Homeownership and Portfolio Choice over the Generations

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Abstract

Earnings are riskier and more unequal for households born in the 1960s and 1980s than for those born in the 1940s. At the same time, despite the improvements in financial conditions that made it easier to borrow, younger generations are less likely to be living in their own homes than older generations at the same age. By using a rich life-cycle model with housing and portfolio choice that includes flexible earnings risk and aggregate asset price risk, I show that changes in earnings dynamics account for a large part of the reduction in homeownership across these generations. Lower-income households find it harder to buy housing, and some households delay homebuying decisions because their income is more unstable. As a result, they also accumulate less wealth. Relatively looser borrowing constraints help to explain how the 1980s cohort bought houses in a context of risky earnings and high house prices.

Keywords: Housing demand, portfolio choice, earnings risk, savings, life cycle, intergenerational inequality.

JEL classification: D31, E21, E24, G11, J31

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1 Introduction

The economic conditions faced by young US households are radically different from those that their parents and grandparents experienced when they were their age. Jobs are more unstable than they used to be, with career-long positions becoming less and less prevalent, and earnings inequality has increased. While the labor incomes of high earners have increased substantially over time in real terms, income-poorer individuals have seen their earnings stagnate or decrease.[1]

Meanwhile, homeownership has shrunk. Within the cohort born in the 1940s, at age 35 almost 75% of households were living in houses they owned. The figure was ten percentage points lower for those born in the 1960s, and more than 20 percentage points lower for the early 'Millennials' born in the 1980s. This happens in a context in which financial markets have become more developed[2] and stock market participation has been increasing for younger generations.

This paper studies the role of these changes in household labor income dynamics and financial conditions in explaining homeownership and portfolio composition across generations. To do so, it proposes two novel contributions. First, it designs a flexible, cohort and business-cycle dependent earnings process, based on Arellano, Blundell and Bonhomme (2017), that allows shocks to household labor income to be age-varying, non-normal, non-linear, and correlated with stock market returns and house prices, as in the data. Second, it builds and calibrates a rich life-cycle model with correlated aggregate and idiosyncratic risk, in which households decide their consumption, savings, housing stocks, portfolio share of safe and risky assets, and mortgage debt. Importantly, households only need to satisfy downpayment constraints and income tests at the time of mortgage origination, which implies that the outstanding mortgage can go above the value of the house if there is a negative shock to house prices. Households can also hold liquidity whilst they have a mortgage.

I use the model to compare the life experiences of three generations, namely, those born

[1] These facts have been established in a large literature surveyed in Acemoglu and Autor (2011) and Goldin and Katz (2009). Guvenen, Kaplan, Song and Weidner (2017), using US administrative data, and Borella, De Nardi and Yang (2019), using survey data, find decreases in median male wages in real terms between the cohorts born in the 1940s and the cohorts born in the 1960s.

[2] Dynan, Elmendorf and Sichel (2006) describe how financial deregulation, changes in risk-assessment methods, and the expansion of secondary markets increased the fraction of households with access to credit and how much those who already had access could borrow.

in the 1940s, 1960s, and 1980s. I assume that an American born in the 1940s differs from younger generations in three main ways. First, they face different experiences in the labor market. I use household earnings data from the Panel Study of Income Dynamics (PSID) to estimate the earnings process separately for all three generations, thus incorporating the changes in earnings inequality and earnings risk in a flexible, data-driven manner. I separate the persistent and transitory components of earnings, which allows me to control for potential measurement error in the survey. Second, they face different conditions in financial and housing markets. Housing has become more expensive over time with respect to average incomes, and different generations entered the labor market in different stages of the business cycle or the house price cycle. Third, the 1980s generation faced particularly looser financial constraints when they started to buy houses in the early 2000s, which I capture with a reduction in downpayment constraints.

Time, age, and cohort are explicit in the model. Average earnings, homeownership, and stock market participation at each age differ across generations as they do in the data. I do not homogeneize age profiles across cohorts and thus do not need to disentangle year and cohort effects to obtain them.[3] I adopt the actual realizations of house prices and stock market returns each year from historical data, and use the Survey of Consumer Finances (SCF), including its earlier versions dating back to 1963, to obtain information about household portfolio compositions by age and generation.

The main results are as follows. First, intergenerational changes in earnings dynamics, asset returns, and housing prices obtained from the data fully explain the differences in homeownership between the 1940s and 1960s cohorts. For the 1980s cohort, who started to buy houses in the early 2000s, looser borrowing constraints partially counteracted the effect of high house prices.[4] I do not need to assume that preferences have changed to explain the lower homeownership rates for younger generations.

To isolate the effect of changes in labor market income dynamics, I perform a counterfactual experiment in which I attribute the earnings process of the 1940s cohort to the younger generations, whilst keeping all other elements of the model constant, includ-

[3] Age, year, and cohort are collinear. To obtain age profiles in a sample with several cohorts and years, the usual practice is to either remove year fixed effects or cohort fixed effects, which can lead to very different implications. See Heathcote, Storesletten and Violante (2005) for a discussion on how the choice of removing year or cohort effects impacts measures of earnings and consumption inequality, and Ameriks and Zeldes (2004) for the effect on household portfolio shares.

[4] Kaplan, Mitman and Violante (2019), in a general equilibrium setting, also find that credit conditions were key for the dynamics of homeownership during the housing price boom and bust.

ing house prices. More than half of the difference in homeownership at age 30 for both generations can be accounted for by changes in earnings inequality and risk. Not all of it is due to delayed home-buying: changes in earnings dynamics still have an important effect at age 40 and afterwards. These results are robust to letting house prices adjust, assuming an empirically plausible level of housing supply elasticities.

The main driver of these changes is the increase in earnings inequality at labor market entry, with a more limited role for the increase in earnings risk. Households with lower initial and expected lifetime earnings find it harder or suboptimal to engage in a large expenditure like a house, which would leave them with a sizeable mortgage with respect to their current income, and thus exposed to income and house price risk.

Second, the increase in stock market participation of younger cohorts can be rationalized with a substantial reduction in stock market participation costs, which reflects easier information acquisition. Today, many workers who are starting new jobs either receive information about retirement accounts or are automatically enrolled into retirement plans like IRAs or 401(k)s.

These intergenerational changes also have implications for household wealth accumulation. In the 1940s generation, relatively poorer households bought housing. They did so to accumulate wealth, but also because they wanted to be homeowners, because it provided insurance against rental risk, and because leveraging with a mortgage allowed them to benefit from gains in the housing market. Similarly ranked households in younger generations are no longer buying houses and, because of these additional reasons to hold housing, they do not fully compensate the lack of housing wealth by saving in financial assets. Financial wealth now represents an increasing share of household portfolios, but it is more unequally distributed than housing wealth. The model predicts that lowering the cost of access to financial markets for lower and middle income households can increase their wealth holdings and reduce wealth inequality. Additionally, the model suggests that younger generations display larger consumption responses to persistent income shocks, which can have important implications for monetary and fiscal policy design.

Overall, these findings suggest that changes in labor market income dynamics and in the housing market are having substantial effects in the life experiences of most Americans, and they can influence, in the longer term, the distribution of income and wealth, intergenerational mobility, and the effects of policies.

Related literature

In this paper I introduce a flexible process for earnings dynamics, which I input into a rich model of housing and portfolio choice over the life cycle to understand intergenerational changes and their macroeconomic implications. Thus, I contribute to three main strands of the literature.

Earnings dynamics. The earnings process that I propose in this paper jointly considers rich features of earnings risk, business cycle variation, and changes over the generations. As such, it expands on a broad literature on earnings dynamics, and its effects on consumption, welfare, and portfolio allocations.[5]

A number of recent contributions have documented that earnings risk varies by age and by the position of an individual in the earnings distribution, and that earnings shocks are left-skewed and leptokurtic (e.g. Guvenen, Karahan, Ozkan and Song (2016) with US administrative data for individuals). Arellano et al. (2017) devise an econometric framework that allows for the separate identification of the distributions of the persistent and transitory components of earnings whilst allowing for flexibility in their distributions, and thus accommodating all of these non-normal and non-linear features. Using their framework, De Nardi, Fella and Paz-Pardo (2019) introduce a flexible earnings process, with a persistent and a transitory component, into a standard life cycle model. They find that allowing for these rich earnings dynamics helps to better understand the evolution of cross-sectional consumption dispersion and the extent to which households can self-insure against persistent earnings shocks.

However, these estimated processes abstract from business cycle variation. Storesletten, Telmer and Yaron (2004) show that, in the context of a standard earnings process with normal shocks, the standard deviation of earnings fluctuations is strongly countercyclical. Guvenen, Ozkan and Song (2014) argue that the key element that fluctuates over the cycle is the left-skewness of earnings shocks: during recessions, large drops in earnings become more likely. This business cycle component of earnings risk and its correlation with asset returns is important to understand household portfolio decisions. In this paper, I propose an extension of the econometric framework devised by Arellano et al. (2017) that allows for business cycle variation in earnings dynamics in the form of a Markov-switching regime, and that displays, when estimated in survey data, the rich

[5]See Meghir and Pistaferri (2011) for a summary of this branch of the literature.

features described in Guvenen et al. (2014).

Another recent contribution that designs and implements an earnings process with variation in higher order moments over the business cycle is Busch and Ludwig (2017). Both their approach and their focus differ from mine. I use a flexible nonparametric model that I estimate in panel data, while they define a rich parametric process and estimate it, à la Storesletten et al. (2004), by using cross-sectional moments identify the sequence of past shocks. I focus on the relationship of rich earnings risk with changes in household portfolio compositions, while they study the welfare costs of risks. Furthermore, my approach also allows for variations in earnings dynamics over different cohorts.[6]

Housing and portfolio choice over the life cycle. An extensive literature has studied the determinants of housing demand over the life cycle, its relationship to non-durable consumption and savings, and its interaction with household responses to income or house price shocks (Attanasio, Bottazzi, Low, Nesheim and Wakefield (2012), Berger, Guerrieri, Lorenzoni and Vavra (2017), etc.). Houses are a large part of the portfolio of most households, and passive saving through house price appreciation is an important determinant of wealth accumulation (Fagereng, Holm, Moll and Natvik, 2019). Additionally, houses have a preferential tax treatment in most countries, which occurs both because owner-occupied rents of housing are not taxed and because of government programmes like the US mortgage interest tax deductibility (Gervais (2002), Díaz and Luengo-Prado (2008), Nakajima (2010), etc.). This paper incorporates all of these important dimensions in the modelling of houses.

In parallel, many papers have used models of portfolio choice over the life cycle to explain important puzzles, such as the high equity premium or the low level of stock market participation. Standard asset allocation models over-predict how many people invest in stocks and, conditional on participation, how much of their wealth they invest in them. This puzzle can be overcome considering alternative preferences and costs of participation in the stock market (Gomes and Michaelides (2005), Alan (2006)), or the correlation between labor market income risk and stock market risk, although its effect is usually quantitatively small.[7] I incorporate these preferences, costs, and correlations

[6] Lippi and Perri (2019) show that the changes in household income dynamics in the US over the past 50 years have an important role in explaining the evolution of inequality and part of the reduction in aggregate growth.

[7] See Ameriks and Zeldes (2004), Cocco, Gomes and Maenhout (2005), Benzoni, Collin-Dufresne and Goldstein (2007) and Fagereng, Gottlieb and Guiso (2017). Fagereng, Guiso and Pistaferri (2016) argue

to my modeling of household portfolio decisions.

Fewer contributions have explored, like I do, the interaction between housing, portfolio choice, and the life-cycle.[8] Cocco (2005) shows that younger and poorer investors have less financial wealth to invest in stocks because they prefer to start investing in housing, and that this reduces the benefits of equity holdings, thus helping solve the stock market participation puzzle. My life-cycle model is similar to his, in that it allows for housing and portfolio choice decisions, but we differ in our focus. While his paper studies how housing crowds out stock market participation, I focus on the joint role of housing and portfolio choice in life-cycle wealth accumulation, the role of labor market income risk, and intergenerational changes. Furthermore, my model is richer and includes flexible earnings risk, mortgages that do not need to satisfy LTV constraints in every period, the possibility of renting, and a richer process for stock returns that features a disaster state.

Intergenerational changes. Changes over time and over the business cycle in asset returns, house prices, and labor market dynamics affect both the decision to buy a house and the allocation between safe and risky assets. The link between those and macroeconomic outcomes is still relatively unexplored.[9] Closely connected with this study are Fisher and Gervais (2011), who in a stationary equilibrium framework find that the increase in earnings uncertainty is a major candidate to explain the reduction in homeownership of the young between 1980 and 2000. This paper builds on their contribution along several dimensions. First, I explicitly consider intergenerational differences by modelling each cohort separately, which allows me to better capture cohort and year effects on earnings and asset prices, including variations in price to income ratios of housing. Second, in my model house prices are risky and agents can hold liquidity while they have a mortgage. Both are important elements because they affect the risk associated with buying a house: the former increases household exposure to risk, but the latter decreases

that this small quantitative effect arises from problems in the identification of uninsurable risk.

[8] These include Flavin and Yamashita (2011), Yao and Zhang (2005), and Vestman (2012), who focuses on the role of preference heterogeneity to explain why homeowners participate more in the stock market. Becker and Shabani (2010) and Chetty, Sándor and Szeidl (2017) study the role of mortgage debt on portfolio allocations.

[9] Relevant contributions include Nakajima (2005), who suggests that rising earnings inequality in the U.S. can be related with the increase in housing prices and lower return of financial assets, or Chambers, Garriga and Schlagenhauf (2009), who study the boom in homeownership between 1994 and 2005 and relate it to mortgage innovations. Fischer and Khorunzhina (2019) relate changes in homeownership rates over the life-cycle to increases in divorce rates, that trigger precautionary savings for the young but reduce homeownership for older households. Jeske, Krueger and Mitman (2013) study how government intervention in the mortgage market via Freddie Mac or Fannie Mae can encourage mortgage origination.

it, because it allows them to better smooth income fluctuations. Third, I study the role of housing in the context of a richer household portfolio decision, and thus can accommodate possible substitution effects across asset classes as housing prices and asset returns change over time.

The increase in earnings uncertainty has also been related to the decrease in marriage rates (Santos and Weiss, 2016) and in fertility (Sommer, 2016). These channels are complementary to the link between earnings dynamics and homeownership proposed in this paper.

2 An overview of intergenerational changes

The 1960s and 1980s generations, when compared to the 1940s, have faced more earnings inequality, more earnings volatility, and more expensive house prices on average. They are less likely to be homeowners, but more likely to participate in the stock market. I now turn to empirical evidence to describe these differences in detail.

2.1 Distribution of earnings

The earnings of the median male earner in the United States at age 25 have decreased from the cohort born in the 1940s, which entered the labor market in the early 1960s, to the cohort born in the 1960s by around 12% in real dollars (see top left panel of Figure 1).[10] Similarly, Guvenen et al. (2017), using Social Security data, find that median income at labor market entry peaked for the generation born in 1947 and decreased thereafter. As the shape of the life-cycle profile of earnings has changed little, both median earnings at each age and median lifetime earnings are lower for younger generations.

However, during this period there was a significant increase in female labor force participation and women's wages, which acted as a counteracting force and almost completely reversed this decrease in terms of household earnings (bottom left panel of Figure 1). After age 30, when most household formation has taken place, median household earnings are higher for the younger cohort than for those born in the 1940s.

Comparing average and median earnings suggests that earnings have become progres-

[10] Appendix A describes the data and sample selection procedures I use, and Appendix C shows robustness with respect to these choices.

