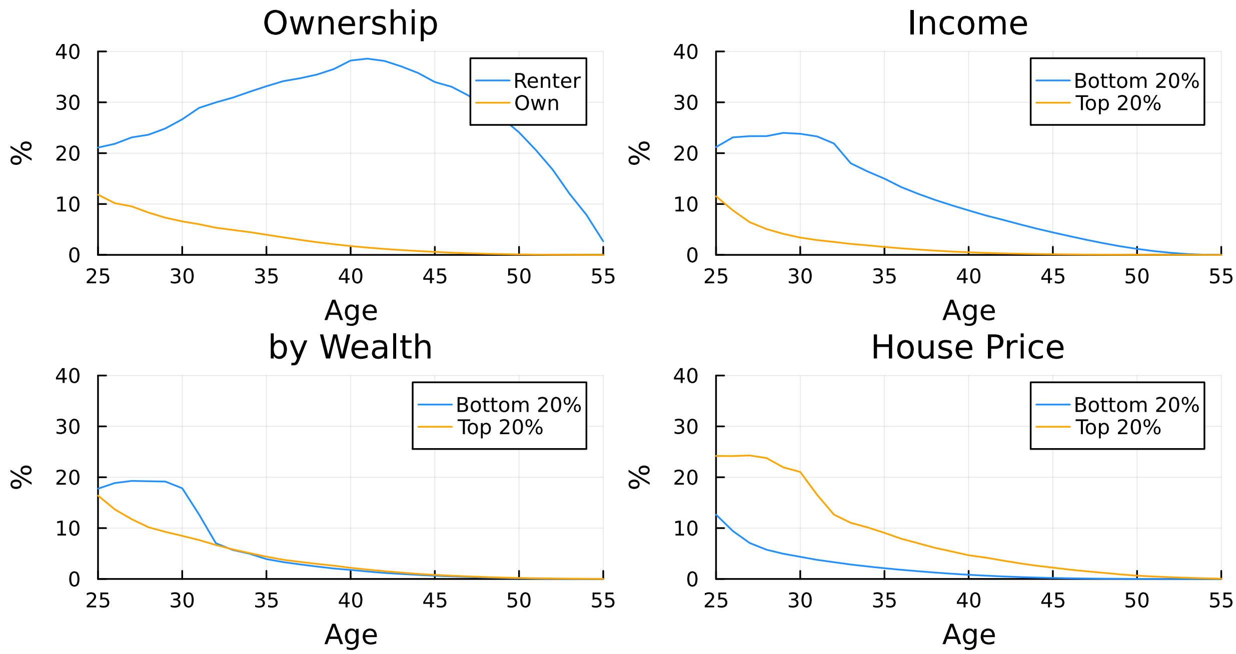


Figure 9 Willingness to Pay (WTP) for PO by Household Type. The figure shows the average WTP for PO by household type. The y-axis shows WTP as a percent of after-tax income. For income, wealth, and house prices, we present the results for the top and bottom 20% of their distribution by age.

(Mabille, 2022).

5.2.3 Sensitivity Checks

We perform sensitivity checks in Appendix B.3. Its primary purpose is to examine whether the WTP estimates, essential output from our analysis, are sensitive to small changes in model parameters. We change parameters related to the house price process, LTV requirements, depreciation, and the rent-to-price ratio. The idea is not to see what the WTP would be in a different country with a different housing market but how each aspect of the housing market—as captured by these parameters—influences the demand for PO. The main takeaway is that the WTP for PO increases when homeownership is more attractive. Second, the WTP estimates are relatively insensitive to small changes in housing parameters. The sensitivity checks provide suggestive evidence for why the PO contracts came early to Norway. The Norwegian real estate market has experienced high price growth, strict borrowing regulation, and low rent-to-price rates, all pushing up demand for PO.

5.3 Financial Stability Concerns

Past crises show that real estate markets are essential from a financial stability perspective. Mian et al. (2017) show that in the last 50 years, higher household debt to GDP ratio predicts lower GDP growth and higher unemployment. Mian and Sufi (2009) point to the pivotal role of excessive lending to subprime borrowers in causing the 2008 financial crisis. A natural concern with PO is, therefore, that PO increases household debt as renters become partial owners. Additionally, PO may transfer risk from homeowners to a few commercial PO vendors and, ultimately, the banking sector and the real economy. In Norway, both the Central Bank and the Financial Stability Authority (FSA) have expressed that increased use of PO may have adverse effects on financial stability. For example, the FSA stated in October 2023: "The FSA cannot see that assessments have been made of the risk that new ownership models [PO] could lead to increased financial vulnerability in Norwegian households''.[22] Motivated by these concerns, we analyze PO's impact on household debt and financial fragility via counterfactual experiments.

5.3.1 PO and Unconditional Debt-to-Income Ratios

The top row of Figure 10 presents the unconditional debt-to-income (DTI) ratios with and without PO. We report the results for the total population and households in the bottom and top 20% of age-specific income distribution. The DTI ratio increases right after the introduction of PO as renters become partial homeowners. The most notable change in the demand for mortgages comes from young households, the primary PO users. In the long run, the increase is more modest, as many use PO instead of traditional ownership.

The plot in the middle shows the same analysis but for households in the bottom 20% of the age-specific income distribution. Without PO, most households under 40 in this group have no debt as they are unable, or unwilling, to borrow to become traditional homeowners. With PO, many switch from renting to partial ownership and use debt to pay for the ownership share. Again, the increase in debt is less pronounced in a more mature PO market.

The plot on the right shows that high-income households are almost unaffected by PO since these households prefer to own 100%. The exception is the youngest households, who,

[22]Original quote: "Finanstilsynet kan ikke se at det er gjort vurderinger av risikoen for at boligkjøpsmodellene kan føre til økt finansiell sårbarhet i norske husholdninger…" FSA 19.10.2023, ref. 23/8080.

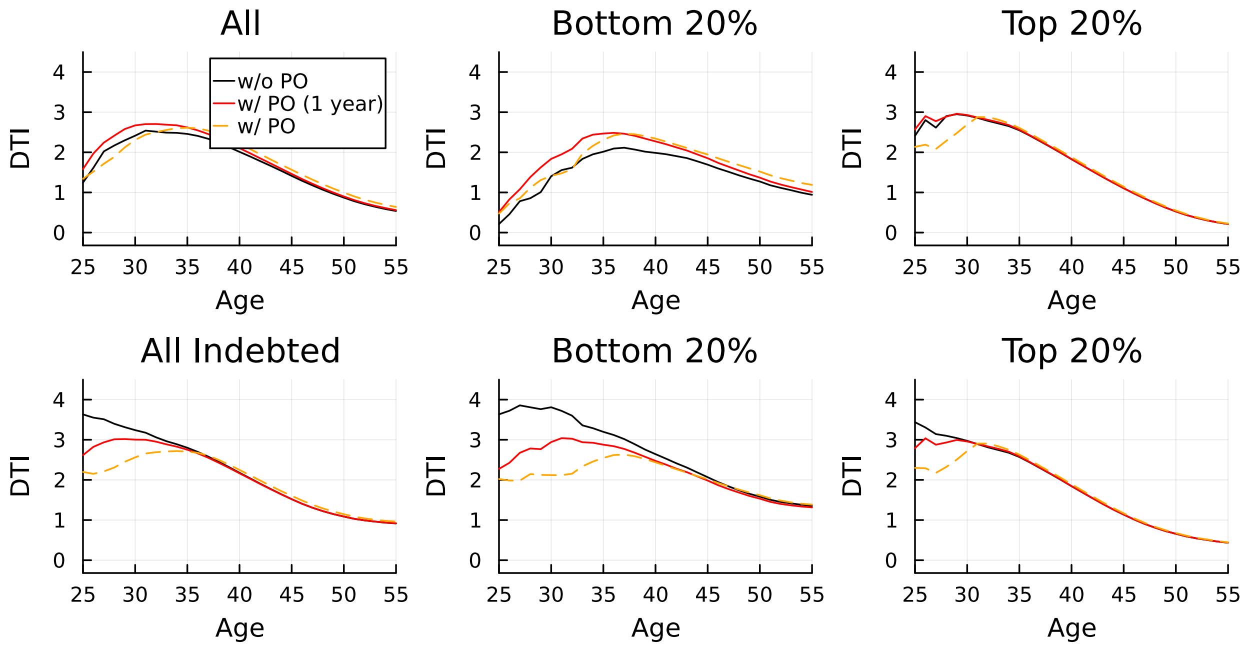


Figure 10 Debt to Income by Income Groups. Top panel: all households. Bottom panel: conditional on debt. The figures plot the average for the population and the top and bottom 20% of age-specific income distribution.

in the long-run (orange line), borrow less when PO becomes available.