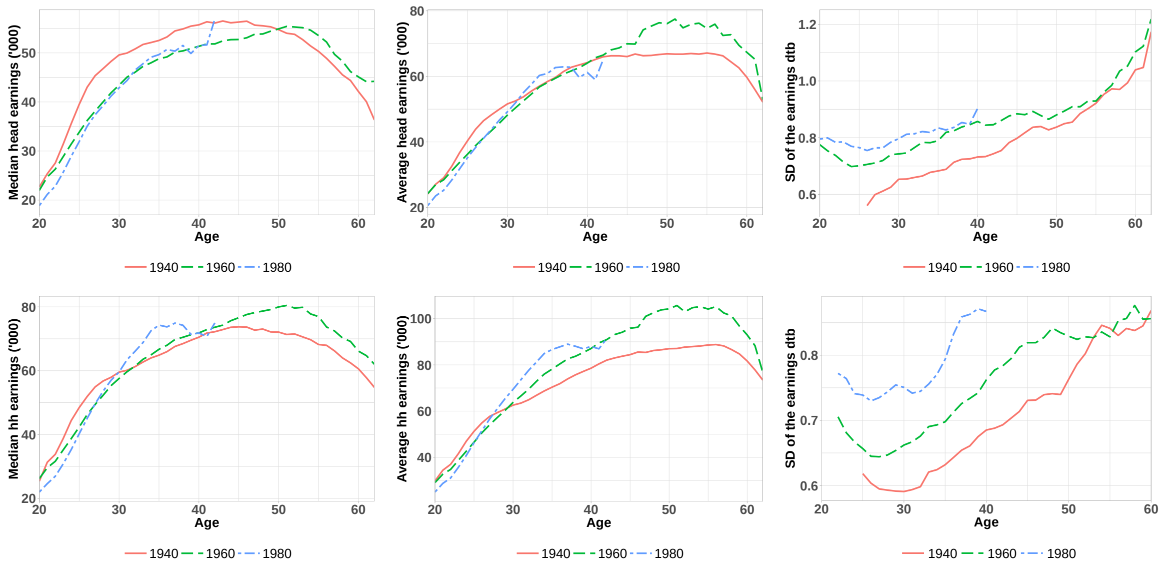

Figure 1: Changes in the earnings distribution over the generations. Top: household heads; bottom: household earnings. Left: median earnings, center: average earnings, right: standard deviation of the log earnings distribution. PSID data, deflated using the CPI.

sively more right-skewed and the earners above the median have seen larger increases than the earners below the median. The two right-hand side panels of Figure 1 confirm this intuition and show that earnings dispersion has grown for younger cohorts, particularly in terms of household earnings. Most of the difference is already present at age 25. This large increase, together with little action in the means, implies that the earnings-poorest of more recent cohorts are relatively worse off than people in the same percentile of earnings of earlier cohorts, and conversely the earnings-richest are better off today. This has important implications for the timing and features of their homeownership decisions, as I describe when I turn to my model and its results in Section 6.

Part of these changes (in particular, the reduction in median and average earnings at younger ages) can reflect intergenerational changes in family composition, and, in particular, delayed household formation. Appendix C.3 shows that, if we restrict the sample to married couples, all patterns are consistent with the main picture, in particular in terms of earnings inequality. I consider this as suggestive evidence that the timing of family formation is not the key driver of the transformations we observe.

2.2 Earnings risk

Apart from a more spread earnings distribution, younger cohorts also face increasing earnings risk. Figure 2 shows that, in general, the standard deviation of earnings *changes* is larger for younger cohorts. The most significant differences between the 1940s and 1960s cohort are concentrated between ages 30 and 50, and the 1980s cohort started its working life with a very large level of earnings variability. However, those changes do not extend to higher-order moments of earnings risk. As Figure 3 shows, earnings changes display negative skewness and high kurtosis for all cohorts, but there has been little change in those measures over time[11]. However, this observation does not imply that the tails of all three distributions are equally fat: given a level of kurtosis and skewness, increasing the variance makes large shocks more likely than before.

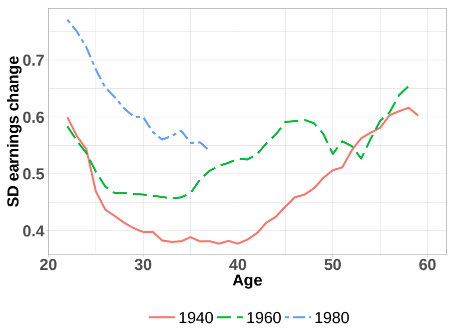

Figure 2: Standard deviation of log earnings changes, by cohort

2.3 Housing prices and stock returns

The ratio of median house prices to median income has increased, on average, in the United States over the last 60 years. Younger generations, at the same age, now have to devote more years of their income to buy a home compared with their parents.

The left panel of Figure 4 shows the evolution of median price-to-income (PTI) ratios, based on PSID data[12], from 1975 to 2017. Two features are particularly salient. First, PTI ratios have been increasing over time. Second, there are large cyclical variations in house prices, although they are not always correlated with the business cycle. These induce an additional source of variation across cohorts, as some of them may have entered

[11] Appendix A.3 provides definitions for these.

[12] Lovenheim (2011) shows that both median and mean home price indices constructed from PSID data track Federal Housing Finance Agency repeat home sales indices very well.

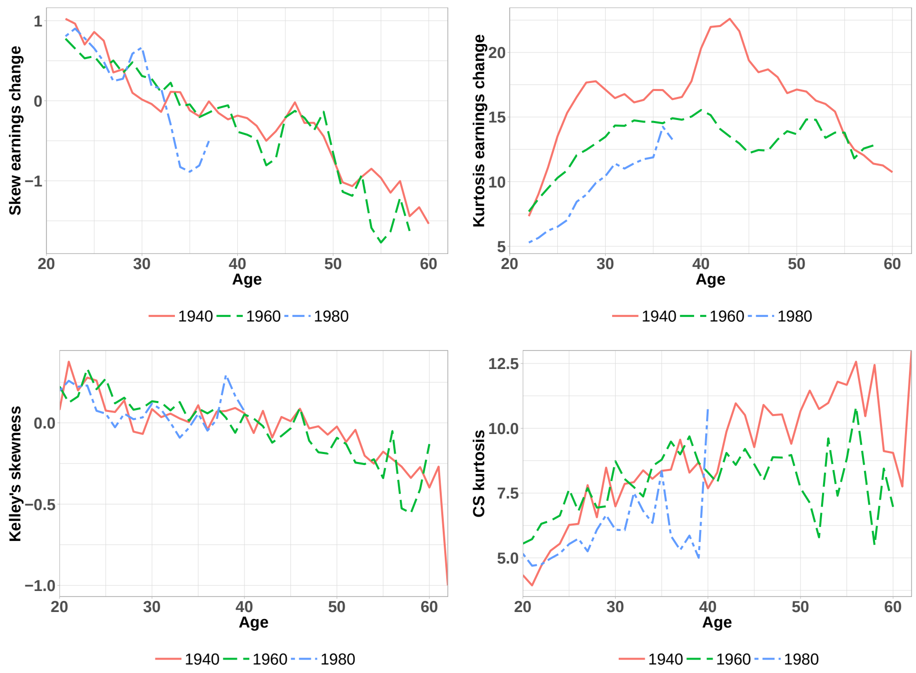

Figure 3: Higher order moments of log earnings changes, by cohort

the labor market in a time where house prices were cyclically low, and benefitted from the situation to make housing purchases earlier on in their lives.

On the other hand, the evolution of stock returns (right panel of Figure 4) shows large fluctuations, which are more strongly correlated with the business cycle, but fewer secular trends.

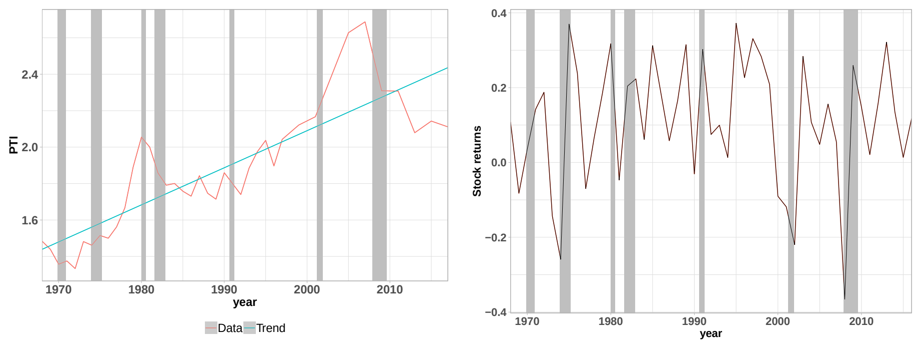

Figure 4: Evolution of asset prices and returns. Left: Price to Income ratios for housing (PSID data). Right: Stock returns, S&P 500. Shaded areas correspond to NBER recessions.

2.4 Financial conditions

The process of financial deregulation and innovation that started in the 1980s and expanded during the 1990s improved the access of households to credit, both from an extensive (more people can get credit) and intensive (the same household can borrow larger amounts) perspective. See, for instance, Gerardi, Rosen and Willen (2007) for a detailed description of the regulatory changes, the changes in the structure of the financial sector, and the new mortgage products that became available over this period. These changes were partially encouraged by policymakers, who were worried about low homeownership rates (for instance, Bill Clinton's National Homeownership Strategy).

Another important change was the introduction of tax-advantaged retirement accounts, such as individual retirement accounts (IRAs), which started in 1974 and became popular in the 1980s, and 401(k)s, which were introduced in 1978 and also became popular later on. Later reforms made these accounts more beneficial and less restricted, and automatic enrollment in pension plans further increased the number of stock market participants by reducing both the financial and psychological costs of enrollment.

2.5 Homeownership and portfolio composition

Parallel with the changes described earlier, homeownership rates have been falling for recent cohorts. I use the word homeownership to refer to the percentage of households that live in owner-occupied housing - this differs from its alternative, more common usage of the percentage of homes that are occupied by their owners.

Using PSID data (Figure 5, left panel), we observe that, at age 35, homeownership has dropped by over 10 percentage points between the cohorts born in 1940 and 1960, and by another 10 percentage points between the cohorts born in 1960 and 1980[13].

At the same time, stock market participation has increased significantly for younger cohorts (Figure 5, right panel). This is related to the introduction and generalization of retirement accounts I have just described in Section 2.4, an explanation which is reinforced by the small differences across cohorts in direct stock market participation (see Figure 33 in Appendix C.8). However, stock market participation also displays strong year effects.

[13]Homeownership rates have also fallen for younger generations under alternative sample selection procedures (Appendix C.1), considering only married households or households with children (Appendix C.3), by education groups (Appendix C.4), and by geographical areas (Appendix C.5).

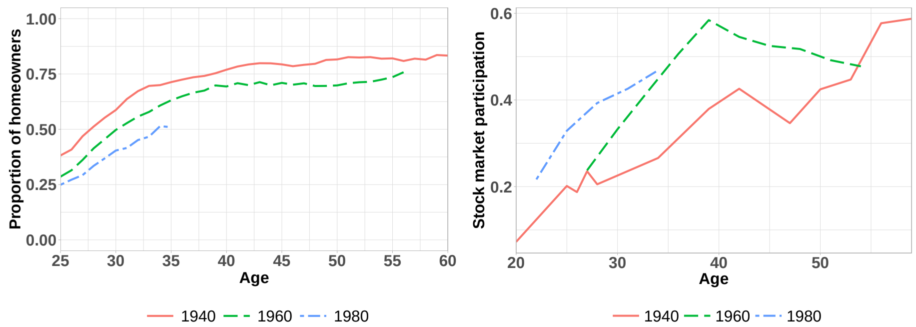

Figure 5: Homeownership (left) and stock market participation (right), three generations. PSID and SCF data.

For instance, direct stock market participation increased significantly in the years before the 2000 stock market crash, and dropped dramatically afterwards, as it can be seen in the profile for the 1960s cohort when they were 40 years old.

3 A business-cycle dependent earnings process

In this section I develop a flexible earnings process that can capture the differences across generations I have just described, whilst encompassing a set of elements that have been shown to be important to describe the features of household earnings risk and its implications on household consumption and self-insurance (De Nardi et al., 2019). These include age-varying persistence, variance, and higher order moments, non-normalities such as high negative skewness and large kurtosis, and non-linearities such as previous-earnings-dependent persistence.

The process is based on Arellano et al. (2017), but, on top of that, it includes three important factors: business cycle variation in earnings dynamics, including its non-normal and nonlinear features, intergenerational changes in the distribution of earnings, and intergenerational changes in earnings risk. The former is necessary because idiosyncratic risk correlates with aggregate asset price risk, which can have implications for household portfolio decisions and insurance over the business cycle. The latter two are necessary to address the questions posed in this paper.

Let $\tilde{y}_{it}$ denote the logarithm of pre-tax labor earnings, net of age effects, for household i of cohort c_i ($c_i \in \{1940, 1960, 1980\}$) living in calendar year t with age age_{it}. I assume earnings are the sum of a persistent and a transitory component:

$$\tilde{y}_{it} = \eta_{it} + \epsilon_{it} \tag{1}$$

where both have absolutely continuous distributions. The persistent component η_{ith} is assumed to follow a first-order Markov process, while the transitory component ϵ_{ith} has zero mean and is independent over time and of the persistent component.

We can introduce these assumptions by writing the processes for η and ϵ, and the initial condition for the persistent component η_1 as:

$$\eta_{it} = Q_\eta(\nu_{it}^\eta | \eta_{i,t-1}, age_{it}, c_i, \Omega_t^y), \nu_{it}^\eta \overset{iid}{\sim} U(0,1), t > 1 \tag{2}$$

$$\epsilon_{it} = Q_\epsilon(\nu_{it}^\epsilon | age_{it}, c_i), \nu_{it}^\epsilon \overset{iid}{\sim} U(0,1) \tag{3}$$

$$\eta_{i1} = Q_{\eta_1}(\nu_{it}^{\eta_1} | age_{it}, c_i, \Omega_t^y), \nu_{it}^{\eta_1} \overset{iid}{\sim} U(0,1) \tag{4}$$

Equation 2 specifies the dependence of η_{it} on its previous realization with a flexible quantile function Q_η. This function depends on the age of the household, age_{it}, its cohort, c_i, and the aggregate state of the labor market, Ω^y. Thus, the features of earnings shocks are allowed to be different in expansions and recessions.[14] In this way, this formulation explicitly includes age, cohort, and year effects.

Q maps draws ν_{it} from the uniform distribution $U(0,1)$ into quantile draws for η. ν_{it} can be thought of as a rank: if it is 0.9, it implies that the realization of η_{it} is on the 90th percentile conditional on age and $\eta_{i,t-1}$. A similar reasoning follows for the initial realization of the persistent component, with the further simplification that it only depends on age, cohort, and the current state of the labor market; and for the transitory component, which only depends on age and cohort. I treat the transitory component as measurement error or alternatively as a fully-insurable source of earnings fluctuations.

Following Arellano et al. (2017), to estimate the process I specify a parametric form for the quantile functions as low order Hermite polynomials:

[14] Section 4.3.1 describes the aggregate state in more detail, and Section 5.1 explains its implementation from the data.

$$Q_{\eta}(q|\eta_{i,t-1}, age_{it}, c_i, \Omega_t^y) = \sum_{j=0}^{J} a_j^{\eta}(q, c_i, \Omega_t^y)\psi_j(\eta_{i,t-1}, age_{it}) \tag{5}$$

$$Q_{\eta_1}(q|age_{i1}, c_i, \Omega_1^y) = \sum_{j=0}^{J} a_j^{\eta_1}(q, c_i, \Omega_1^y)\psi_j(age_{i1}) \tag{6}$$

$$Q_{\epsilon}(q|age_{it}, c_i) = \sum_{j=0}^{J} a_j^{\epsilon}(q, c_i)\psi_j(age_{it}) \tag{7}$$

$$\tag{8}$$

where the coefficients a_j^i, $i = \epsilon, \eta_1, \eta$, for all states are modelled as piecewise-linear splines on a grid $\{q_1 < \ldots < q_L\} \in (0, 1)$.[15] The intercept coefficients $a_0^i(q)$ for q in $(0, q_1]$ and $[q_L, 1)$ are modelled as the quantiles of an exponential distribution with parameters λ_1^i and λ_L^i respectively. All coefficients are allowed to differ across cohorts.

If one could directly observe the two components ϵ_{it} and η_{it}, it would be possible to find the coefficients above by quantile regression at each point of the quantile grid q_j. However, both components are latent. To deal with this, the estimation starts at an initial guess for the coefficients and iterates between draws of the posterior distribution of the latent persistent components and proceeds to find the coefficients by quantile regression. The process is repeated until convergence of the sequence of coefficient estimates.

This process nests more standard earnings process such as that proposed in Storesletten et al. (2004), which I refer to as *canonical process*:

$$y_{it} = \eta_{it} + \epsilon_{it} \tag{9}$$

$$\eta_{it} = \rho\eta_{it-1} + \xi_{it} \tag{10}$$

with $\xi_{it} \sim N(0, \sigma_t^2)$, $\epsilon_{it} \sim N(0, \sigma_\epsilon^2)$ and

$$\sigma_t^2 = \begin{cases} \sigma_{r,c}^2 \text{ if } \Omega^y = \text{Recession} \\ \sigma_{b,c}^2 \text{ if } \Omega^y = \text{Boom} \end{cases} \tag{11}$$

[15] Following Arellano et al. (2017), I use tensor products of Hermite polynomials of degrees (3,2) in $\eta_{i,t-1}$, and age for each state k of $Q_{\eta,\Omega}(q|\eta_{i,t-1}, age_{it})$ and second-order polynomials in age for $Q_{\epsilon}(q|age_{it})$ and $Q_{\eta_1,\Omega}(q|age_{i1})$.

where usually $\sigma^2_{r,c} > \sigma^2_{b,c}$. Unlike in this process, my procedure implies that there is no need to assume age-independence or normality of earnings shocks, nor linearity in the dependence of the persistent component on its past realizations. While the earnings process is estimated on pre-tax rather than post-tax household earnings, most of its features regarding non-linearity and non-normality are qualitatively similar to De Nardi et al. (2019) and therefore I refer the interested reader to the discussion therein. Furthermore, the earnings process I propose can accommodate business-cycle varying features of higher order moments of earnings risk, such as countercyclical skewness.

I estimate the earnings process on PSID data for all three cohorts. Given that the PSID became biennial from 1997 onwards, the period is two years for both the earnings process and the structural model. I use the full length of the PSID (1968-2017).[16] More details about the data treatment, cohort definitions, and sample selection are available in Appendix A.

3.1 Implications of the earnings process

3.1.1 Intergenerational differences

The earnings process captures the intergenerational changes in earnings dynamics documented in Section 2.2 well (see Appendix C.6). An additional notion that has changed over time is *nonlinear persistence* (Figure 6) by previous earnings and the quantile of the earnings shock. For the youngest cohort, persistence is much larger for higher-income agents and all ranks of their shocks, and lower for low-income agents, particularly for large shocks.

3.1.2 State-dependence of the earnings process

The state dependence of the earnings process implies that it has potentially different features in expansions and recessions. The left panel of Figure 7 shows the average expected change in earnings for individuals in different points of the earnings distribution for both aggregate states for the 1940s cohort. The other three cohorts display similar qualitative characteristics. During normal times, most individuals expect slight increases

[16]The semiparametric implementation of the nonparametric model defined in Arellano et al. (2017) allows to interpolate and obtain an earnings process for every state and age even if not all combinations are present in the data.

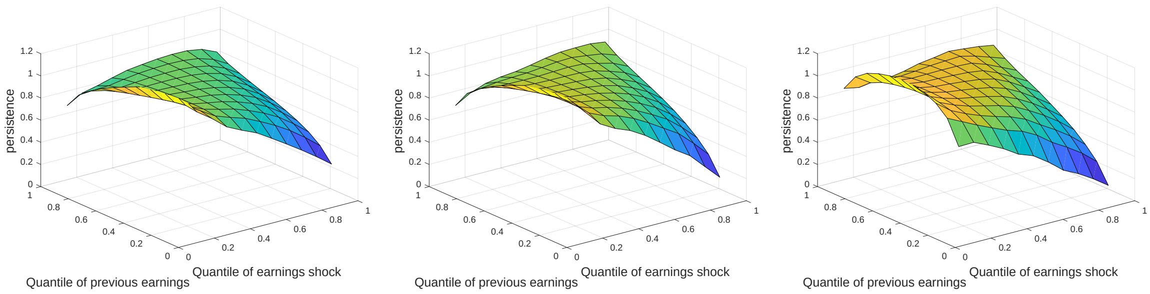

Figure 6: Nonlinear persistence, by cohort. Top left: 1940s; top right: 1960s; bottom: 1980s. For all cohorts: all agents below 40 years old. Figure 32 in Appendix C.7 provides the version with all ages included but thus varying composition across cohorts.

in their earnings. The very poorest expect the highest improvements in relative terms, while there is a certain level of mean reversion for the earnings-richest. In recessions, the expected increase in earnings shifts downwards. The earnings-poorest expect lower increases, and the earnings-richest expect larger drops.

These average measures mask significant heterogeneity. Figure 7, right panel, plots Kelley's measure of skewness of earnings changes during an expansion and during a recession. During normal times, the skewness is basically zero for most of the distribution: the distribution of earnings changes is symmetric and large negative shocks and large positive shocks of equal magnitudes are equally likely. However, during a recession skewness becomes negative, particularly so for the very richest. Thus, large decreases in earnings become more likely with respect to large increases in earnings.

Capturing these features of the distributions is important to better understand how households take portfolio decisions. For instance, the combination of high likelihood of disaster risk in the stock market and large skewness in labor earnings for a particular household can explain why they choose to keep some of their savings in safer investments.

An additional realistic feature that the Markov-switching earnings process captures is history dependence: at any point in time, the distribution of earnings for a given cohort depends on the set of expansions and recessions that the cohort has lived through. In particular, the recovery from recessions is usually sluggish.[17] Figure 8, left panel, shows that the earnings process I propose replicates this feature without large increases in the state space. It represents, for the simulated earnings process of the 1940s cohort,

[17] A broad literature has studied both the large negative long-run effects of displacement for individual workers (e.g. Jacobson, LaLonde and Sullivan (1993)), that are particularly severe within recessions (Davis and Von Wachter, 2011), and the slow recovery of employment after downturns like the Great Recession (Ravn and Sterk, 2017).

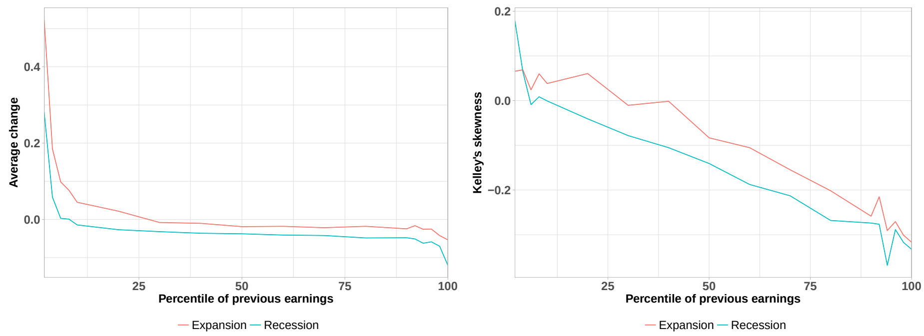

Figure 7: Average expected change in earnings (left), and Kelley's skewness of earnings changes (right), by previous earnings percentile and aggregate state of the economy. Percentiles refer to the distribution during an expansion.

the percentage difference in average earnings between a cohort that underwent a single recession at age 44 ("NL process") and one that never lived through a recession throughout its entire labor market history. Suffering one recession has important effects on impact that last for relatively long. In contrast, the canonical earnings process generates a counterfactual *increase* in average earnings because higher variances in logs, at a constant average, imply higher averages in levels. The purple line represents it for the estimated parameters in Storesletten et al. (2004), while the yellow line represents the canonical counterpart to the process I estimate for the 1940s cohort (see Appendix E.3 for details).

The rich earnings process also captures differential impacts by initial position in the earnings distribution (middle panel). Recessions affect the earnings of the highest and lowest earners by more than those around the median. The impact of a recession also differs by age (right panel): younger agents are hit harder and take longer to recover. By construction, the canonical earnings process does not replicate either of this facts.

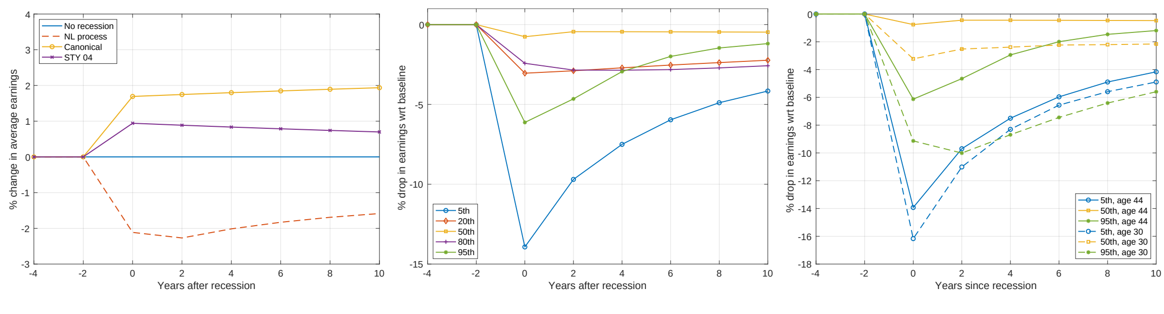

Figure 8: Earnings by age with respect to the counterfactual in which a recession never occurs. Left: average earnings, recession at age 44. Middle: by initial earnings percentile, recession at age 44. Right: by initial earnings percentile, comparing ages 30 and 44.

4 Model

I build a life-cycle structural model to evaluate to which extent the changes in earnings and financial conditions described in Section 2, modelling the former using the process described in Section 3, can account for the intergenerational differences in homeownership and portfolios I described earlier.

In the model, the economy is populated by a continuum of households i that belong to cohort c. From the perspective of a cohort, age and time are equivalent and indexed by t. The model period is two years. Households enjoy nondurable consumption and housing, are subject to exogenous earnings risk, and can hold three types of assets:

- Safe, liquid accounts.
- Housing (if they don't hold any, they must participate in the rental market).
- Risky financial assets.

To finance their housing expenditures, they can also hold liabilities in the form of mortgages.

4.1 Demographics

Households are born in the model at age 20, retire at age 60 and face positive and increasing death probabilities ξ_t starting at that age. They die for sure at age 86. An average demographic profile at each age is introduced in the model with a taste shifter θ_t, which represents the average OECD equivalence scale at each age, and generates age-varying marginal utility from nondurable and housing consumption.

4.2 Preferences

Preferences are Epstein and Zin (1989) and allow to disentangle the elasticity of intertemporal substitution ψ and the risk aversion coefficient γ. Whenever $\gamma > \frac{1}{\psi}$ (which is the benchmark case in this paper), they imply that agents prefer an early resolution of uncertainty, as standard in studies on the equity premium and risk-free rate puzzles, and in portfolio choice models (Cocco et al. (2005), Campanale, Fugazza and Gomes (2015) or Kaplan and Violante (2014)).

Utility at age t is therefore represented by:

$$U_{it} = [(\theta_t c_{it}^{\nu} s_{it}^{1-\nu})^{\frac{(\psi-1)}{\psi}} + \beta(\mathbb{E}_t U_{it+1}^{1-\gamma})^{\frac{1}{1-\gamma}\frac{\psi-1}{\psi}}]^{\frac{\psi}{\psi-1}} \tag{12}$$

where θ is the taste shifter described earlier, c is nondurable consumption, and s is the housing service flow. In this specification, β is the discount factor, ψ is the elasticity of intertemporal substitution, γ is the coefficient of relative risk aversion, and ν measures the relative importance of nondurable consumption with respect to housing. This Cobb-Douglas specification assumes an elasticity of substitution between housing and nonhousing of 1, which is justified by the almost constant shares of expenditure in housing in micro data (e.g. Davis and Ortalo-Magné, 2011). In practice, since housing in the model is discrete, this is equivalent to assuming that housing utility is a proportional scaling of the utility from nondurable consumption.

The utility value of housing s_t depends on the quality of the owned home and does not vary with its price. It is highest for owners of high-quality houses ($\bar{s}^2$), lower for owners of low-quality houses ($\bar{s}_1$), and lowest for renters ($\bar{s}^0$).

Households value bequests left according to:

$$v(b) = \phi_1(\phi_2 + b)^{\frac{(\psi-1)}{\psi}} \tag{13}$$

This specification mimics, in an Epstein-Zin framework, De Nardi (2004). The term ϕ_1 determines the intensity of the bequest motive and ϕ_2 determines the extent to which bequests are a luxury good.

4.3 Environment and technologies

4.3.1 Aggregate state

During each year t, the economy is in an aggregate state Ω_t composed of three elements: the state of the housing market Ω^h, which determines house prices, the state of the stock market Ω^f, on which stock returns depend, and the state of the labor market Ω^y, which determines the evolution of the earnings process. Thus, $\Omega_t = \{\Omega_t^f, \Omega_t^h, \Omega_t^y\}$. Households know the process governing the aggregate state, and use it to make predictions about the future, which in turn affect their decisions.

The assumptions regarding the evolution of each of these elements and their correlations, together with the estimation of the aggregate state in the data, are described in more detail in Section 5.1.

4.3.2 Earnings

Log earnings are composed of a deterministic component, which depends on age, and a stochastic persistent component η_{it}, which depends on the aggregate state of the labor market:

$$\log y_{it} = f(t) + \eta_{it}(\Omega_t^y) \tag{14}$$

Section 3 contains more details about the earnings process and its estimation. Transitory shocks may be reflecting measurement error or almost fully insurable fluctuations, so to save on computational costs I do not include them in the model.

4.3.3 Liquid accounts

Liquid accounts a_t are risk-free and they yield an exogenous and constant interest rate r^a. They cannot be negative: if they wish to borrow, households must apply for a specific type of financial asset, mortgages m_t, which I describe in detail in Section 4.3.6.

$$a_{t+1} \geq 0 \tag{15}$$

4.3.4 Risky financial assets

Households can also hold risky financial assets or stocks f. Stock returns r_t^f depend on the aggregate state of the stock market Ω_t^f. Households cannot short financial assets, thus the constraint for stocks is:

$$f_{t+1} \geq 0. \tag{16}$$

When $f_{i,t} = 0$, households pay a fixed entry cost κ^f to start investing in stocks. This cost represents psychological, financial, and technical barriers to start investing in the stock market (opening financial accounts, acquiring information about them, etc.), and is frequently used in the portfolio choice literature (Gomes and Michaelides, 2005). Once a household participates, there are no additional costs of adjusting financial assets.

4.3.5 Housing

Households can buy houses h that come in discrete sizes:

$$h_{i,t} = \{0, h_1, h_2, \dots, h_H\}, \tag{17}$$

where 0 indicates renting and the other values indicate increasing qualities of housing. The discrete specification for housing follows Attanasio et al. (2012). I set $H = 2$ due to computational considerations.[18]

Average house prices p_t^h depend on the aggregate state of the housing market Ω_t^h. They are expected to grow, but fluctuate around a trend as described in Section 5.1. The price of the different housing qualities h_j is assumed to be a fixed fraction of average house prices $p_t^h(\Omega_t^h)$ [19], which I denote h^j.

$$h^j = \frac{p_t^{h_1}(\Omega_t^h)}{p_t^h(\Omega_t^h)} \tag{18}$$

Housing is illiquid. Households pay a proportional transaction cost to buy or sell housing $\kappa^h p_t^{h_j}(\Omega_t^h)$, which depends on the price of the house which is being bought (as in Bajari, Chan, Krueger and Miller (2013)). It reflects the costs associated with selling or buying a home, which can include taxation, real estate agent fees, and other costs.