The bottom row only includes households with debt. Quite startingly, PO decreases the average debt level among households with debt. The decrease is large, most pronounced for the youngest households and those with the lowest incomes. About half of the reduction happens within one year. These results show that while PO increases total debt, it may decrease borrowers' average debt and hence make borrowers less financially vulnerable.

5.3.2 On the Average Effects of PO on Debt-to-Income

We now study the effect of PO on DTI for three types of households that change their housing choices when PO is available. These households are renters who would remain renters but now switch to PO, owners who would remain owners but now switch to PO, and renters who would become owners but now instead use PO. Specifically, we take the simulated distribution before PO and simulate it for one year, both with (red line) and without PO (black line). Figure 11 presents the results.

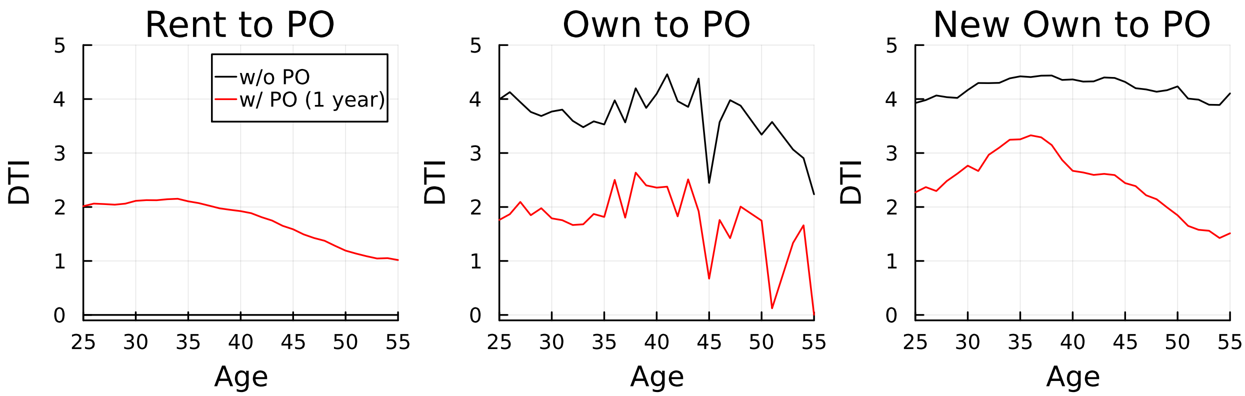


Figure 11 Average Effects on Affected Households: Debt-to-Income (DTI) by Income Groups. The left plot shows renters at time $t = 0$ who would be renting at $t = 1$ without PO but now use PO. The middle plot shows owners in $t = 0$ who would be owning at $t = 1$ without PO but now use PO. The right plot shows renters at time $t = 0$ who would be traditional homeowners at $t = 1$ without PO but now use PO.

The first plot shows the average DTI ratio for renters who switch to PO. After the introduction of PO, many renters get modest mortgages to become partial owners. This is the main driver of the increase in household borrowing. The plot in the middle shows the corresponding results for switchers from traditional to partial ownership. Without PO, these households are close to the DTI constraint of 5.0. By selling their home and becoming partial owners, they become less indebted. The plot on the right shows the outcome of renters who would become traditional homeowners but now use PO. Without PO, these households would take on substantial debt, resulting in a DTI ratio close to the limit. With PO, many choose partial ownership instead. The result is that the group, on average, has a substantially lower DTI ratio.

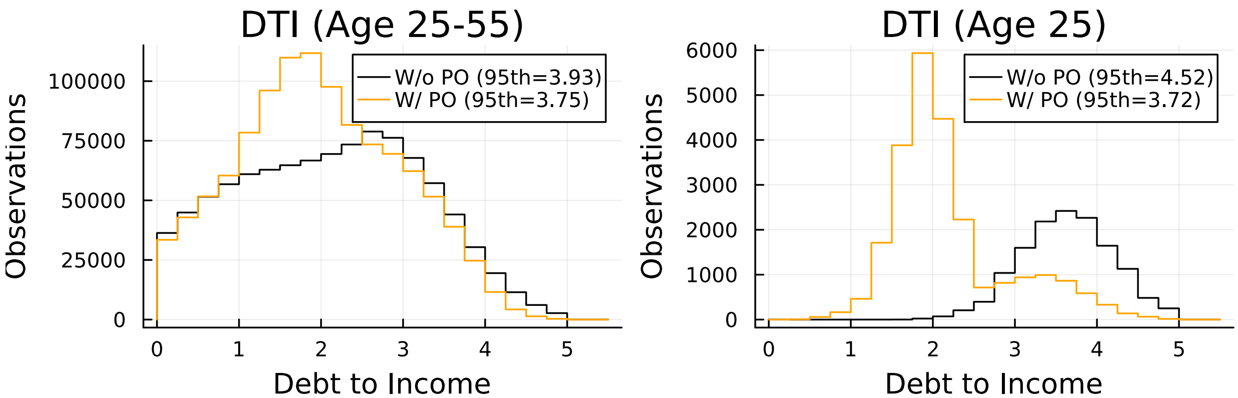


Figure 12 Financial Stability: Debt to Income Distribution. The figure plots debt to income (DTI) for households with debt. The legend includes the 95th percentile of the DTI distribution.

To reiterate the last result, we plot in Figure 12 the distribution of DTI ratios for all households between 25 and 55 years. There are two main effects of PO on DTI ratios. First, PO increases the number of borrowers, which adds a large group of low DTIs. Second, the right tail of the DTI distribution shrinks as fewer households now borrow up to the limit. To see this more clearly, we plot the DTI distribution for 25-year-old households in the right panel. The right tail is now almost eliminated. The reason is that without a PO, the strong preference for homeownership dominates the aversion against financial distress, so people borrow up to the limit. With PO, the same households can become homeowners without borrowing to the limit, which they prefer. Taken together, our results suggest that allowing for PO contracts is a trade-off between an increase in total outstanding debt and a reduction in the number of households with DTI ratios close to the borrowing limit.

5.3.3 Household Downsizing

Downsizing in the housing market refers to buying a smaller or less expensive unit and is often motivated by financial considerations. For example, a household can choose to downsize after a persistent negative income shock to save on interest expenses and maintenance. If changes in aggregate outcomes cause downsizing, then many will choose to downsize simultaneously, which can trigger a collapse of the financial system (Gabriel et al., 2020, Shleifer and Vishny, 2011, Corbae and Quintin, 2015).

The top row of Figure 13 plots downsizing with and without PO. We observe that PO has little impact on the number of households that downsize. In the second panel, we plot the share of traditional owners who downsize. Fewer young households downsize and with little change for older households. The decline in downsizing among young households occurs because fewer households are close to the regulatory borrowing constraints with PO, as shown in the DTI distribution in Figure 12. As a result, they can bear more adverse shocks without downsizing. The right panel shows that young partial owners have a similar downsizing probability as traditional owners.[23]

The bottom row of Figure 13 shows the average value of downsized housing ($P(SH - S'H')$), conditional on downsizing. It measures the net value of "fire sales" in housing. The left plot shows that the downsized value is reduced by about 50%. Hence, the value of the total housing stock listed for sale due to downsizing—collective downsizing—is much smaller with PO. The main reason is that traditional homeowners can now downsize to partial ownership. The panel illustrates this mechanism. The last panel plots the value downsized among partial owners. This implies that most downsizing partial owners become renters.

Introducing PO can impact financial stability both negatively and positively. One adverse effect is that more people borrow—as many switch from renting to partial ownership—and as a result, the average DTI ratio in the economy rises. On the positive side, many households just wealthy enough to become traditional homeowners choose partial ownership instead and take out smaller loans. Overall, PO increases aggregate debt but decreases average debt among borrowers. In addition, PO leads to about a 50% decrease in the housing value listed for sale along the intensive margin due to downsizing. Our results indicate that PO leads to less extreme borrowing and a less fragile household sector.

6 Conclusion

Partial Ownership (PO), a convex combination of renting and homeownership, now exists in multiple countries, and its popularity is increasing. For example, Norway's biggest home-builder is currently selling about 20%–the legal limit—of new construction through partial ownership. We are the first to incorporate a for-profit PO contract in a life-cycle model.