Households that do not own a home must participate in the rental market. I assume that foreign or institutional investors, who are not explicitly modelled, supply housing in the rental market, and I abstract from the equilibrium determination of house prices for tractability and simplicity[20]. The rental price $r_t^s(\Omega_t^h)$ depends on current housing prices $p_t^h(\Omega_t^h)$:

$$r_t^s(\Omega_t^h) = \gamma^r p_t^h(\Omega_t^h). \tag{19}$$

I assume that the government provides housing aid to income-poor households for whom rental costs are large. In particular, the government pays all rent that is above 30% of household income. This is a stylized representation of housing aid programs in the

[18] Appendix E.10 shows that results are robust to several specifications where $H = 3$.

[19] Some papers, like Li, Liu, Yang and Yao (2015), distinguish between idiosyncratic and aggregate house price shocks. My main results do not explore that possibility, but Appendix E.9 studies a case in which idiosyncratic house price risk is correlated with labor income risk.

[20] Section 6.4 contains an approximation to how my counterfactual results would change under endogenous determination of housing prices

United States, in particular the Section 8 program (Housing Act of 1937), which provides families with low income with Housing Choice Vouchers or project based assistance. In the PSID data roughly 2% of working age households receive this subsidy. In the model this fraction is about 3%.

During the working period, households are subject to exogenous moving shocks with probability π_{hm}. They represent events such as finding a new job in a different place or suffering a job relocation. These further reasons to move add to the riskiness of owner-occupied housing as an investment. In the model, when the moving shock realizes, agents sell their houses at the beginning of period, before they take their consumption and saving decisions. They must then spend that period in rental housing but can freely reoptimize afterwards.

4.3.6 Mortgages

When a household wants to acquire a house of quality j, it can apply for a loan or mortgage m_t. I define mortgages so that $m_t \leq 0$. In order to get it, the household must fulfill two conditions: a downpayment or loan-to-value (LTV) restriction and an income test or loan-to-income (LTI) restriction.

$$m_{t+1} \geq -\lambda_h p_t^{h_j}(\Omega_t^h) \tag{20}$$

$$m_{t+1} \geq -\lambda_y y_{it}(\Omega_t^y) \tag{21}$$

where $\lambda_h < 1$. There is no uncollateralized debt, so households can only get indebted when they buy a house.

Borrowers pay an exogenous interest rate on their debt r^b which is larger than the risk-free rate r^a. Households decide on their repayment schedule, but in every period they must at least pay the interest accrued by their debts and cannot reach their terminal age T with an unpaid mortgage balance, even if their net worth is positive (as in Attanasio et al. (2012)).

$$m_{t+1} \geq \frac{m_t}{1+r^b} \tag{22}$$

$$m_T = 0 \tag{23}$$

Within this framework, households can extract equity from their homes in two ways. First, they can sell them and either move to rental housing or buy a new smaller or cheaper house. Second, they can decide to delay the repayment of the mortgage principal, thus extending their mortgage duration. For simplicity, I assume that they cannot increase the principal of their debt by remortgaging or accessing home equity lines of credit.

To reduce the dimensionality of the problem, due to computational considerations, I assume that households cannot simultaneously hold both a mortgage m_t, risk-free assets a_t, and risky assets f_t, but only two of the three. This assumption is weaker than modeling mortgages as negative safe assets, because it still allows households in debt to make a choice between positive safe and risky assets, as long as the choice is not interior. Therefore, mortgagors in the model are able to hold liquidity without incurring the participation cost to the stock market.

$$a_{t+1}f_{t+1}m_{t+1} = 0 \tag{24}$$

4.4 The government

Disposable income $\lambda(y_{i,t})$ is obtained from pre-tax income $y_{i,t}$ using the tax function $\lambda(\cdot)$ (Benabou (2002), Heathcote, Storesletten and Violante (2014)):

$$\lambda(y_{i,t}) = \lambda y_{i,t}^{1-\tau} \tag{25}$$

This specification can be negative at lower income levels and thus includes, in a parsimonious way, both progressive labor income taxation and many income-tested welfare programs, such as unemployment insurance, EITC, food stamps, etc.

The government also taxes capital income from risky and safe assets at a flat-rate τ_a. It uses the proceedings to finance useless government spending g and social security for old people $p(\cdot)$. The latter is a function of a household's last income realization.

Households can deduct mortgage interest from their labor income tax. Both in the US tax code and in the model, they can choose between getting the standard deduction, which is a fixed amount, and itemization, which implies that they individually deduct qualifying expenses such as mortgage interest. Thus, only households who have a sufficiently large mortgage get the mortgage interest deduction. Furthermore, stock market losses are deductible against asset income and labor income up to $3,000.

4.5 Timing

At the beginning of the period, households learn the common realization of the aggregate state Ω_t, which implies that they find out about housing prices $p_t^h(\Omega_t^h)$ and stock returns $r_t^f(\Omega_t^f)$, and their individual realization of labor income $y_t(\Omega_t^y)$. Jointly, those determine their net worth or cash-on-hand in period t:

$$coh_t = p_t^h(\Omega_t^h)h_t + (1+r_t^f(\Omega_t^f)(1-\tau_a))f_t + (1+r^a(1-\tau_a))a_t + (1+r^b)m_t + T(y_t(\Omega_t^y), m_t) \quad (26)$$

where $\lambda(\cdot)$ represents progressive taxation of labor earnings net of mortgage interest payments.

Households get utility from their housing stock h_t at the beginning of the period. Then they decide on their consumption c_t and their savings for the next period, which are composed of their liquid accounts a_{t+1}, stocks f_{t+1}, and housing h_{t+1}, minus any outstanding mortgage balance m_{t+1}.

Both in the model and in the data, a household can have negative net worth. In the model, that is represented by $coh_t < 0$ and can arise when a household suffers a negative housing price, income, or financial shock while holding a significant mortgage. Households can continue to hold their house as long as they are able to make interest payments to their mortgage out of their financial savings or labor income.

If a household has exhausted all of their financial assets, cannot make interest payments to their mortgage, and cannot pay for all of its debt even after selling its house, it goes bankrupt. They return the keys of their house to the bank, their debt is cancelled, and suffer a utility penalty, which incoporates stigma effects and the negative consequences of a bankruptcy flag on future credit reports.

$$\begin{aligned} &\text{If } coh_t < 0 \\ \text{and } T(y_t(\Omega_t^y), m_t) + r^b m_t + (1 + r^a(1-\tau_a))a_t + (1 + r_t^f(\Omega_t^f)(1-\tau_a))f_t &< 0, \\ a_{t+1} = 0, f_{t+1} = 0, h_{t+1} = 0, c_t = c^{bk}, m_{t+1} &= 0 \end{aligned} \quad (27)$$

4.6 Budget constraint

The period by period budget constraint is:

$$\begin{aligned} p_t^h(\Omega_t^h)h_{t+1} + \kappa^h p_t^h(\Omega_t^h)h_{t+1}\mathbb{I}(h_{t+1} \neq h_t) + r_t^s(\Omega_t^h)\mathbb{I}(h_t = 0) + \\ f_{t+1} + \kappa^f \mathbb{I}(f_{t+1} > 0, f_t = 0) + a_{t+1} + m_{t+1} + c_t = \\ p_t^h(\Omega_t^h)h_t + (1 + r_t^f(\Omega_t^f)(1-\tau_a))f_t + (1 + r^a(1-\tau_a))a_t + \\ (1+r^b)m_t + T(y_t(\Omega_t^y), m_t) \end{aligned} \tag{28}$$

where $T(y, m)$ represents the tax system described in Section 4.4.

4.7 Household's problem

Working-age households. They solve the following problem:

$$U_t(y,a,h,f,m,\Omega) = \max_{c,a',h',f',m'} \left\{ [(\theta_t c_t^{\nu} s_t^{1-\nu})^{\frac{(\psi-1)}{\psi}} + \beta(\mathbb{E}_t U_{t+1}(y',a',h',f',m',\Omega')^{1-\gamma})^{\frac{1}{1-\gamma}\frac{\psi-1}{\psi}}]^{\frac{\psi}{\psi-1}} \right\} \tag{29}$$

subject to the no-shorting condition for safe and risky assets (15, 16), LTV and LTI constraints when buying a home (20 and 21), the requirement to at least pay interest on debt in every period (22), the restriction on holding both risky and safe assets while having a mortgage (24), the bankruptcy condition (27), and the budget constraint (28).

Retired households. Their social security income p is a function of their last realization of labour earnings before mandatory retirement (they cannot retire before 65). They solve the following problem (where y_l is their last realization of income before retirement):

$$\begin{aligned} U_t(y_l,a,h,f,m,\Omega) = \max_{c,a',f',h',m'} \Big\{ [(\theta_t c_t^{\nu} s_t^{1-\nu})^{\frac{(\psi-1)}{\psi}} + \\ \beta\xi_t(\mathbb{E}_t U_{t+1}(y_l,a',h',f',m',\Omega')^{1-\gamma})^{\frac{1}{1-\gamma}\frac{\psi-1}{\psi}} + \\ (1-\xi_t)v(b))]^{\frac{\psi}{\psi-1}} \Big\} \end{aligned} \tag{30}$$

where $v(b)$ is determined by Equation 13. Their maximization problem is subject to the no-shorting condition for safe and risky assets (15, 16), LTV and LTI constraints when buying a home (20 and 21), the requirement to at least pay interest on debt in every period (22), the restriction on holding both risky and safe assets while having a mortgage (24), the bankruptcy condition (27), and a budget constraint with no income risk (31).

$$\begin{aligned} p_t^h(\Omega_t^h)h_{t+1} + \kappa^h p_t^h(\Omega_t^h)I_t^h + f_{t+1} + \kappa^f I_t^f + a_{t+1} + m_{t+1} + c_t + r_t^s(\Omega_t^h)\mathbb{I}(h_t = 0) = \\ p^h(\Omega_t^h)h_t + (1 + r_t^f(\Omega_t^f)(1-\tau_a))f_t + (1 + r^a(1-\tau_a))a_t + (1 + r^b)m_t + T(p(y_l), m_t) \end{aligned} \tag{31}$$

where $p(\cdot)$ represents social security.

5 Calibration

5.1 Aggregate state

The aggregate state of the economy in a calendar year Ω_t is the combination of the state of the labor market Ω_t^y, the state of the stock market Ω_t^f, and the state of the housing market Ω_t^h.[21]

The aggregate state of the labor market Ω^y in $t+1$ takes two possible realizations, expansions and recessions, and determines the conditional distribution of earnings shocks that agents face given their earnings in t, as described in Section 3. I define a period to be recessionary if any part of it falls under an NBER-defined recession.

The stock market state Ω^f determines stock market returns r^f and takes four possible realizations. Three of those correspond to historical averages of each tercile of the distribution of stock market returns in the S&P500 during my sample period (1963-2015). Additionally, I include a disaster state, that corresponds to the average of the lowest 5% of annual stock market realizations during this period.[22]

With respect to the housing state Ω^h, I assume that households know the current realization of house prices, and whether they have grown or decreased from the previous

[21]For the description of the model, t indexed both year and age, which were equivalent from the perspective of a cohort. Naturally, calendar years and their associated states happen at different ages for different cohorts. To keep the notation in this section clear, I describe it from the perspective of a single cohort.

[22]The possibility of stock market crashes is important to understand the low stock market participation and high equity premium puzzles (Bansal and Yaron (2004), Barro (2006)), as well as the age patterns of stockholding (Fagereng et al., 2017). This framework extends these previous studies by letting the stock market Ω^f and labor market Ω^y states be correlated.

period. This can equivalently be understood as two separate states (current house prices and current house price *growth regime*), or as a restricted Markov 2 process for housing prices, in which $Pr(p^h_{t+1} = x | p^h_t = y, p^h_{t-1} = z)$ is the same for any (y, z) such that $y < z$ and for any (y, z) such that $z > y$. Given that house price growth regimes are persistent in the data, households expect house prices to continue growing when they have grown in the past. Housing prices are discretized to four possible realizations in every period.

In the simulation, the realizations of the aggregate state Ω_t correspond to their data counterparts for each specific year. For instance, when agents of the oldest cohort, born in 1942, reach 53 years of age, they face a good realization of the stock market state because 1995 was a year of high stock returns. Figure 9 shows how biennial stock returns (left) and housing price-to-income (PTI) ratios in the model compare with the data.

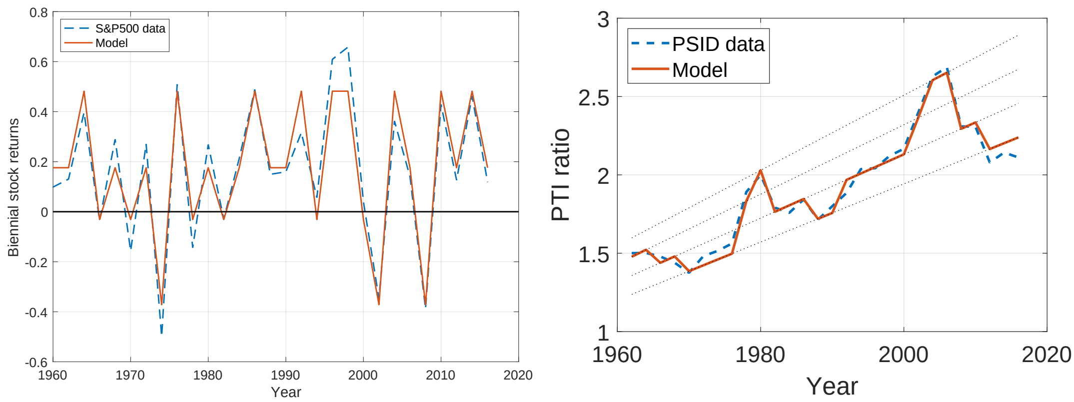

Figure 9: Stock market returns, housing median price-to-income ratio

From the perspective of the agents in the model, the realization of the aggregate state is stochastic, so it is necessary to determine how they form predictions over it and how they perceive the correlation between its different elements. Equation 32 represents these assumptions as restrictions on a Markov transition matrix.[23] Namely, I assume that house price growth regimes and recessions are persistent and potentially mutually correlated, that the distribution of stock market returns is different in recessions, and that the distribution of house price realizations depends on the current house price and on the current house price growth regime. I estimate $Pr(\Omega^{hg}_{t+1}, \Omega^y_{t+1} | \Omega^{hg}_t, \Omega^y_t)$, $Pr(\Omega^f_{t+1} | \Omega^y_{t+1})$, and $Pr(\Omega^h_{t+1} | \Omega^{hg}_{t+1}, \Omega^h_t)$ directly from their empirical counterparts.

[23] For purposes of this representation Ω^{hg} represents housing growth regimes and Ω^h represents house prices.

$$Pr(\Omega^h_{t+1}, \Omega^{hg}_{t+1}, \Omega^y_{t+1}, \Omega^f_{t+1} | \Omega^h_t, \Omega^{hg}_t, \Omega^y_t, \Omega^f_t) = \\ Pr(\Omega^f_{t+1} | \Omega^y_{t+1}) Pr(\Omega^h_{t+1} | \Omega^{hg}_{t+1}, \Omega^h_t) Pr(\Omega^{hg}_{t+1}, \Omega^y_{t+1} | \Omega^{hg}_t, \Omega^y_t) \tag{32}$$

The restrictions imposed in Equation 32 imply that households do not use certain information to make their predictions. First, households assume that Ω^h_t and Ω^{hg}_t only correlate with Ω^f_t through Ω^y_t. This is empirically justified by the low correlation between the housing state and stock market returns. Second, I assume that agents do not use the state of the stock market Ω^f_t to predict the aggregate state Ω_{t+1}, including both future stock returns and future recessions.[24] However, this assumption does not mean that stock returns are fully i.i.d. in this model, as the correlation between them and Ω^y_t induces some persistence in high (low) returns during expansions (recessions).

I impose these restrictions due to several considerations. First, with around 50 years of data, the estimation of an empirical transition matrix that allows for all possible correlations would be very noisy. Second, even if it could be estimated, it would be a strong assumption to claim that such a correlation structure is fully incorporated into household decision making. In any case, the precise structure of household expectations about the movement of aggregate variables and how it is updated over time remains an open question.

5.2 Externally calibrated parameters

Table 1 represents the most relevant externally calibrated parameters and their sources.[25] I set the risk aversion coefficient to 4, which is on the higher side of usual estimates in the macro literature, but on the lower side for the household finance literature that rationalizes the equity premium puzzle with Epstein-Zin preferences (10 in Bansal and Yaron (2004), 5 in Campanale et al. (2015), etc.). The elasticity of intertemporal substitution is also disputed in the literature. In the presence of disaster risk, in models in which

[24] A significant part of the literature has established that price-dividend and earnings-price ratios are predictors of future stock returns (Campbell and Yogo, 2006), although some of the relationships between economic and financial variables and future stock performance are unstable and change over time (Pesaran and Timmermann, 1995), and sometimes they react to studies being published about them (McLean and Pontiff, 2016).

[25] For presentation purposes, all variables and parameters that correspond to a time period are presented in annual terms, and converted to biennial terms in the model.

asset prices are endogenous, an elasticity above one is needed to make the probability of a disaster and asset prices inversely related (Barro, 2009). I follow Kaplan and Violante (2014) for its exact quantification (see their footnote 28 for a discussion regarding this estimate) and set it to 1.5.

I establish the risk-free rate at 1%, plus an additional 1% to account for the liquidity services of risk-free money. The mortgage interest rate is set to 4%. Both rates correspond to historical averages for the 1940s generation. I assume that the mortgage interest rate is 1% higher for retired people to reflect the more stringent credit conditions they are subject to, which is a much looser assumption than assuming they cannot get a mortgage. I assume that the downpayment is 20% of the value of the house, and that the income test consists in having yearly household income that is at least 1/9th of the value of the mortgage.

For the social security replacement rate, I follow studies that have empirically estimated it from household data. Frequently used values for tax progressivity with the tax function represented in Equation 25 are around 0.15-0.18 (0.151 in Heathcote et al. (2014)). However, as described in Section 4.4, I am explicitly modelling itemization and the standard deduction, so I already incorporate part of this progressivity by construction. Thus, I re-estimate the progressivity coefficient from PSID data following the procedure described in Appendix A.1.2. I set the parameter that controls average taxation λ to the level that implies an average tax rate of 35% for the average household, close to the historical level for the 1940s generation comprising federal and state taxes and FICA contributions. With respect to the standard deduction, I set it at a level that implies that the percentage of people choosing to itemize is close to the data, which is around 30%. This level, 6% of average income, is lower than its historical levels (e.g, around 10% of average income in the early 70s) because the model abstracts from itemizable expenses other than mortgage interest and local property taxes, such as out-of-pocket medical expenditure, state taxes, charitable contributions, etc.

As for the bankruptcy penalty, I assume that going bankrupt makes households as unhappy as consuming 15% of average income for a period (Equation 27), which keeps bankruptcy rates for the 1940s generation very low. Housing adjustment costs are around 10% of the value of the property (Smith, Rosen and Fallis, 1988), which I distribute equally amongst seller and buyer.

Risk aversion	γ	4	Kaplan and Violante (2014)
EIS	ψ	1.5	Kaplan and Violante (2014)
Housing utility share	ν	0.2	NIPA data
Risk-free interest rate	r^a	2%	
Mortgage interest rate	r^b	4%	
LTV restriction	λ_h	0.8	Downpayment 20%
LTI restriction	λ_y	9	Johnson and Li (2010)
Taxation level	λ	0.64	See text
Progressivity	τ	0.085	See text
Soc. sec. replacement rate	$p(\cdot)$	55%	Mitchell and Phillips (2006)
Housing adjustment cost	κ^h	5%	Smith et al. (1988)
Standard deduction	sd	6%	See text
Bankruptcy penalty	c^{bk}	15%	See text

Table 1: Externally calibrated parameters and sources

5.3 Internally calibrated parameters, targets, and model fit

The model has 7 free parameters which are jointly calibrated to match 7 targets in the data. I perform the calibration for the 1940s cohort, and then keep them constant across cohorts in the experiments unless otherwise specified. Table 2 summarizes the data and the parameter which is more closely related with each of the targets.

The wealth to income ratio of 3.1 is standard in macroeconomic studies and corresponds to the wealth to income ratio of the bottom 95% of the wealth distribution, which I am focusing on. I obtain house ownership data from the PSID, stock market participation from the SCF, and bequest targets from Hurd and Smith (2001), adjusted for this specific cohort (see Appendix A for more details).

Matching homeownership at a particular age allows me to get an estimate for the extent to which households enjoy living in owner-occupied housing, over and above its value as a financial investment and collateral. On the other hand, getting the level of stock market participation right at a relatively early age allows me to discipline the stock market participation cost κ^f. This parameter is not straightforward to estimate directly from the data, as it not only includes direct costs such as opening a brokerage account, but

Moment	Data	Model	Key parameter	Value
W/Y ratio	3.1	3.1	Discount factor β	0.930
Average bequest (/average income)	2.7	2.7	Bequest taste ϕ_1	4.7
Fraction of population leaving no bequests	20%	16%	Bequest taste ϕ_2	6.4
Housing ownership at age 40	77%	78%		
... of detached houses	68%	71%	Housing taste s_2	8.5
... of other housing at age 40	9%	7%	Housing taste s_1	2.0
Percentage buying houses at age 40	4.5%	4.2%	Moving shock π_{hm}	0.05
Stock market participation, age 40	36 %	36%	Participation cost k^f	0.25

Table 2: Targeted moments, model fit, and calibration

also the opportunity costs generated by spending time acquiring information about the stock market. Finally, the percentage of people buying houses after prime homebuying age is informative of the number of people who are moving for reasons that I do not model explicitly, which I summarize in the moving shock.

As Table 2 shows, the model fits its targets very well with the associated calibrated coefficients. The discount rate is relatively low with respect to what is standard in a one-asset model. Households value housing, and the utility value of owner-occupied houses provides a further motive to hold assets beyond life-cycle and precautionary savings, which reduces the calibrated value of household patience. Besides, relatively low levels of β are also frequent in the portfolio choice literature when stocks are available as an investment option with high returns.

The housing taste parameters s_2 and s_3 do not have a direct interpretation. The calibration for s_3 implies that, for an agent who is currently consuming the average level of labor income, living in a large owner-occupied house provides, ceteris paribus, the same utility increasing nondurable consumption by 70%. There is a 5% yearly probability of receiving a shock that forces the household to move. A particularly relevant parameter is the one-off cost to start participating in the stock market k^f, which is calibrated to be 25% of average yearly earnings.

There is scarce data about the initial wealth of the 1940s cohort at labor market entry. I set the initial condition of the model to the most conservative possibility that is consistent with the observed homeownership (20% equity on the house for the initial homeowners) and stock market participation (1$ in stocks for the initial stockholders). In Appendix E.1 I provide results for the case in which all agents start at zero wealth. All conclusions are unchanged, although the model with initial zero wealth underestimates homeownership at earlier ages.

Appendix B briefly describes the solution method of the model.

6 Results

6.1 Untargeted moments, 1940s cohort

The model replicates life-cycle homeownership profiles and the patterns of house buying by age for the 1940s cohort very well (Figure 10, top panel). Most households become homeowners between ages 20-35, and then the share of households that live in their own home stabilizes around 80%.

It also generates a share of households participating in the stock market that increases like in the data (Figure 10, bottom left panel). Standard portfolio choice models struggle to generate the low levels of participation observed amongst the young. In the model, young households do not participate in the stock market because they are concentrating their resources in saving for a downpayment and starting to pay their mortgages, rather than spending time and resources in acquiring information and access to the stock market.

Many households hold mortgages at the same time as they start investing in stocks. Figure 10, bottom right panel, shows that in the model households pay back their mortgages slowly, a feature which is not targeted in the calibration. Thus, the model suggests that the horizon of available mortgage products closely resembles what households would choose if they were to freely decide on their repayment schedule.

The model is also successful in replicating portfolio patterns by wealth (Figure 11). As stressed in Gomes and Michaelides (2005), a standard portfolio choice model would yield stock holding patterns which are mildly *decreasing* rather than increasing in wealth. In this model, the role of housing and the correlation of labor income and stock returns reduce the incentive of the income-poorer to participate in the stock market. Richer individuals, on the other hand, have sufficient resources available even after buying their homes, and they invest them in the stock market, in which they reap higher returns that in turn make them wealthier.

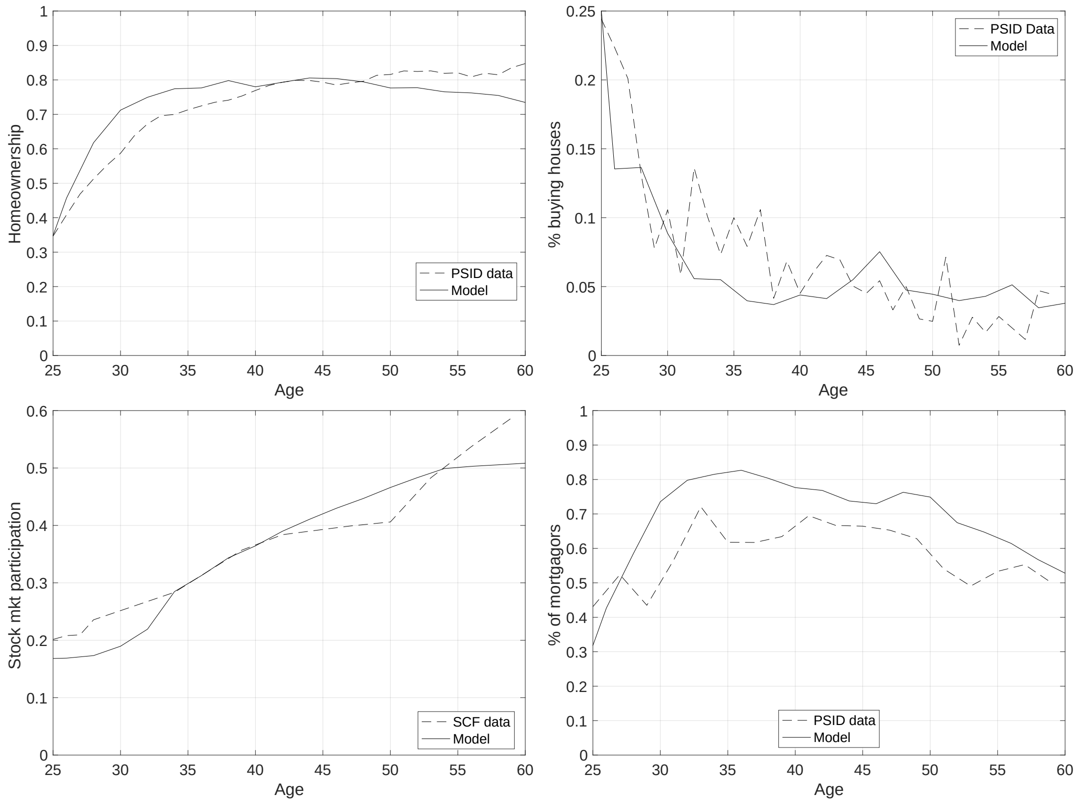

Figure 10: Life-cycle profiles for the 1940s cohort. Top left: homeownership by age; top right: proportion of households buying a house by age; bottom left: stock market participation; bottom right: percentage of all households with a mortgage by age.

Figure 11: Bottom: portfolio shares of assets by wealth decile at retirement age (left: PSID data, right: model).

6.2 Explaining intergenerational differences in homeownership

Keeping constant the preference parameters that I have calibrated to the 1940s cohort, I now turn to studying which are the key intergenerational changes that explain the reduction in homeownership for younger cohorts.

In this experiment, cohorts differ in four ways. First, younger cohorts face more unequal and riskier earnings processes, as described in Section 2.1. Second, the exogenous house prices and stock returns correspond to those that each generation actually faced, thus implying that, for younger generations, the median earner needs to spend more years of income to buy a house. Third, there have been changes in financial conditions. On the one hand, different mortgage products were available to the 1980s generation during their homebuying years, which I replicate as a reduction in downpayment requirements. Namely, I assume that the maximum LTV ratios of mortgages increased from their baseline level of 80% to 100% between 2000 and 2010, after which they unexpectedly went back to normal.[26] On the other hand, I reduce stock market participation costs to match the stock market participation profile (see Section 6.3). Fourth, I input to each generation their specific average demographic profile by age, which captures the effect on consumption needs of differential timings in marriage and childbearing.[27] For a cleaner comparison, the initial condition that captures the percentage of households that enter the model as homeowners does not change across generations.[28]

Figure 12 shows the homeownership rates for each of the three cohorts in the data, compared with the profile implied by the model. The line for the 1940s replicates what I have shown in Figure 10. Notably, keeping preference parameters constant, the model very closely replicates the decrease in homeownership that occurred between the 1940s and the two latter cohorts.

[26] Duca, Muellbauer and Murphy (2011), using American Housing Survey data, show that average LTV ratios for first time buyers, which were stable around 0.80-0.85 in the 1980s and early 1990s, jumped up to 0.90-0.95 during the 2000s. Glaeser, Gottlieb and Gyourko (2012) use housing industry data and show that for most of the 1998-2008 period the 75th percentile of LTV ratios at origination was above 95%, with the 90th percentile consistently around 100%.

[27] Appendix C.9 represents these OECD equivalence scales, obtained from PSID data, for each of these generations

[28] This assumption is conservative, as it is likely that this percentage has been decreasing over time, as labor market entry takes place later for younger generations.

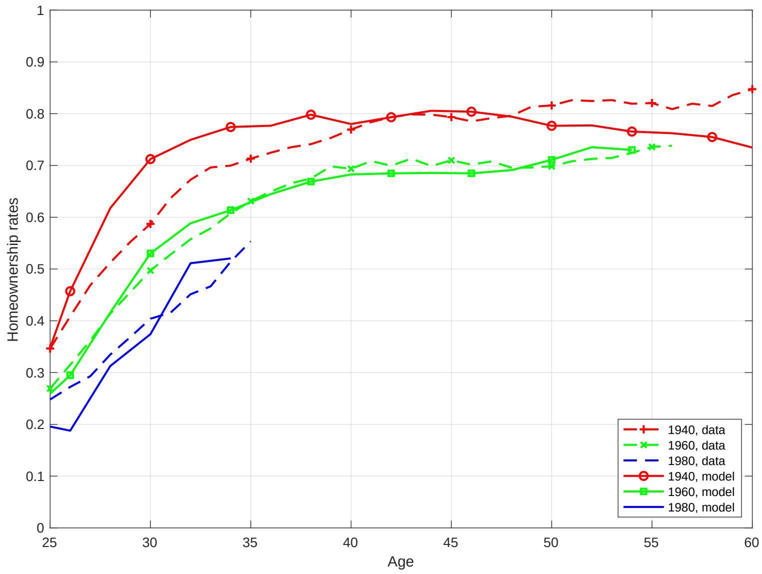

Figure 12: Homeownership by cohorts, data vs. model

6.2.1 Decomposing the decrease in homeownership

I now turn to evaluating, using the model, which are the key factors that drove the decrease in homeownership. Table 3 shows the results of a Shapley-Owen decomposition in which I evaluate the relative contributions of six key elements in explaining the reduction in homeownership at different ages: initial earnings inequality, earnings risk thereafter, changes in average housing price-to-income ratios, histories of aggregate shocks, average demographic structure at each age, costs of participation in the stock market and, for the 1980s generation, changes in financial conditions. These are the only differences across cohorts in the model, so changing all of them to their corresponding values for the 1940s generation would replicate the model-implied profile for the 1940s. Thus, by counterfactually changing them one by one I can quantify their relative contribution to the difference between the observed profile for a given generation and that of the 1940s.[29]

Changes in earnings dynamics are a key driver of the decrease in homeownership rates. At age 30, changes in labor market outcomes explain 68 percent of the homeownership gap of the 1960s generation with respect to the 1940s, mostly due to initial earnings inequality. With a more unequal earnings distribution, and little average increases in

[29] All elements in the decomposition have potential interaction effects, which means that shutting them on and off alternatively would not sum to 100% of the changes observed. The Shapley-Owen decomposition allows to obtain the total contribution of each element to the change by considering its contribution to every possible permutation of the other factors being on and off, and averaging over all of these.