[23]The likelihood of downsizing for partial owners increases non-linearly with age, partly due to how we model the cost with PO. This assumption does not impact the estimates for those under 45, who are the main users of PO in the data.

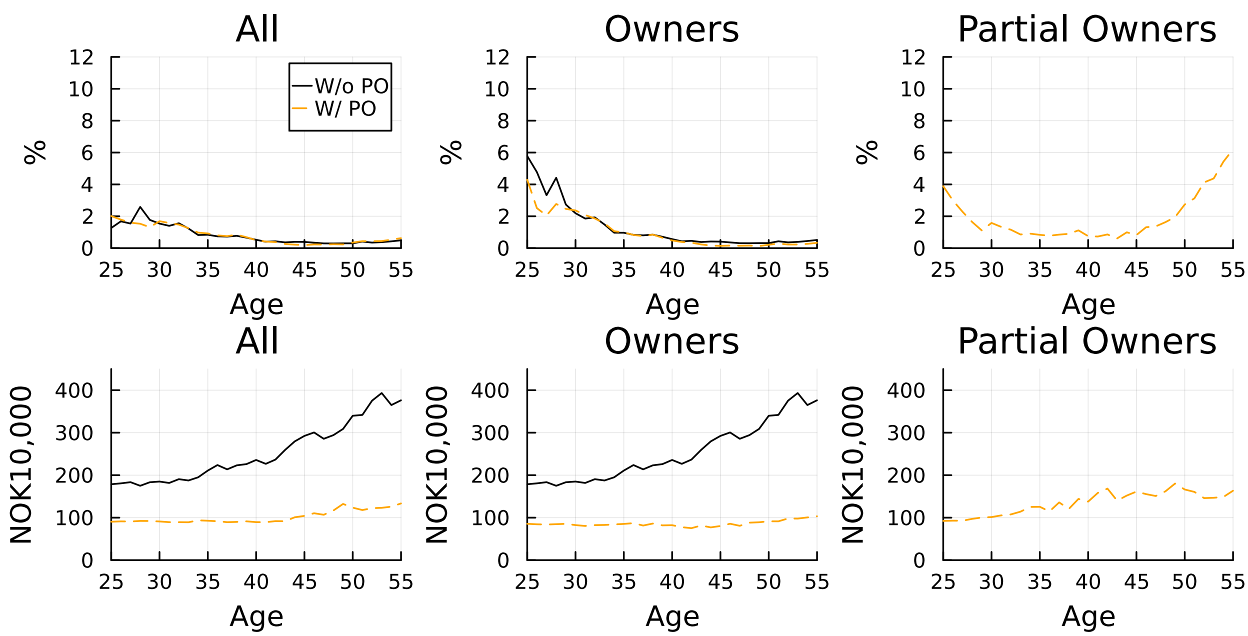


Figure 13 PO and Downsizing. The upper plots look at downsizing along the extensive margin in a world with and without PO. The first plot presents the aggregate results, while the second and third plots show the results for traditional- and partial homeowners. The lower plots show the corresponding results along the intensive margin.

Our analysis delivers predictions about a future PO market, including take-up rates, drivers of demand, willingness-to-pay (WTP), and effects on variables linked to financial stability.

In the short run, PO reduces the share of households that rent with almost no reduction in traditional homeownership. However, over time, PO decreases traditional homeownership because many prefer to increase ownership shares gradually. We measure the WTP for PO for households across multiple characteristics and housing market conditions. For example, households aged 25 to 45—the primary users—would pay between 19% to 4% of after-tax income to access PO. The welfare benefits of PO are particularly high for poorer households and those that are just below the regulatory constraints that exclude them from the mortgage market or just above, making them high-risk borrowers.

While PO has the potential to increase household welfare, policymakers and regulators may remain skeptical. One concern is that PO increases the borrowing of financially fragile households. Because many of these households would rent without PO, introducing PO transfers risk from landlords to these households, the commercial PO vendors, and, ultimately, the banking sector and the real economy. To address financial stability concerns, we study how PO affects debt-to-income (DTI) ratios. As expected, as many switch from renting to partial ownership, the average DTI ratio rises. Interestingly, many households who are just wealthy enough for traditional homeownership choose partial ownership instead and thus take out smaller and safer loans. A macro implication of these choices is that the DTI distribution becomes much less right-skewed. We also observe a large drop in the housing wealth sold due to voluntary downsizing following adverse shocks. While Gabriel et al. (2020) show that flexible mortgages reduce downsizing, our findings suggest that flexible homeownership contracts can accomplish the same.

There are several ways of extending our work. First, a general equilibrium analysis of how PO affects financial risk, aggregate house prices, and wealth inequality would undoubtedly be interesting. In such an analysis, the new preference parameter we identify—the ownership-elasticity—will largely determine the composition of PO users and, therefore, the sustainability of the PO market. All else equal, the lower the ownership-elasticity, increases the share of aggregate house price risk borne by financial intermediaries, which will affect the pricing and possibly the regulation of PO.

Second, Kiyotaki et al. (2023) use a macroeconomic model with housing to examine the causes and consequences of housing market volatility and evaluate alternative housing policies. They suggest that a well-functioning rental market can protect young and less fortunate households from house price shocks. PO is a potential substitute for improving the rental market but has an additional benefit. As renting, partial ownership reduces the sensitivity of household wealth to changes in house prices. Unlike renting, PO allows households to benefit from homeownership (Sodini et al., 2023). A welfare comparison of an improved rental market and PO would be interesting.

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A Appendix: Data and Institutional Details

A.1 Appendix: The Sample

For each individual, we observe the birth date (variable name: "foedsels_aar_mnd") from the population database. Educational level is based on the Norwegian standard for education grouping ("NUS"). NUS is a six-digit education code, where the first digit indicates the level of education. We report results for all educational levels: low (0-2), medium (3-5), and high (6-8). Low includes middle school; medium includes high school, and high starts with a bachelor's degree.

The unit of analysis is the household. We distinguish between individuals living alone and individuals with a partner. We obtained the national identity number of the spouse/registered partner from the SSB's population statistics. We observe the ID (anonymized) of the spouse ('ekt_fnr_aaaa") or cohabitant ("sambo_snr_aaaa"). We use this information to classify an individual into a one-adult household or more than one adult household. We restrict the sample to one-family households[24]

For each household, we define disposable income Y ("wsaminnt") as the sum of gross salary income and pension plus net capital income and total government transfers minus tax ("utskatt"). A broad measure of income implicitly allows for several ways of self-insurance against labor income risks (Campbell and Cocco, 2015). We define net worth, W, as total assets ("ber_brform") minus debt ("gjeld"). We define a household as a homeowner ($S = 1$) if it does not rent ("eie_leie"). We refer to the oldest individual in the household as the household head. If two individuals are the same age, the man is the household head. All households are at least 25 years old. The head of the household determines the age and the educational level of the household.

A.2 Residential Real Estate in Norway

In Norway, the main forms of homeownership are "traditional" ownership and through a co-op or a housing association ("borettslag"). In practice, these two types of ownership have been largely identical since 1980. Though co-ops originally served a social-civic-minded purpose, they are today behaving like for-profit companies (Sørvoll and Bengtsson, 2018).

[24]That is, we require the first digit of the variable "regstat_hushtyp" to be one.

For landlords, there are differences between renting a part of a primary residence and a separate unit: Landlords who lease a portion of their primary residence or, in extenuating circumstances, can offer contracts for only one year. In contrast, all other landlords typically offer a three-year tenancy agreement. The consumer rights are stronger in the latter case. Moreover, landlords who rent out parts of their primary residence do not pay taxes on rental income. These factors contribute to the low share of commercial landlords.

Strictly speaking, 'owning' a co-op apartment means owning a share in the co-op, which includes the right to live in a specific unit. However, in practice, a Norwegian co-op is more like a condominium than a co-op in the North American setting. For more details on the history of co-ops, we refer to Sørvoll and Bengtsson (2018). In Norway, housing cooperatives are mainly in cities. In Oslo, the shares of households living in the three types have been stable since 2015, with about 36% in "self-ownership,'' about 32% in owned coops, and 32% in rental housing (Source: Statistics Norway Table 11084). For comparison, about 25% of American households live in some form of community-managed developments (e.g., condominiums, homeowner associations, or coops) and 80% in New York City. Coops mainly build new multifamily buildings in large cities, and OBOS is the largest home builder in Norway.