	1960s generation			1980s generation	
Age	30	40	50	30	35
Total	-9	-8	-9	-14	-22
Earnings	68	48	15	73	38
initial inequality	61	25	-17	41	14
risk	7	23	32	32	24
Aggregates	33	45	91	90	74
house price trend	63	79	46	45	47
histories	-30	-34	45	45	27
Financial conditions	1	-2	-3	-63	-15
stock participation costs	1	-2	-3	5	0
borrowing conditions	0	0	0	-68	-15
Demographics	-2	9	-3	0	3

Table 3: Contribution of each factor in the change in homeownership with respect to the 1940s generation (% of the change), by age

earnings, households in low ranks of the income distribution have lower initial and expected lifetime earnings than their counterparts in older generations. These households face two issues when they decide whether to buy a house. First, they are financially constrained, as they need to save for a downpayment and pass an income test. Second, they are aware that having a large mortgage with respect to their incomes is risky, as negative shocks could take them to a situation in which they must reduce a lot their nondurable consumption to make mortgage payments. Thus, in a period of relatively low rental prices, they choose to be renters. For some this is a delay in the decision to buy houses, but for some this state is relatively persistent. At age 40, earnings dynamics still explain almost half of the homeownership gap between generations.

Earnings inequality and risk are closely linked. Even if everyone faced the same distribution of earnings shocks, their impact would depend on the initial realization of earnings. However, to get an intuitive idea of the role of changes in earnings risk, I compute the contribution of changes in earnings dynamics over and above initial realizations. At age 40, at constant initial inequality, riskier earnings explain 23% of the drop in homeownership rates. The higher volatility of earnings discourages households from engaging in a large, risky expenditure like a house. At later ages, the dependence on initial earnings realizations progressively dies out and it is harder to disentangle the effects of initial inequality and risk.

The intuition about earnings inequality and earnings risk is supported by the empirical evidence shown in Figure 13. The gap in homeownership rates between the 1940s and 1960s generations is larger for the lowest earners, which is consistent with the contribution of earnings inequality, but there are also differences all across the earnings distribution, which is consistent with the role of earnings risk.

House prices explain more of the decrease in homeownership as the 1960s generation ages. This generation entered the labor market in a period of cylically low house prices, which explains the negative contribution to homeownership of aggregate shocks. In the absence of all other factors, the model predicts that homeownership rates for those born in the 1960s given their histories should be higher than that of the 1940s until age 40. Then the 1960s generation lived through the 2000s boom in house prices. While at the beginning some bought houses as an investment, eventually their cost was too large and many decided to either wait until prices decreased or stay as renters.

Despite later household formation and a lower number of children for younger generations, the change in the average number of people in a given household at each age (θ_t in the model), which affects consumption needs, has a very small effect on homeownership rates.[30] The same applies to changes in stock market participation costs, which I describe in more detail in Section 6.3.

The 1980s generation entered the labor market in a radically different period. House prices were high both from a secular and cyclical perspective, but financial constraints were laxer. Prices alone would have explained almost all (90%) of the drop in homeownership at age 30, but the lower downpayment requirements counteracted two thirds of the potential decrease. This result suggests that changes in financial conditions were key to prevent homeownership rates of younger cohorts to plummet in a context of unstable, unequal earnings and high house prices.

The remainder of the difference, over 70 percent, is accounted for by earnings dynamics. For this generation, earnings risk is more relevant than for the 1960s group, which is consistent with the empirical observations in Figure 2 and also with Figure 13, which

[30]This study abstracts from cross-sectional heterogeneity in marital status and fertility choices, which would be an interesting avenue for future research.

shows that there was a decrease in homeownership across the earnings distribution.

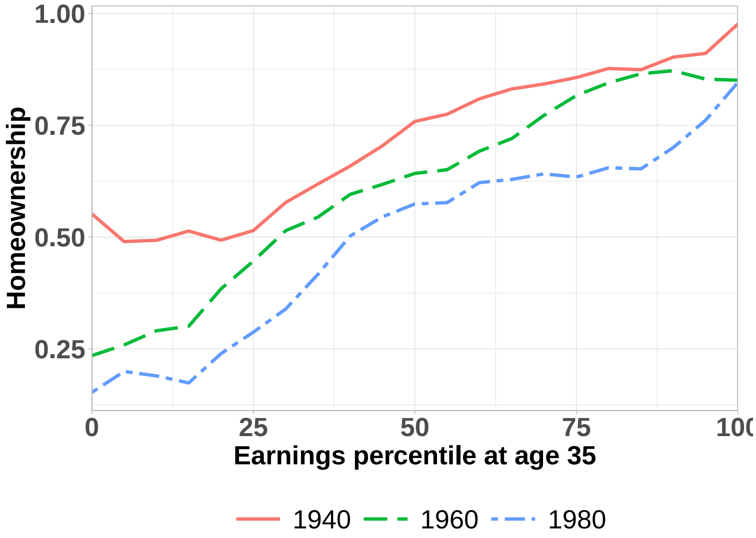

Figure 13: Homeownership by cohorts, by percentile of the earnings distribution at age 35

Figure 14 represents an alternative way of measuring the role of earnings dynamics in explaining lower homeownership rates. It represents the changes predicted by the model if we attribute the earnings process of the 1940s generation to the younger generations, whilst keeping all other factors constant. This experiment differs from the previous decomposition because it also incorporates possible interaction effects between factors, which make the effect of the changes in labor market income dynamics even larger.

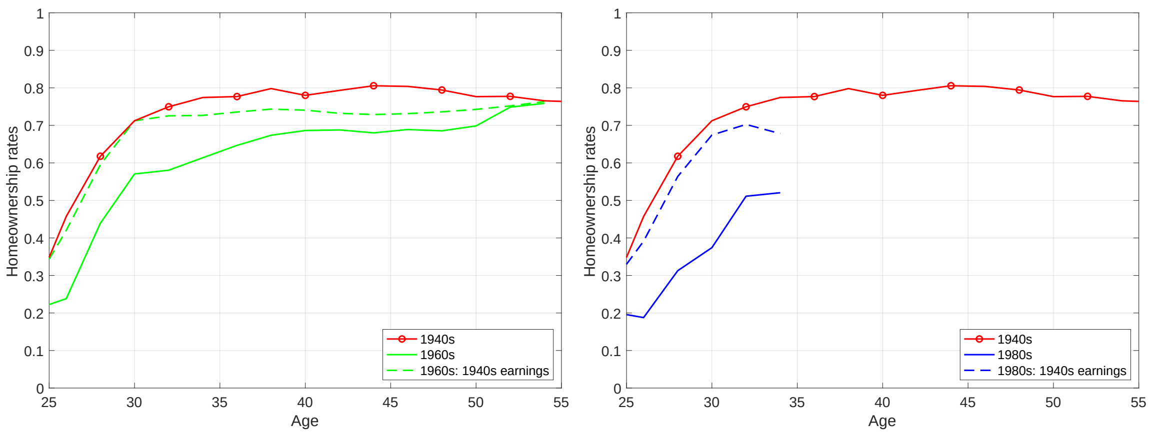

Figure 14: Homeownership by cohorts, the role of earnings dynamics. Left: 1960s generation; right: 1980s generation.

In all of these experiments, earnings dynamics are computed on household income, so they embed other factors that changed over the generations such as the timing of family formation. However, as shown in Appendix E.6, these results are robust to focusing on married couples alone.

Additionally, these counterfactual experiments assume that housing supply is perfectly elastic and so house prices would not react to the increase in housing demand induced by the change in the earnings process. In Section 6.4 I relax this assumption and show that a reduction in earnings inequality and risk would imply a significant increase in homeownership for younger cohorts even if we assume that the increase in demand would drive prices up.

6.3 Explaining the changes in stock market participation

Understanding the increase in stock market participation documented in Section 2.5 requires taking into account not only the changes in earnings dynamics and asset returns, but also the progressive reduction in the cost of access to financial markets over time, which is partially related with the introduction of tax-advantaged, employer-sponsored retirement plans.[31]

Figure 15 shows the implications of the model in terms of stock market participation when these changes are taken into account. More specifically, it assumes that stock market participation costs are 30% lower for the 1960s and 70% lower for the 1980s generation than they were for the 1940s generation, and additionally that the initial share of people with positive participation in the stock market has increased over the generations from just below 20% to 25% and 30%. Both of these changes capture the reduction in information costs and the effect of auto-enrolment.[32]

If the reduction of stock market participation costs is not taken into account, even under the assumption that the initial condition has changed, the profiles generated by the model are counterfactual (central panel of Figure 15). Indeed, the model would predict a reduction rather than an increase of stock market participation over the generations. Similarly, the fiscal incentives of IRAs and 401(k)s do not explain the increase in stock market participation either (see Appendix E.8).

[31] See Section 2.4 for details on these and the timing of their introduction.

[32] Appendix E.7 shows that changing the fixed cost of participation for per-period participation costs can generate similar patterns, but a worse life-cycle fit.

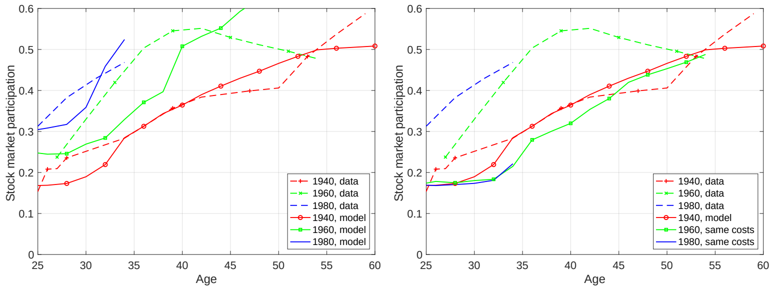

Figure 15: Stock market participation by age and cohort, data vs model. Left: main model; right: constant participation costs

6.4 Adjusting housing prices

The counterfactual experiments presented so far abstract from general equilibrium effects. However, as the earnings process for the 1960s and 1980s cohort counterfactually changes, so do household decisions, which may impact the evolution of aggregate prices in the economy. It is likely that the increase in housing demand would have had equilibrium effects manifested in an increase in house prices, which could dampen the increase in homeownership rates implied by the experiments.

As such, all results so far can be seen as an upper bound of the possible effects of income dynamics on homeownership, calculated under two equivalent assumptions: either housing supply is perfectly elastic or a non-modelled investor owns all rental housing and is willing to sell or buy any of it at the observed prices.

In this section, I provide an approximation to these equilibrium effects. I assume that housing supply can be summarized by an isoelastic supply function with elasticity of 1.75, an empirical value estimated for the average U.S. metropolitan area by Saiz (2010). Then I compute the variation in housing prices induced by the increase in housing demand, and find homeownership rates for each cohort under those new prices.[33]

Figure 16 compares the homeownership rates by age and cohort between the baseline (solid lines), the counterfactual with fully elastic housing supply (dashed lines), and the counterfactual with empirically determined housing supply elasticity (dash-dot lines). Although naturally homeownership is a bit lower for most cohorts and ages, the joint effect of earnings inequality and risk is still very relevant even if we allow for adjustments

[33] Throughout these experiments, from the perspective of households, house prices are still exogenous shocks. Appendix D.1 contains more details on how the computations in this section are performed and also shows results with fully inelastic housing supply.

in average house prices.[34]

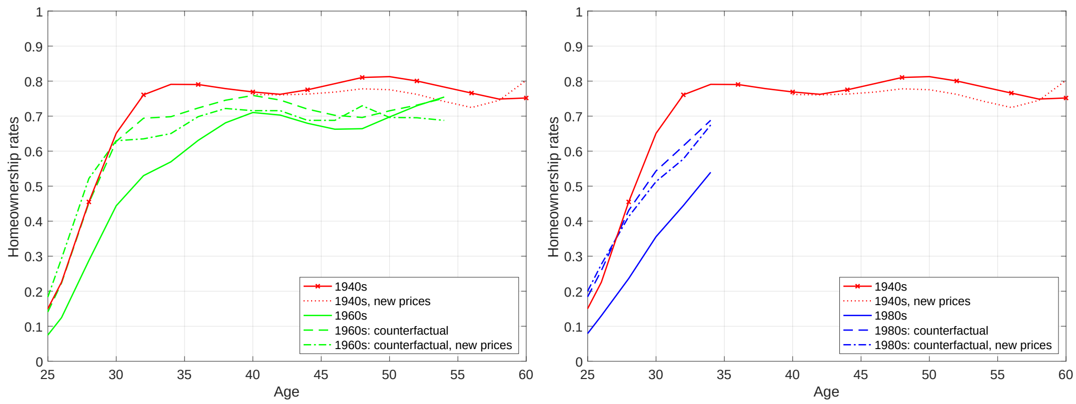

Figure 16: Homeownership by cohorts, benchmark vs. counterfactual earnings processes, empirical housing supply elasticity. Left: 1960s generation, right: 1980s generation. Zero initial wealth.

All results in this section still assume that stock market returns and income dynamics are exogenous. The stock market is very integrated internationally, so it is less harmful to assume that changes in domestic household demand for stocks do not impact stock returns. With respect to income dynamics, the model is already capturing very well their changes over the cohorts and the business cycle, and endogeneizing them would imply losing much of this richness. However, both are interesting questions that are left open for future research.

7 Implications

7.1 Wealth accumulation and projections for the future

As a result of these changes in earnings dynamics and asset returns, many younger households are accumulating less wealth than similarly-ranked households in earlier generations (left panel of Figure 17). The right hand side panel of Figure 17 shows that housing played a key role in this change. Whilst the fully-fledged model (dotted lines) can replicate the decrease in wealth accumulation, the model where households do not enjoy owner-occupied housing (solid lines) counterfactually generates similar levels of wealth for most

[34] A more detailed approach could imply modelling the housing supply and rental market sectors, together with a realistic representation of housing devaluation and renovation, and thus obtaining a more flexible formulation of the housing supply function. While such a study could shed light on slow-moving dynamics of housing prices, it is beyond the scope of the model presented in this paper given current computational constraints.

of the wealth distribution of both generations. Households in the 1940s and 1960s generations used to save more because they bought houses, partially because they enjoyed owning them, which made them act as an indirect way of forced savings. Additionally, homeowners could use their mortgages as leverage. When, because of changes in earnings dynamics, house prices, and financial conditions, households cannot access houses or buy them later, these forces are not in play and households save less.