Buying a co-op unit is equivalent to acquiring a co-op share and a co-op association membership. With that, the co-op grants the holder the right to live in the unit indefinitely. To give such a right, the board must prepare a financial plan, including information on maintenance costs. The co-op charges monthly fees to its members, which must cover maintenance costs, the amortization of the co-op debt, and its interest expenses. Shares can be pledged as collateral against the home mortgage but do not entitle buyers to property rights over the unit. However, in practice, homeowners in Norwegian housing cooperatives have the same control over their homes as single-family owners.

A.2.1 Tax Details

While the residential property tax rate is set at the municipal level, it is centrally regulated. The tax rate cannot be higher than 0.07% on 75% of the market value of the property. In addition, many municipalities set a standard deduction. For example, in Oslo, the average asking price is approximately 7 million NOK, the property tax rate is 0.28%, and the deduction is 4.7 million. Hence, the annual property tax is $(7 \times 0.7 - 4.7) * 0.0028 = 560\text{NOK}$, or about \$60. Hence, property taxation is relatively unimportant, especially for the smaller units that come with the PO option. Moreover, property taxes are implicitly included in both the rent-to-price ratio and depreciation in our calibration. Sources: Statistics Norway, Tables 12843, 14155; Oslo Municipality.

The Norwegian wealth taxes are progressive and treat owner-occupied housing favorably. The tax is levied on net wealth above 1.7 million NOK (≈\$ 170,000), with tax rates up to 1.1%. While most other assets are taxed at market values, the owner-occupied primary residencies are taxed at 25% of the market value. Thus, a household that owns 100% of a 7 million home only has taxable real estate worth 1.75 million. With no other assets or liabilities, the wealth tax is only 500NOK (≈\$50) per year. As a result, only 15% of Norwegians with taxable income paid wealth taxes in 2022–source: Statistics Norway, Table 08564.

A.2.2 Default and Foreclosure

To our knowledge, there is no data on the share of mortgages that have missed payments or are in foreclosure ("mislighold"). If a borrower cannot repay, the bank initiates debt collection procedures. In general, the bank will first notify the borrower in writing before placing a credit lock ("betalingsanmerkning") that prevents the household from accumulating more debt. A frequent solution is to extend the length of the loan to reduce monthly payments. If no other solutions are found, the bank will go through the tax authority to garnish wages. In rare instances, the unit will go through forced liquidation. Through 2001-2023, about 0.5% of all residential sales were forced sales (including sales initiated due to non-payment of taxes).

A.3 Appendix: The OBOS-contract

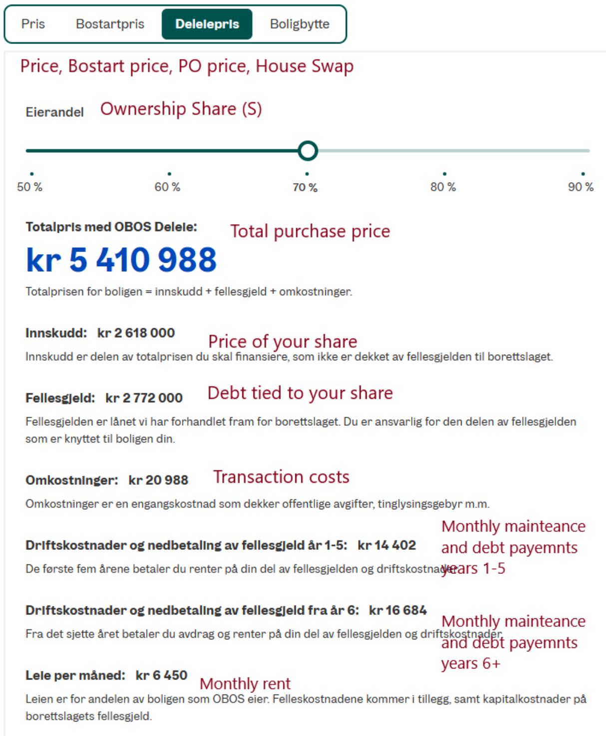
The paper uses a standard life-cycle homeownership model augmented with partial homeownership (PO). The calibration of the PO contract is based on the contract offered by OBOS. In what follows, we provide additional details about the contract.[25] To be consistent with the main text, we refer to it also here as PO. Figure A1 provides an example from one of OBOS' new housing projects in Oslo.

[25]The main source is OBOS's website: https://www.obos.no/ny-bolig/obos-deleie/.

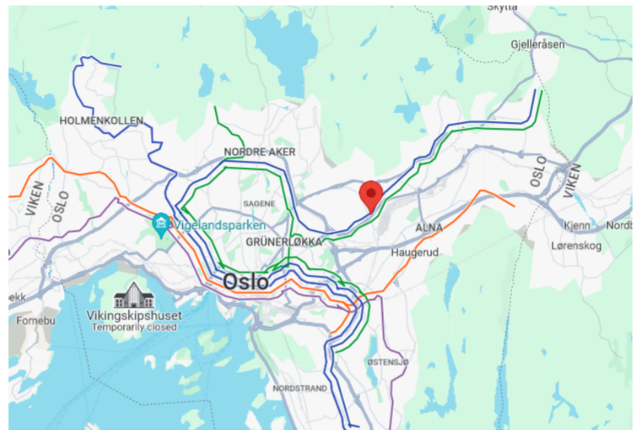
PO allows people to buy a fraction of a home yet use the home as a traditional homeowner. Almost all new OBOS projects offer PO. The minimum ownership share is 50%. Above this threshold, one can choose any share in 10% increments. It is easy to increase ownership share later while living in the home. The equity requirement is the same for PO as traditional house investments. The equity requirement is 15% of the total purchase price of the share. Thus, if you buy 50% of a home for a total of NOK 4 million, the price for your share is NOK 2 million. For the fraction you do not own, you pay rent equivalent to the market rent but cover all maintenance. As explained in the main text, buying, increasing ownership, or selling partial housing incurs fixed legal fees. When buying larger shares, the market value is bounded from below by the initial price. All these features are in the model.

While we attempt to reproduce the contract as closely as possible, we deviate in some aspects. First, the PO contract ties rent to CPI, not the house price, which in the model would imply that the rental payment is given by the initial price κP_0^H instead of the market value κP_t^H. However, this feature of the contract differs from standard rentals. We ignore this aspect to keep the contract valuation simple and the findings generalizable. Second, we omit the put option for the financial intermediary. That is, OBOS can unilaterally put the house for sale after ten years. If OBOS terminates the contract, the household has one chance to buy the remaining share as usual. If not, the unit is sold on the open market, with each party getting their share of the proceeds. Since the contract was introduced in 2020, we do not yet know whether the option will be used in general. In our simulations, very few households have held the contract for more than ten years. Finally, in practice, if the contract is terminated after ten years, the household can become a partial owner again. Moreover, this contract feature is another reason for the age cost function (Eq. 7). The shorter guaranteed duration of the contract makes it less appealing for retired households, who want to gradually decrease ownership without moving since contract termination forces a sale and a subsequent move. Third, there is a single price in the model, so there is no regional price index that is used to estimate the current market value.

Finally, we reiterate that other providers also offer PO contracts with slightly varying contract terms in Norway. Some providers are financial intermediaries offering contracts for both existing and new homes, with rental payments potentially linked to the intermediary's interest payments. Other home builders and some joint public-private partnerships also offer PO contracts.



(a) PO example with 'Calculator'



(b) Location of project in Oslo

(c) Scale of Project

(d) Example Building

Appendix Figure A1 PO Example: The Vollebekk Construction Project. Here, we show one typical example of an Obos project with PO. Figure a) shows the online 'calculator' where households can, by adjusting the different options, choose their desired ownership share and see what they pay for their unit as well as the various monthly payments. New housing cooperatives are usually partially debt-financed, and each unit is associated with their share of the debt, reflected in the purchase price. Figure b) shows the location within Oslo with the Metro system overlaid and the nearest metro station is within a 10 minute walk. Figure c) shows the scale of this big residential construction project, while Figure d) shows one specific building (the example apartment in panel (a) is on the sixth floor of this building).