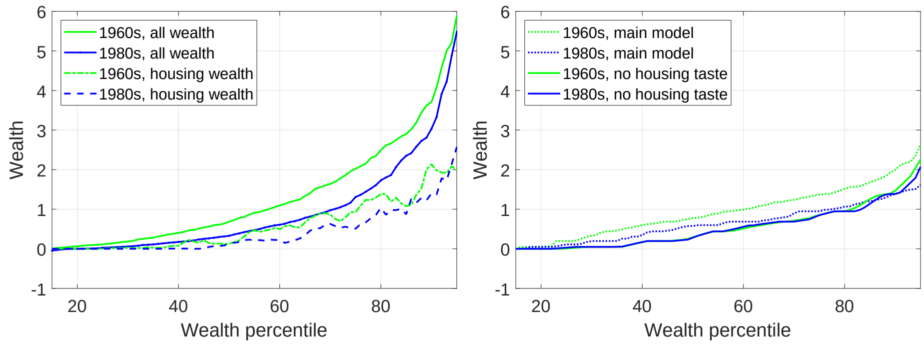

Figure 17: Net worth by wealth percentile, ages 30-40, by generation. Left, SCF data (not available for 1940s); right: model implied. Units are multiples of average income. For clarity, the top 5% and bottom 15% of the wealth distribution are not reported.

Given that 35-year-olds frequently do not have full equity on their homes, the gap in wealth accumulation between generations is likely to become larger as households age and they miss out on house price appreciation. I now turn to using the model to predict, under several assumptions for the evolution of the exogenous earnings process and house prices, the evolution of homeownership rates and other economic variables for the 1980s generation beyond 2015-2020.

In my main experiment (Figure 18) I assume that house prices will continue to grow on average with respect to median income at a rate of 1.5% per year, and that the earnings process of the 1980s cohort will be that of the 1960s or 1940s cohort for all unobserved years. I then simulate 1000 possible histories of the realizations of house price shocks and aggregate states, consistently with their conditional probabilities in the sample I observe, and plot the median homeownership rates. The dotted lines are percentiles 2.5 and 97.5 within the simulations.[35] Broadly, the model predicts that the 1980s generation will eventually catch up with the 1960s, but not with the 1940s, in terms of homeownership.

Figure 19 shows the associated wealth accumulation profiles. Although the 1980s

[35] Appendix E.4 shows this projection under alternative assumptions.

generation accumulates wealth slowlier, on average they end up accumulating a similar level of housing wealth, but more financial wealth, partially because of the reduction in costs of participation in the stock market.[36]

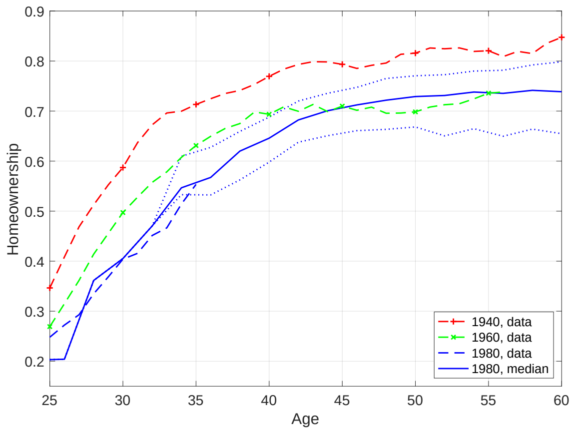

Figure 18: Homeownership: projecting the 1980s cohort into the future

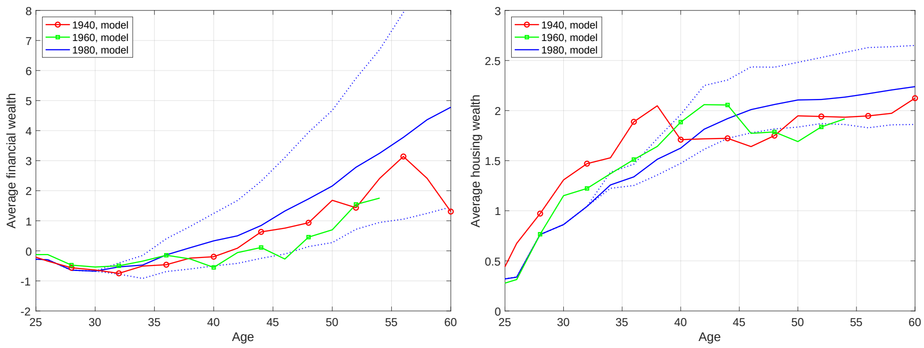

Figure 19: Wealth accumulation: projecting the 1980s cohort into the future. Units are multiples of average income.

However, the substitution of financial wealth for housing wealth can be related with an increase in wealth inequality if less households accumulate housing wealth and financial assets are still concentrated amongst the rich. Table 4 shows the wealth Gini index at retirement for the two older generations and for two different simulations for the 1980s cohort, which differ only in stock market participation costs k^f. The model generates an increase in wealth inequality between the 1940s and 1960s cohort, as we observe in the data, and predicts that wealth inequality will continue to grow, unless stock market

[36] These results abstract from possible general equilibrium effects on stock returns induced by the increased accumulation of financial wealth. Appendix E.5 shows that a reduction of 2% in average stock returns would still imply an accumulation of financial wealth comparable to the 1940s cohort.

Generation	1940	1960	1980	
Reduction in k^f	-	-	0%	70%
Implied participation at 60	53%	56%	59%	87%
Wealth Gini, data	0.78	0.83	-	-
Wealth Gini, model	0.50	0.53	0.57	0.52
			(0.026)	(0.017)

Table 4: Wealth Gini at retirement, data vs model. The data is obtained from people aged 55-64 in the SCF (2001 and 2016 SCF for the 1940s and 1960s cohort respectively). For the model, standard errors from simulation are in parentheses.

participation costs are reduced such that more than three quarters of the population access the stock market by age 60. The larger the share of households that participate in the stock market, the stronger the negative effect on wealth inequality.

In any case, the model underestimates total wealth inequality, as it does not include a set of elements that are important to explain it, such as entrepreneurship or intergenerational links (De Nardi and Fella, 2017). The extent to which these vary over the generations will also have a determinant effect on the evolution of wealth inequality.

7.2 Reaction to shocks

These secular changes in earnings dynamics, wealth accumulation, and portfolio composition have impacted the way households react to shocks. As a simple representation of these, Figure 20 (top left panel) plots Blundell, Pistaferri and Preston (2008) (BPP) *insurance coefficients*, which represent the percentage of a given shock to persistent earnings that does not get translated into nondurable consumption. The larger this coefficient, the lower the pass-through of earnings shocks to consumption. The decreasing value of this coefficient suggests that younger generations are less insured against income shocks and thus display larger consumption responses when these shocks hit. This is closely related to their lower wealth accumulation (Figure 20, top right panel).

The bottom left panel represents the average marginal propensity to consume. in the model, by age and cohort, as a response to a one-off marginally small wealth shock. MPCs are larger for the youngest, who have lower amounts of wealth to use for self-insurance purposes than the old. These have also increased slightly over generations at earlier ages, suggesting that they are more reactive to shocks. However, the fact that younger generations own less housing and thus less illiquid wealth has helped to mitigate this effect. The bottom right panel of Figure 20 shows that, if we attribute to younger generations the portfolio of older generations, their MPCs would be even higher.

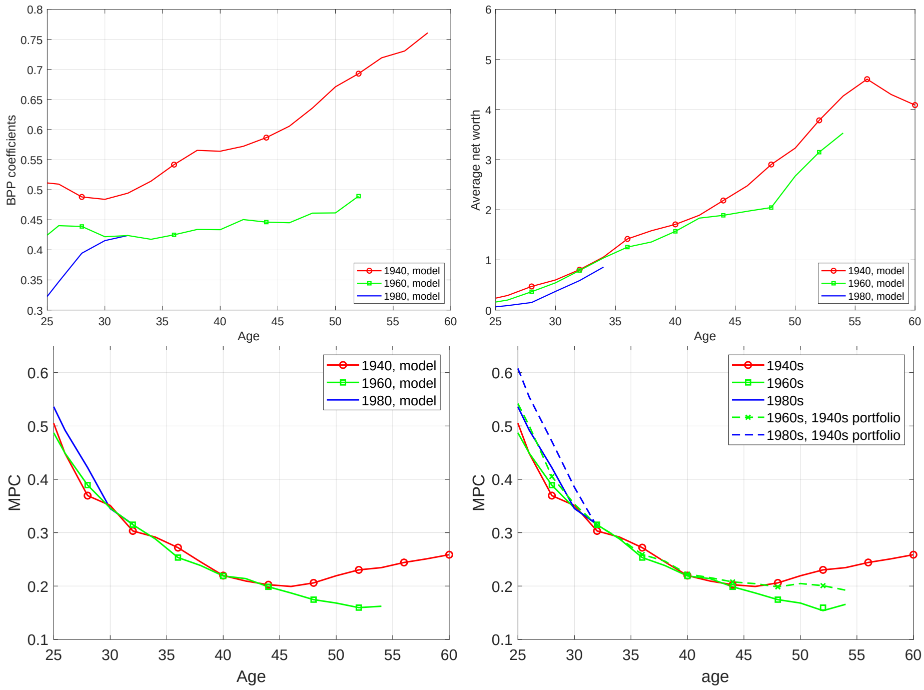

Figure 20: Household responses to shocks. Top left: Blundell et al. (2008) coefficients. Top right: average net worth. Top bottom: average marginal propensity to consume, by age and cohort. Bottom right: including case in which household portfolios are fixed to their 1940s value.

8 Extensions and alternative specifications

8.1 Canonical earnings process

I now to turn to evaluating to which extent a *canonical* earnings process, such as that described by Equations 9-11 in Section 3, with changes over generations, can explain the observed changes in homeownership. I obtain its parameters by fitting the cohort-conditional profiles of variances and autocovariances over the life-cycle.[37]

Based on these estimated processes, I recalibrate the model for the 1940s cohort following the same procedure as in my main results, and then simulate the model for

[37] Appendix E.3 shows the estimated parameters for the canonical process. For this experiment I assume that households start life with zero wealth.

the 1960s and 1980s cohort changing only earnings process, asset returns, and financial conditions. Figure 21 shows that the model also generates a decrease in homeownership rates across cohorts, which supports the argument that changes in earnings inequality and earnings risk are key drivers of the observed changes. However, the canonical process substantially overestimates this intergenerational decrease. Earnings are estimated to be a random walk or close to it, and thus the effects of large initial inequality are more persistent than in the more flexible process proposed in this paper.

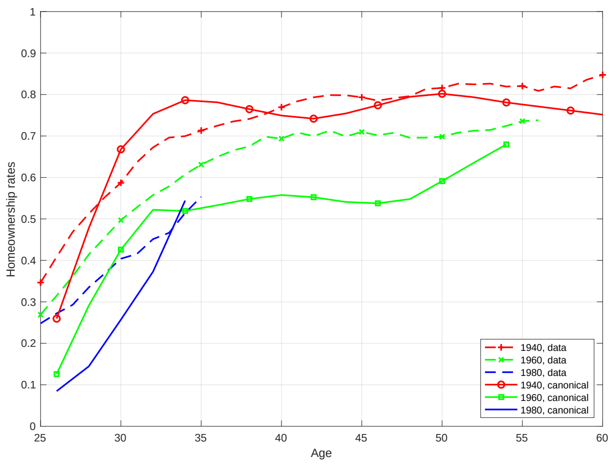

Figure 21: Homeownership by cohorts, data vs. model, canonical earnings process

Additionally, as argued in Section 3.1.2, this process has a set of counterfactual implications. It does not replicate the countercyclical skewness of earnings and it implies increases of average earnings when recessions hit. Besides, as shown in Gálvez (2017), it also generates counterfactual implications for stock market participation decisions.

8.2 Other extensions

Appendix E shows a set of robustness checks. They show that starting households at zero wealth or at an empirical level of initial wealth, considering changes in marital dynamics and family formation, per-period stock market participation costs, local correlation of income shocks and house prices, and alternative versions of the discretization of houses do not affect the main messages in this paper.

9 Conclusion

In this paper, I study how changes in earnings dynamics over different cohorts have affected their homeownership and portfolio choice decisions. First, I provide empirical evidence, extracted from PSID and SCF data dating back to the 1960s, that there has been a secular increase in household earnings inequality and risk, together with substantial reductions in homeownership and an increase in stock market participation.

Second, I design a flexible earnings process that accomodates rich, non-normal, non-linear features of earnings risk whilst allowing it to be correlated with the aggregate performance of the economy and asset returns. This process replicates important features of earnings data by age, over the earnings distribution, and over the business cycle, including the sluggish recovery after a recession.

Third, I develop a rich life-cycle model of housing and portfolio choice that is able to generate key life-cycle and cross-sectional patterns with a relatively parsimonious parametrization. Key elements are a taste for owner-occupied housing, a minimum size for houses, transaction costs, and stock market entry participation costs. I use the model to explain the intergenerational changes I observe in the data without assuming preference changes across generations. Differences in earnings dynamics account for more than half of the reduction in homeownership at ages 30-35.

Looking at the broader implications of my findings, they suggest that taking into account intergenerational changes is important to study household earnings, consumption, and wealth accumulation. At any point in time, the cross-sectional distribution of the economy is formed by many different households who have lived through different histories of shocks at different points in their lives. Acknowledging this fact matters to understand the economic decisions that have led them to be where they are today, and thus to infer parameters to study the effects of policies or the evolution of the economy.

Besides, these results are of interest to policymakers who care about homeownership, intergenerational redistribution, and the evolution of inequality. For instance, the model suggests that reducing the costs of access to financial markets can spur wealth accumulation for middle income households, thus reducing overall wealth concentration.

Finally, this paper also adds to a burgeoning literature that, based on elements from household finance, points out that considering household portfolio compositions is important for many macroeconomic questions, such as consumption responses to shocks or wealth accumulation over the life cycle.

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A Data

The data used in this paper is taken mostly from the Panel Study of Income Dynamics (PSID) and the Survey of Consumer Finances (SCF). The former is particularly valuable because it allows to follow several cohorts of households over a very long period of time (1968-2013), and it is the base for the estimation of the earnings process and most of the housing-related measures. However, it contains, particularly in its earlier periods, very limited information about stock market participation, wealth, and financial asset allocation of households. For these measures I rely on the Survey of Consumer Finances, which contains very detailed information about households' balance sheets. However, with limited exceptions, it lacks a panel dimension.

I now briefly describe the characteristics of each of the surveys, the sample selection criteria, and the estimation of the several targets and profiles used in the paper.

A.1 PSID

The Panel Study of Income Dynamics (PSID) follows a large number of U.S. households and their qualifying spinoffs since 1968 and provides information about demographic characteristics, sources of income, housing status, and, since more recently, their wealth and consumption. When it started, the PSID was composed of two main subsamples: the SRC (Survey Research Center), which was designed to be representative of the U.S. population at the time and which is a random sample itself, and the SEO (Survey of Economic Opportunity), which oversampled the poor. Later, the PSID was augmented with the Immigrant and Latino subsamples.

The survey was yearly from 1968 to 1997, and started being biennial since then. Wealth information was available in the 1984, 1989, 1994 waves, and from 1999 onwards, and has become progressively richer and improved in quality. Since 1999 it broadly replicates the wealth inequality patterns present in the SCF without oversampling the richest.

For my main results, I drop the SEO, Latino and Immigrant samples and am therefore left with a random sample, which makes computations simpler given that weights are not needed (Haider, 2001). However, the weighting of the final dataset can be affected by attrition and the sample selection requirements. In Appendix C I report how different sample selection and deflation procedures affect some key features of the earnings process.

A.1.1 Measures and sample selection

In the PSID data, I define cohorts as follows:

- The **1940s cohort** are the households whose head was born between 1940 and 1950. For the estimation of the income process, I increase the sample size and consider households between 1930 and 1950. For simulation purposes, I consider they were born in 1942.
- The **1960s cohort** are households whose head was born between 1960 and 1970 (1950-1970 for the income process). For simulation purposes, I consider they were born in 1962.
- The **1980s cohort** are households whose head was born between 1980 and 1990 (1970-1990 for the income process). For simulation purposes, I consider they were born in 1982.