B Robustness Analysis

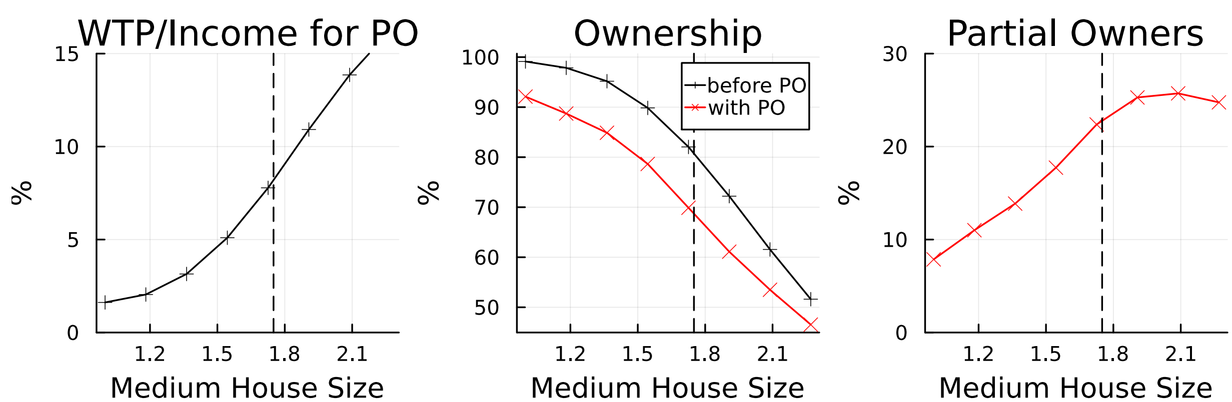
This section contains the robustness analysis referred to in the main text.

B.1 House Sizes

A possible concern with our setup is that the demand for PO depends heavily on how we model house sizes, that is, the house size grids $\mathcal{H}(0) = [1.0, 1.75]$, $\mathcal{H}(1) = [1.75, 2.27]$ and $\mathcal{H}((0, 1)) = [1.75]$. Note that the grids we use match the 5th, 25th, and 50th percentile of the empirical house size distribution.

One can ask two different but related questions: 1) if households could choose from a larger choice set of house sizes, how would that affect the demand for PO? 2) how important is the relative size of the PO unit for the results? We now show, using simulations, that our conclusions are insensitive to alternative specifications of the house size grids.

To address both concerns simultaneously, we vary the size of the medium unit from the smallest to the largest unit and calculate the main outcomes. Figure A2 plots, from left to right, the WTP/Income (summarizing Fig. 8 in the main text), the homeownership rate with and without PO (summarizing Fig. 7), and the share of households who are partial owners (same figure).



Appendix Figure A2 Robustness: House Size of the PO Unit. The x-axis plots different medium house sizes; the dashed vertical line is the calibrated value of [1.75]. All moments are sample means calculated using all households aged 25-50. Ownership is the share of housing owned by households.

As expected, the WTP for PO is increasing in the size of the middle unit (the one available for rent, PO, and traditional homeownership).

Unsurprisingly, the demand for PO declines as the "housing ladder" stops being a "ladder" as many can afford their preferred house size early in life. When the medium house is tiny (and thus cheap), most households become traditional homeowners, but still about 8% switch to PO after its introduction. This result is striking: even in an economy where the homeownership is 100% without PO, about 8% of all households (and hence current owners) prefer to be partial owners, and the average WTP for PO is still positive. By the same logic, as we instead increase the size of the medium house, we observe fewer households becoming traditional owners and more households using PO, and the WTP increases.

To conclude, a realistic calibration of house sizes and valuations will generate demand for PO. Indeed, as our results show, even in a calibration so unrealistic that all households are traditional owners *when PO is not available*, some (owning) households prefer to be partial owners, and hence, the average WTP is positive.

B.2 The Option Value Element

As explained in the text, a reason why the option element of the PO contract has little impact on households' WTP for PO is that households can, if prices fall, "reset'' the contract by selling the unit, receiving their share, and then entering into a new PO contract. Concretely, the cost of buying a larger share using the contract is (including l_c, the cost of changing size)

$$\max\{P^H, P_0^H\} \times H \times (1 + m_b) \times (S' - S) + l_c. \tag{A1}$$

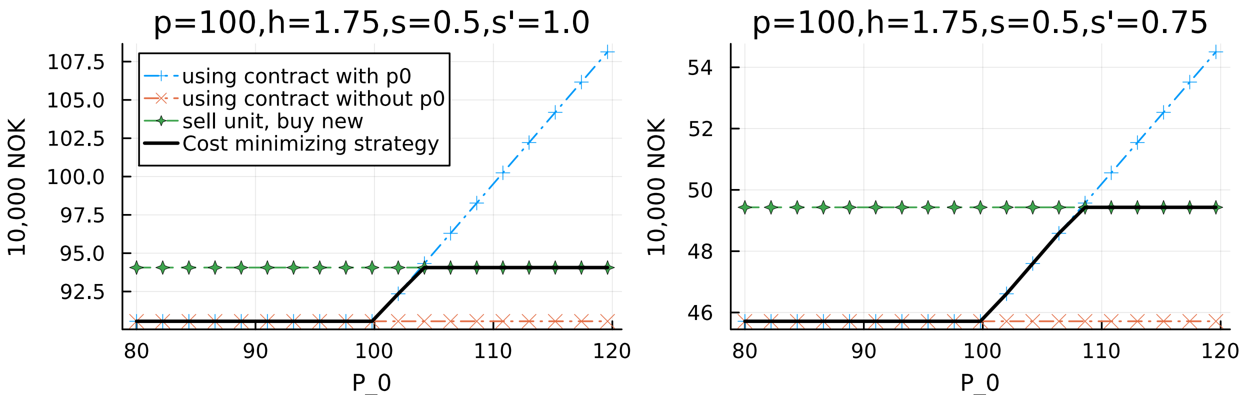
The cost of buying a larger share, by selling the current share and buying a new house is (including l_s, the cost of canceling a PO contract, and l_b the cost of entering a new PO contract if they do not buy a new house outright):

$$P^H \times H[((1 + m_b)S' - (1 - m_s)S] + l_s + l_b \mathbf{1}_{s'<1}. \tag{A2}$$

The household in the model chooses the cheapest alternative.

Now, consider a household with a medium house that bought half of it at a price of 100 per unit (the price of the entire unit is 1,750,000NOK). In the next period, the price drops by half. If the household chooses to buy the remaining 50%, it pays $100H(1+m_b)(S'-S)+l_c =$

89.69875 + 0.87 since the contract binds them to the initial price per unit of 100. If the household instead chooses to sell and buy it outright, it pays $50H[((1+m_b)-0.5(1-m_s)]+l_s = 47.03125 + 0.0$. Thus, if P_0^H is much higher than today's market value, the household can re-enter into a new contract at a low price. Figure A3 below illustrates the cost of increasing ownership to 100% or 80% from 50%, as we vary the initial price (P_0^H). The current market price is 100.



Appendix Figure A3 Upsize costs, by choice of S'. This figure plots the cost of increasing ownership shares as a function of the initial purchase price under various contracts. The dashed blue line plots the cost using the baseline contract in the model. The dashed red line plots the cost for a contract that does not include the initial price but is otherwise identical. The green line plots the cost of selling the unit and buying a new one. Finally, the black line is the lower envelope of the costs when the contract includes the initial price.

Suppose the initial price was below the current price (100), then the household always uses the contract; P_0 becomes irrelevant. If house prices have fallen but not by much, the cost of upsizing increases a little. If the prices tank, using the contract to increase ownership becomes very expensive, so the household uses the alternative strategy. On net, the option value element of the initial price has little impact.

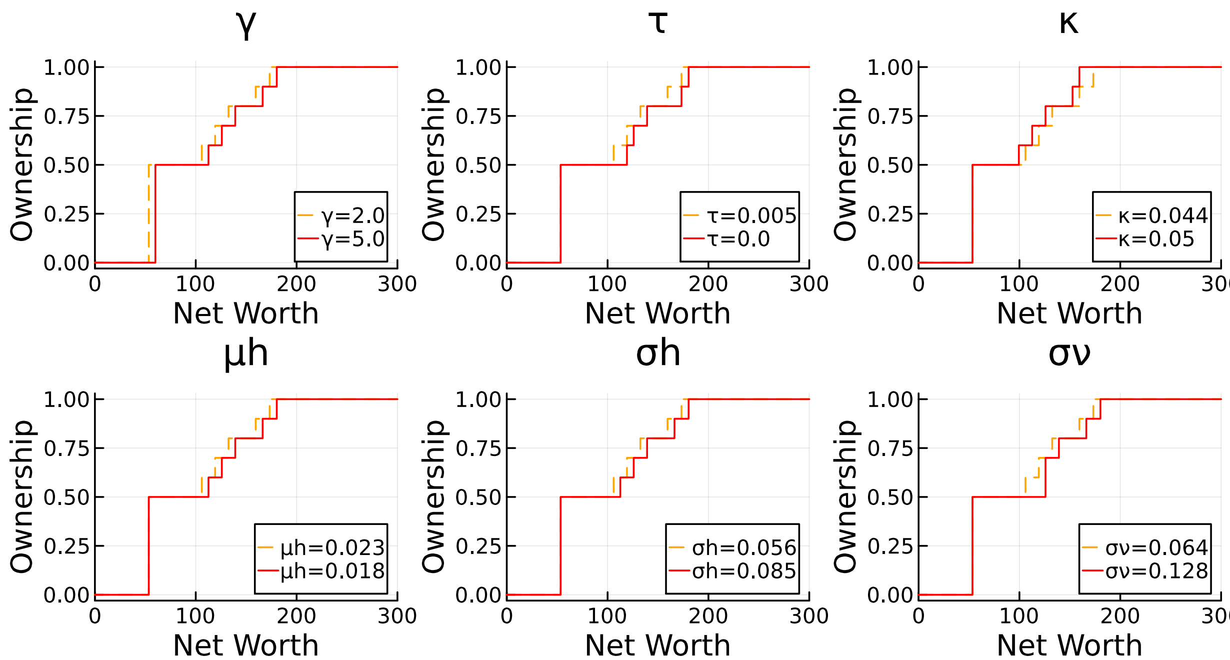
B.3 Sensitivity Analysis for WTP

We perform the sensitivity calculations for WTP in the following way. We solve the model without PO after changing one parameter and then solve the same decision problems with PO. With the new policy functions and the simulated outcomes, we calculate WTP using Eq. 19. In all simulations, households receive the same shocks. Hence, the WTP estimate only reflects the parameter change. Table A1 presents the results.

	Bench.	Price Growth	Loan-to-Value	Depreciation	Rent-to-Price
New Value		$\mu_h = 0.025$	$LTV = 0.2$	$\delta + \tau = 0.022$	$\kappa = 0.04$
Old Value		$\mu_h = 0.023$	$LTV = 0.15$	$\delta + \tau = 0.025$	$\kappa = 0.044$
WTP, 25-55	7.4	8.3	7.9	8.2	8.1
Age 25	18.7	19.8	22.7	20.0	19.9
Age 35	8.5	9.7	8.2	9.5	9.4
Age 45	3.1	3.9	3.0	3.6	3.6
WTP, top 20%					
Age	30.4	30.6	29.9	30.3	30.6
Wealth	39.0	43.8	36.4	42.2	38.7
Own (%)	16.7	17.5	11.0	20.0	15.6
WTP (%)	25.3	27.3	27.9	27.2	27.3
<HS (%)	28.6	28.9	26.7	28.9	28.7

Appendix Table A1 Housing Market Parameters and the Willingness-to-Pay for PO. The table reports the average WTP for PO, expressed as a percent of annual income, as we vary various housing-specific parameters. When we change total depreciation, we keep the shares allocated to the two types of maintenance constant. The first panel reports the WTP by age groups, while the second panel reports the average within the top 20% of the variable among households aged 25-55.

The WTP is increasing in price growth since the benefit of house price exposure—through PO—increases with expected price growth. Next, we increase the LTV. As the LTV increases, households need more wealth to become homeowners. As a result, PO, which relaxes borrowing constraints, becomes more attractive, especially for the youngest households. Next, we decrease depreciation on owner-occupied housing. This decrease in the user cost of owning increases the WTP for PO through the same mechanism as higher price growth; the expected net return on housing goes up. Finally, we decrease the rent-to-price ratio. Surprisingly, the WTP for PO still increases, even though rental prices are now lower. This happens for two reasons. First, part of the cost of being a partial owner is that the household still pays market rent on the share they do not own, which is now lower. Second, the drop in rental prices increases the region where households prefer PO to traditional ownership, which increases the demand for PO. The WTP increases for all age groups since these benefits occur at all

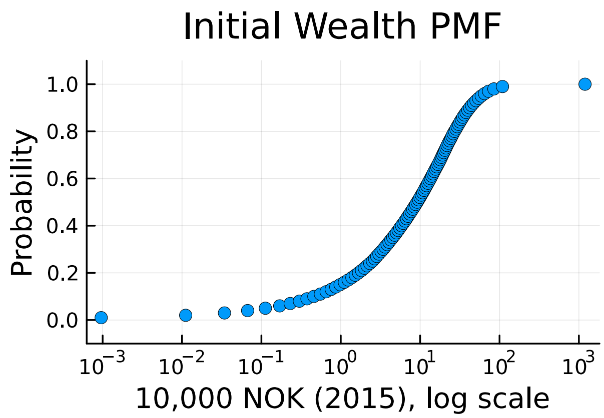


Appendix Figure A4 Comparative Statics on Housing Decisions. These figures are equivalent to the figures in Fig. 6, just with different parameters.

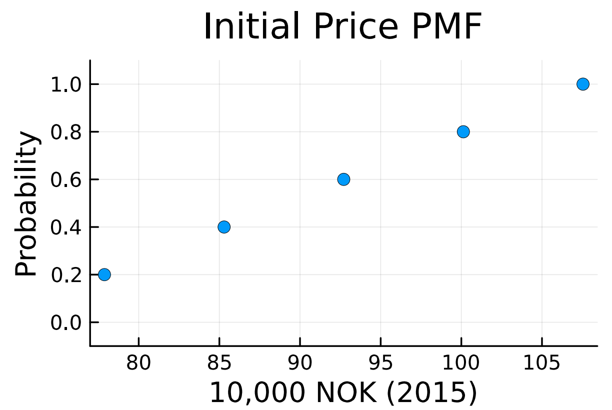
ages.

Table A1 also reports how the characteristics of the households with the highest WTPs change with changes in housing market conditions. Stricter LTV requirements lower the marginal PO user's average age, wealth, and educational level. A drop in the effective price of using PO modeled as a decline in house depreciation has the opposite effect. Small changes in expected house price growth, or the rent-to-price ratio, have a negligible impact on the composition of marginal PO users.

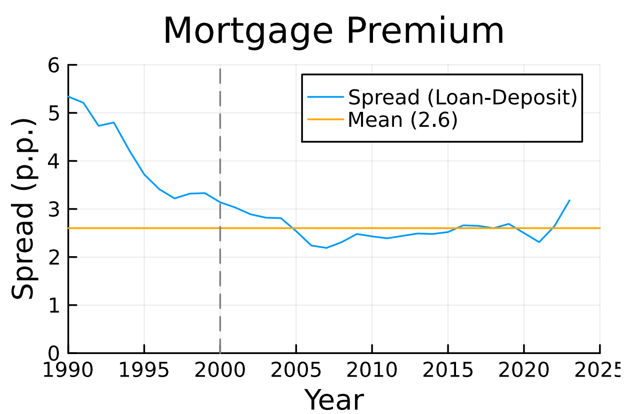
C Supplementary Figures



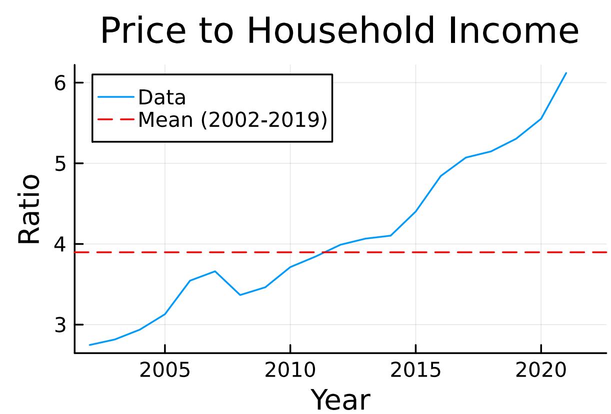
(a) Initial Wealth



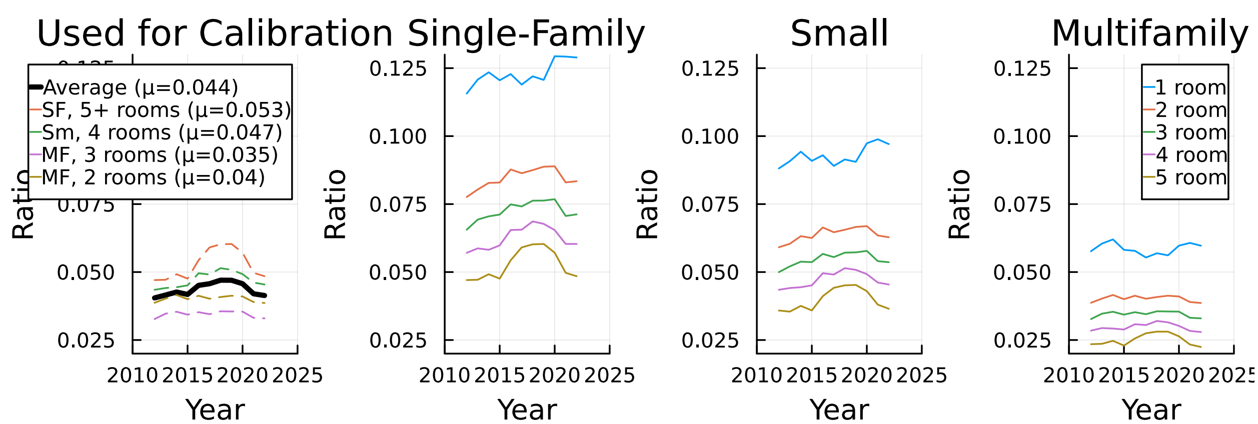
(b) Initial Price



(c) Mortgage Premium

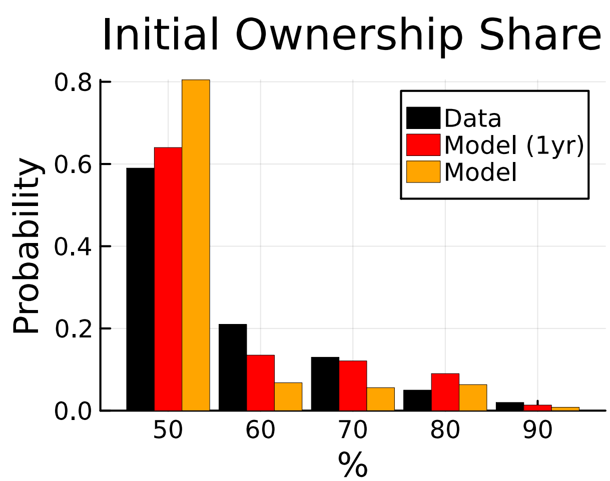


(d) Price-to-Income



(e) Rent-to-Price Ratios, Select Sizes and Units

Appendix Figure A5 Calibration. These figures present various moments used in the calibration, see Section 4 for details.



Appendix Figure A6 Initial Ownershipshares (S'). This figure plots the distribution of initial ownership for households entering into a PO contract in the data and the model. The data (black bars) are identical to the ones in Figure 1.

Internet Appendix

Partial Homeownership: A Quantitative Analysis

This Internet Appendix describes the estimation of the income process, the numerical solution, and structural estimation of the preference parameters.

D Appendix to Section: Institutional Setting and Data

D.1 Labor Income Calibration

We use Norwegian Microdata from Statistics Norway to estimate Equations 2 and 3. We scale nominal disposable income Y by the consumer price index, and denote log real earnings by $y_{i,t} \equiv \ln(Y_{i,t}/CPI_t)$. The base year is 2018. We require all households to have a minimum of 100,000 in disposable income Y and 5,000 NOK in financial wealth.

We use all one-family households and partition the sample into three education groups based on the educational attainment of the head of the household.[26] We estimate the following model for household i aged a at time t separately for each educational group

$$y_{i,a,t} = \sum_{j=25}^{67} c_j 1_{(a_{i,a,t}=d_j)} + \lambda_t + \varepsilon_{i,a,t}, \tag{A3}$$

where $1_{(a_{i,a,t}=d_j)}$ takes the value of one if the age of household i at time t equals d_j, λ_t denotes calendar year fixed effects, and $\varepsilon_{i,a,t}$ denotes the regression residual. Following Cocco et al. (2005), we fit a third-order polynomial to the age coefficients, $\hat{c}_{25}, \hat{c}_{26}, ..., \hat{c}_{67}$ to obtain the labor income profiles for the numerical solution. Table A2 presents the results.

To estimate the error structure of the labor income process, we use the full sample from 1993 to 2018. We impose the same requirement as in the estimation of the deterministic part of labor income, except for the one-family household criteria, which we only observe from 2004 and onward.

We first define the d-year difference in labor income shock as

$$\begin{aligned} r_{a,d} &\equiv (\nu_{a+d} + \epsilon_{a+d}) - (\nu_a + \epsilon_a) \\ &= (\nu_{a+d} - \nu_a) + (\epsilon_{a+d} - \epsilon_a) \\ &= \sum_{j=1}^{d} u_{a+j} + (\epsilon_{a+d} - \epsilon_a), \end{aligned} \tag{A4}$$

where the last equality follows from Equation (3). The variance of Equation (A4) is $Var(r_{a,d}) =$

[26] Because information about whether the household is a one-family household starts in 2004, the estimation of the deterministic part of income is based on the period from 2004 to 2018.

Appendix Table A2 Labor Income Process: Age Polynomials. The table shows the coefficients of the third-order polynomial fitted to the estimated dummy variable coefficient in Equation A3.

	All	< High School	High School	College
Constant	9.267***	10.526***	10.419***	8.151***
	(0.170)	(0.059)	(0.112)	(0.258)
Age	0.218***	0.129***	0.148***	0.284***
	(0.012)	(0.004)	(0.008)	(0.018)
Age2 × 100	−0.390***	−0.218***	−0.253***	−0.511***
	(0.027)	(0.010)	(0.017)	(0.040)
Age3 × 1000	0.022***	0.011***	0.013***	0.030***
	(0.002)	(0.001)	(0.001)	(0.003)
Observations	43	43	43	43
R^2	0.98	0.96	0.99	0.98

$d\sigma_u^2 + 2\sigma_\epsilon^2$. To estimate σ_u^2 and σ_ϵ^2 we define the d-difference in prediction error from Equation A3 as:

$$\hat{r}_{i,d} \equiv \varepsilon_{i,a,t+d} - \varepsilon_{i,a,t}. \tag{A5}$$

With h consecutive observations of income for household i, we get $h-1$ estimates of $\hat{r}_{i,d}$. We calculate the variance of Equation (A5) by pooling together all individuals for each d. Following Campbell and Cocco (2015), we winsorize each d sample at the 5% level top and bottom. Finally, we regress the empirical variances on d and a constant. The coefficient in front of d is the estimate of σ_u^2, and half of the intercept is the estimate of σ_ϵ^2. Table A3 presents the results.

E Appendix to Section 4:

E.1 Estimation

In this section, we first provide more detail on how we choose the initial conditions required to simulate the model before expanding on the second step of our estimation procedure.

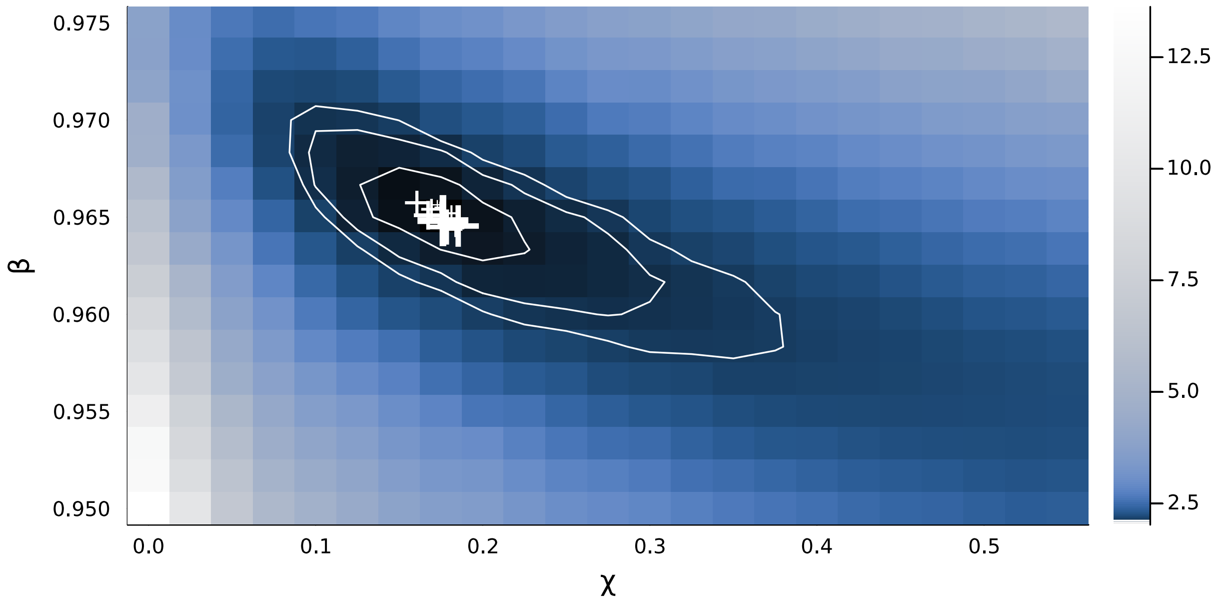
Appendix Table A3 Labor Income Variance Decomposition. This table reports the estimate of the volatility of permanent and transitory labor income shocks. The estimate is based on the decomposition in Equation A5.

	< High School	High School	College	All
Education	0.176	0.408	0.416	1
Transitory	0.176	0.169	0.185	0.180
Permanent	0.062	0.064	0.066	0.067
Constant	0.062	0.0569	0.0684	0.0645
S.e	0.004	0.0037	0.0040	0.0041
d	0.004	0.0041	0.0043	0.0045
S.e	0.000	0.0002	0.0003	0.0003

E.1.1 Simulation

First, we assign net financial assets to each household by drawing from the empirical distribution. We estimate the empirical distribution by pooling households at age 25 into 100 financial wealth groups of equal size (see Figure A5a). In the first year, we randomly assign all households to a financial wealth bin and give everyone in the same bin identical initial values. Second, we draw the initial persistent income shock from the stationary distribution implied by Equation (3). Third, all households start as renters but may choose to become homeowners in the first period. Fourth, households are randomly allocated to an education group in line with our data, with the following PMF: 0.176, 0.408, and 0.416 in the less-than-high-school, high school, and college groups, respectively.

Finally, households draw the price level at age 24 from a five-binned discrete uniform distribution. We calibrate the mean of the initial price in the following way. We find the ratio of the average square meter price of owner-occupied housing (Table 06035) to median household income over time (Table 04751). We then multiply the square meter price-to-income ratio by 77, the size of the smallest owner-occupied house in our model, and take the average over 2002-2019 (the years we have data before PO). We find that the mean price to income of the unit is 3.9 (see Figure A5d. In our simulation, the median household income for households aged 24-45 is 41.6. Thus, to find the typical starting price, we take



Appendix Figure A7 Structural Estimation: Optimization Space. This is the minimum value of the objective function (Eq. 18) over the global search space, with darker colors indicating lower values (better fit).

$3.8 \times 41.6/1.75 = 92.71$. We set each bin at ±10% increments (see Figure A5b).

E.1.2 Second-Stage Estimation

In the second-stage estimation, we draw $N = 4000$ candidate parameter vectors $\omega = \{\beta, \chi\}$, using Sobol sequencing. Figure A7 shows the minimum of the objective function (Eq. 18) over the search space, with darker colours indicating a lower objective (better fit). The crosses in Figure A7 mark the 10 best model fits, which are in a small area around $\beta = 0.965$ and $\chi = 0.176$ while the white level curves mark the 1st, 5th, and 10th percentiles. The figure shows that the search space is big and surrounds the global minimum. As β is lower, we also need a higher χ to match the data well, to incentives homeownership when households accumulate less wealth.

The global optimization procedure lends itself to verifying identification, as we now show. After solving the model for the N parameter vectors and finding the simulated moments, we follow the same procedure for all moments and parameters. First, pick a parameter, say β, and divide it into 20 quantiles. Note that the remaining parameter is uniformly distributed within each quantile. Find the 25th, 50th, and 75th percentiles within each quantile for a moment. We can then show how the moment depends on the parameter by plotting the percentiles within each quantile. One can think of this procedure as taking the partial derivative of the moment rate with respect to the parameter while keeping the distribution of the other parameter constant. We can then repeat this process for every moment.

A moment is informative for a parameter if the moment percentiles move as we move across the quantiles of the parameter. The steeper the slope, the more informative the moment is for the parameter. A parameter is relatively more important when the distance between the 25th and 75th moment percentiles is smaller.

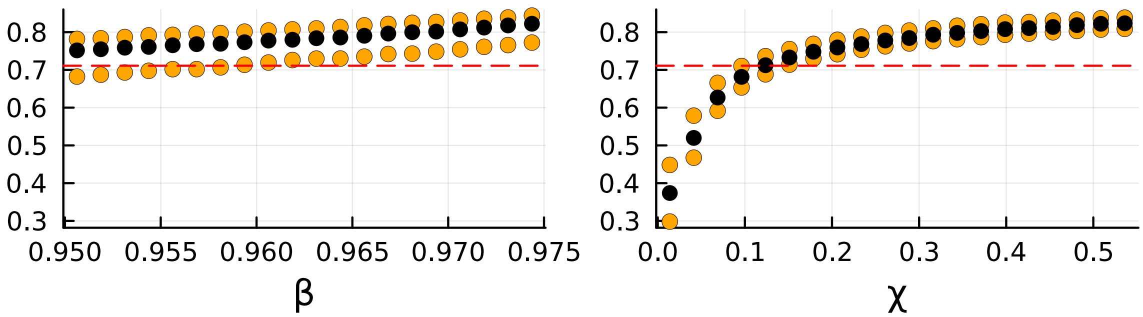
In Figure A8, we plot the results of this exercise for homeownership and wealth at age 30. As expected, wealth and homeownership are both increasing in the two estimated parameters, β and χ. We observe that χ allows us to pinpoint the homeownership rate for young households (Fig. A8a), which is key for identification. As households age, χ loses its importance for ownership as wealth becomes more important.

We get bootstrapped standard errors as a by-product since we can calculate the SMM objective function for 100 bootstrapped empirical moments.

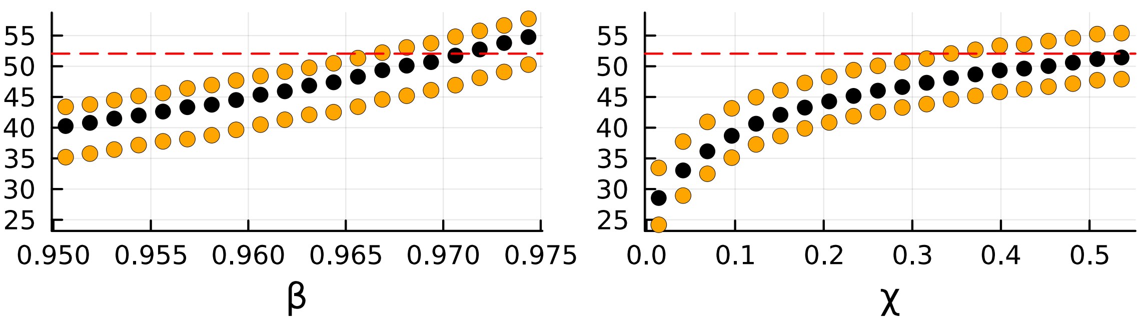
E.2 Numerical Details

The problem is solved backward by first solving the value function of a retiree in the final period when death is certain. For each discrete choice (given by a feasible combination of renting, owning, PO, and house sizes), we find optimal consumption (the choice that maximizes the current utility and the expected continuation value) using Brent's root-finding algorithm. The optimal policy is then given by the discrete choice and its associated optimal consumption choice. This process is repeated backward until we reach the lowest age in the model. When evaluating continuation values, we perform linear interpolation over next-period wealth and house prices.

The persistent income process is discretized using the generalized Rouwenhorst algorithm (Fella et al., 2019). The price shock and transitory income shocks are discretized on an equal probability basis. That is, for a grid with n points, the nodes are positioned at the midpoints between groups determined by the $n-1$ quantiles, each having an equal probability of $1/n$. For instance, in a setup with three nodes, each node has a probability of 1/3, and the nodes



(a) Homeownership, age 30, over β and χ



(b) Wealth, age 30, over β and χ

Appendix Figure A8 Structural Estimation: Identification. Red dashed line is the empirical moment. The orange and black dots denote the 25th, 50th, and 75th percentiles.

would be positioned at the 1/6th, 3/6th, and 5/6th percentiles (with the first tertile at the 33rd percentile and the second at the 66th).

The persistent income shock ν follows a 3-state Markov chain process, and the transitory income shock is discretized to 2 states, while the house price shock is discretized to 5 states. The net worth, price, and initial price grids are all unevenly spaced, with higher density for lower values with 71, 11, and 6 grid points, respectively. For the ownership grid, we use 7 nodes at $\{0.0, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0\}$, and the ownership share must be on the grid.

The model is solved in Julia `1.10.4`, and in addition to standard packages, we use `Interpolations.jl v0.15.1` and `Optim v1.9.4` for interpolation and optimization routines.