Naturally, the changes in earnings dynamics, homeownership, etc. have happened progressively over time and do not necessarily correspond with the admittedly arbitraty boundaries set. To some extent, the features of the 1940s earnings process are a weighted average of the earnings process of people born between 1930 and 1950. However, including those allows me to increase the sample sizes, and to obtain more observations of people going through a recession at different ages.

For the earnings process, I assume that all business cycle effects are absorbed by the business-cycle dependent process, so I do not extract year effects. For the representation of changes in earnings risk and the computation of age-efficiency profiles, I extract a linear yearly trend from earnings data.

The estimation of the household income process requires eliminating households that display very low attachment to the labor market (whose labor income in a given year is below a minimum level of $1500 in 2013 prices). This assumption is standard in the earnings processes literature (see De Nardi et al. (2019) for details) and avoids issues related with taking logs of very small numbers. Furthermore, I also drop those households for whom there are no two consecutive observations available.

For the older ages of the younger cohorts, there are some cases in which there are very few observations for a particular combination of the labor market aggregate state, which are not sufficient for the estimation of the flexible parameters. In those cases I replace the missing cohort-age-states with their correspondent levels of the previous cohort. This affects the 1960s cohort after age 50 for the states of recovery and staying in a recession, and the 1980s cohort for all states related to a recession after age 30. I follow a similar procedure for years which are not yet observable (1980s cohort from ages 35-40), and provide some robustness checks with respect to this assumption in Section 7.1.

For all of the other measures reported in the paper (homeownerhip, etc.) none of these restrictions are imposed. In particular, I do not require the sample to be composed of the same households in every year. This allows me to keep a bigger sample, but implies the assumption that any attrition or nonresponse happens randomly and does not affect the evolution of the measures reported.

With respect to the two types of housing, "detached houses" are those defined in the PSID as "detached single family houses" and "non-detached houses" are all other types of structures (including 2-family houses, apartments, etc.).

From 1968 to the end of the sample, housing PTI ratios are computed as the ratio of the median house price reported by PSID homeowners to median household income in the PSID. In order to estimate the evolution of housing PTI ratios before the start of the PSID (as agents are born with age 20 in the model, they live in the model from 1962 to 1967), I use the housing data provided by Robert Shiller (Shiller, 2015) and assume the PTI to be above trend whenever the house price index is above its trend and viceversa.

A.1.2 Tax progressivity

As explained in Section 4.4, the model explicitly includes the choice between taking the standard deduction or itemized deductions. However, this implies that the tax progressivity coefficient τ in Equaton 25 needs to be reestimated, because in previous studies, such as Heathcote et al. (2014), it was computed taking into account the existence of itemization and the standard deduction. Removing the standard deduction from disposable income implies a reduction of the progressivity coefficient, as it is an important driver of progressivity in the US and other tax codes (Blackburn, 1967).

To perform this estimation, I need to compute the counterfactual disposable income or, alternatively, the counterfactual level of taxes paid T^*_{it} by a household with pre-tax income y_{it} in the absence of standard deduction or HMID. To do so, I first estimate the following equation in my PSID sample:

$$\log \hat{y}_{it} = \lambda_1 + (1 - \tau_1) \log y_{it} \tag{33}$$

where $\hat{y}_{it}$ is post-tax pre-benefit household income. I use the estimated parameters from this equation to predict T^*_{it}, assuming that $T^*_{it} = \log \tilde{y}^*_{it} - \lambda_1 + (1 - \tau_1) \log y^*_{it}$, where $y^*_{it} = y_{it} + max(sd, HM)$, sd stands for the standard deduction, and HM for the HMID that corresponds to a given household. The basic assumption here is that the taxes paid by a household with a certain level of income in the counterfactual world with no standard deduction are the same as those paid by a household with that level of income plus the deduction in the observed world. As for the mortgage deductions, I define them to be the product of the average mortgage interest rate in a certain year and the outstanding mortgage the household claims to have in the PSID, as long as they are smaller than the total mortgage payments the household has made in the previous year.

Once I have counterfactual taxes T^*_{it}, I construct counterfactual disposable income (post-tax, post-benefit) $\tilde{y}^*_{it} = \tilde{y}_{it} + T_{it} - T^*_{it}$, run the following regression:

$$\log \tilde{y}^*_{it} = \lambda + (1 - \tau) \log y_{it} \tag{34}$$

and obtain $\tau = 0.085$.

A.2 SCF

The Survey of Consumer Finances (SCF), conducted every three years since 1983, provides information about the financial situation of US households. It contains detailed data on household balance sheets, income, and other demographic characteristics. Given the focus on wealth, the survey oversamples the rich, who hold most of the assets in the economy. To do so, it combines an area-probability sample (geographical stratification) with a list sample that guarantees that a sufficient amount of wealthy individuals are included.

Apart from the 1983-2007 waves, I also consider the older historical waves of the Survey of Consumer Finances made available by the University of Michigan. Namely, I consider the 1963, 1968, 1969, 1970, 1971, and 1977 waves to construct, where relevant, statistics like wealth to income ratios or shares of stock market participants. While this data is less exhaustive than the recent waves of the SCF, it is the only source to provide reliable information about household wealth and its composition for the cohorts I am interested in before 1980. For a longer discussion, analysis and harmonization procedures of these waves of the SCF, see Kuhn, Schularick and Steins (2017).

I use the SCF to obtain stock market participation data. I consider a household to be participating in the stock market if any of its members hold stocks directly or indirectly via an IRA account, Keogh plan, mutual fund or pension plan like a 401(k). For most of the waves the composition of these funds is provided as a categorical variable, so for indirect holders I consider them to be stockholders if they hold any such plan which is formed of "mostly or all stock".

A.2.1 Bequest targets

The main bequest targets are based on Hurd and Smith (2001), who use the Asset and Health Dynamics among the Oldest Old (AHEAD) study from the Health and Retirement Study (HRS). This study focuses on households whose heads were born in 1923 or before, which is significantly earlier than the first cohort considered in this paper. Therefore, the bequest targets reflect bequests left by a generation which had potentially different characteristics to the ones I consider.

Bequest data for the 1940s cohort is not yet available. However, SCF data reveals that the generation born in the 1940s had accumulated around 30% more wealth at age 75 than the generation born around 1910-1920. Thus, for the main version of this model I adjust the average bequest target by increasing it by exactly as much as average wealth increased at age 75 between these cohorts. This imperfectly captures several possible reasons for holding more wealth during retirement (longer life expectancies, different patterns of medical expenditure, different histories) - future data on wealth decumulation by this cohort can impose more discipline on this assumption. I do not adjust the targeted percentage of people with zero bequests, but the calibration tends to underpredict it.

A.3 Higher order moments of earnings

I define skewness and kurtosis as the third and fourth standardized moments of log earnings changes, respectively. Kelley's skewness (KS) and Crow-Siddiqui kurtosis (CS) are defined following Guvenen et al. (2016):

$$KS = \frac{(P_{90} - P_{50}) - (P_{50} - P_{10})}{P_{90} - P_{10}} \tag{35}$$

$$CS = \frac{P_{97.5} - P_{2.5}}{P_{75} - P_{25}} \tag{36}$$

where P represents a percentile in the distribution of earnings changes. Thus, Kelley's skewness is more positive the further away the 90th percentile is from the median; and more negative the further away the 10th percentile is from the median, while Crow-Siddiqui kurtosis is larger the fatter the tails of the distribution are. I refer to both as *robust* measures because they are less affected by outliers than standard skewness and kurtosis.

B Computational appendix

B.1 EGM method

For a given set of parameters, the model is solved using a combination of a nonlinear maximizer and the endogenous gridpoint method (EGM), following the algorithm described in Fella (2014).

The model has several discrete states (housing, aggregate state) and continuous states (safe assets, risky assets, earnings). After the last period of life (age $T+1$), utility is known as it can be directly derived from the bequest function (13). From then I proceed via backwards induction.

For any age t, given a set of states (y, a, f, h, m, Ω) we need to find the policy functions for the household for current period's consumption c and next period's safe assets a', risky assets f', housing h', and mortgages m'. Using standard methods, this would imply computing the value associated with each of the feasible choices and maximizing over the 4-D space (as we can always solve for one of the choices using the budget constraint) to find the optimal choice for each set of states.

Using the EGM method allows to substantially speed up the computation of a pair of these choices. For this paper, I use the EGM method to solve the (c, a') choice conditional on the f', h' choice. For computational purposes, $m = -a$, and I allow for the grid of f to include some points that correspond to possible positive holdings of a. Given f' and h', I use the inverted Euler equation to compute the consumption choice c that corresponds to each future choice of assets a'.

By the budget constraint, the sum of consumption and all savings must equal current cash on hand. This means that, given f', h' and the pair c, a' we have found with the Euler equation, we can interpolate the endogenous grid of consumption to the exogenous grid of cash on hand that is determined by the states in period t, and obtain the f', h'-conditional choices of c and a' for those particular states.

The only point left is to then run a nonlinear maximizer over the f' and h' choices, thus obtaining all required policy functions. Using this procedure, the nonlinear maximizer is only run over a 2-D space, which implies the algorithm is significantly faster.

The Euler equation does not necessarily hold in all scenarios for safe assets (for instance, when the household is borrowing constrained with no housing, or at the boundary of the condition that requires it to pay interest on its debt). These situations are dealt with specifically.

B.2 Global minimization

I solve the model using FORTRAN 2008. Due to the large state space, it is very computationally intensive - in a workstation with 44 cores it takes roughly 25 minutes to solve for a given parametrization. In order to find the parameter values that minimize the weighted square distance between the targets and their values in the data, I use a modified version of the NEWUOA numerical optimization algorithm.

I acknowledge the use of the UCL Myriad High Throughput Computing Facility (Myriad@UCL), and associated support services, in the completion of this work.

C Intergenerational differences: additional evidence

The changes across cohorts described in Section 2 are based on the SRC, which is the PSID's representative sample of the 1968 US population and their offpsring, are deflated with the CPI, and consider household earnings for all households, whether married or not. In this Section, I describe the qualitative and quantitative implications of considering several alternative approaches: picking the whole PSID and weighting it (Appendix C.1), deflating with the PCE (Appendix C.2), selecting married households only (Appendix C.3), splitting by education (Appendix C.4) and geographical area (Appendix C.5).

C.1 Sample composition

In this section, I make use of the whole PSID rather than the SRC. Because only the SRC is a random sample, this also requires making use of the PSID-provided weights. In the earlier years of the survey, this means considering the Survey of Economic Opportunity part of the PSID, that oversamples the poor; in later years of the survey, in particular after 1997, it implies taking into account the immigrant population that has arrived to the US since. Using the SRC rather than the whole PSID for the main results leads to a cleaner comparison - keeping the offspring of the same population of reference helps to ascribe the changes in labor market dynamics to structural changes in the labor market, opportunities, and family formation, rather than changing demographics across the whole society. However, it has the disadvantage on missing out on additional population growth of potentially different socioeconomic characteristics, which has implications for house prices and more broadly any general equilibrium effects.

Figure 22 shows median and average earnings for this broader sample. Including immigrants reduces the median earnings of younger cohorts with respect to the oldest generation.

Turning to distributional features, we observe in Figure 23 that considering all immigrants has the interesting implication that the difference between the 1940s and 1960s cohort is preserved, or even larger than before, but the difference between the 1960s and the 1980s cohort becomes almost insignificant. While earnings have become more unequal for the sons and daughters of the original PSID sample members, the entrance of immigrants has contributed to reduce the variance of the earnings distribution of the 1980s cohort with respect to the 1960s.

The measure of homeownership considered in this paper can also depend on sample choices, particularly if immigrants and newer incorporations to the PSID sample have substantially different homeownership patterns. Figure 24 shows the resulting compari-

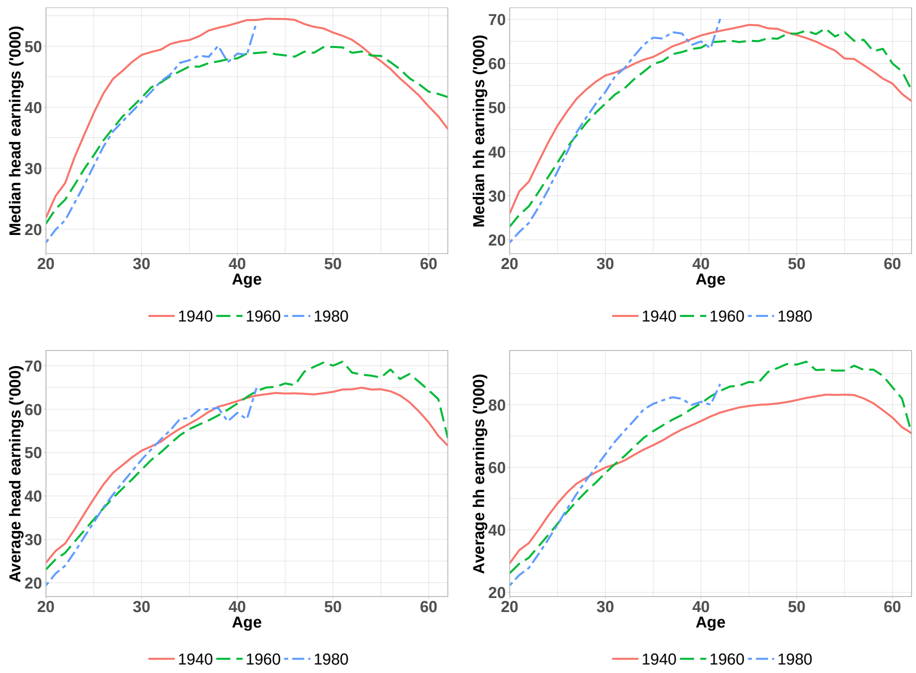

Figure 22: Median earnings (top) and average earnings (bottom), for household heads (left) and households (right), 2013 dollars, sample including SEO and immigrants.

son. All main patterns are similar: if anything, taking into account the whole population implies a marginally larger gap between the 1940s and 1960s cohort, and a marginally smaller gap between the 1960s and 1980s cohort, which is consistent with the smaller gap in earnings inequality and risk in this wider sample.

C.2 Choice of deflator

In this section, I deflate earnings with the PCE or personal consumption expenditure deflator rather than the CPI. These two measures differ slightly on their scope and their computation procedure. While the PCE takes into account all expenditure made by households and also on behalf of households, such as total medical expenditures, the CPI only considers what households spend out-of-pocket. The PCE is based on business surveys, while the reference basket for the CPI is based on data from the Consumer Expenditure Survey or CEX. Given that the focus of the paper refers to the consumption and portfolio possibilities of all but the richest of households, the main results are deflated with the CPI, which more closely reflects the changes in prices of the goods and services that households actually pay. The PCE index is instead more frequently used when performing aggregate macroeconomic analysis.

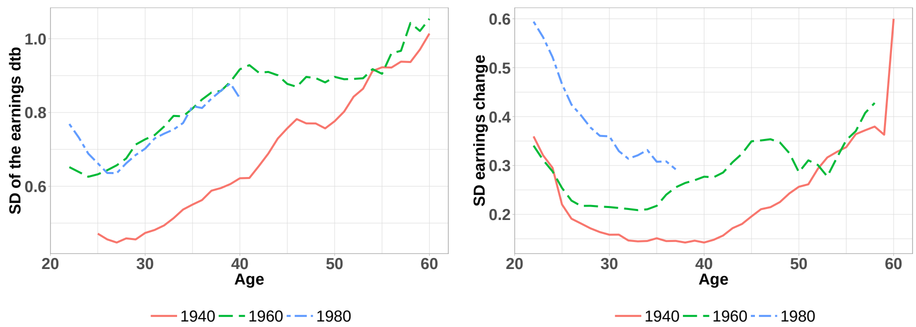

Figure 23: Standard deviation of log earnings (left) and earnings changes (right), sample including SEO and immigrants

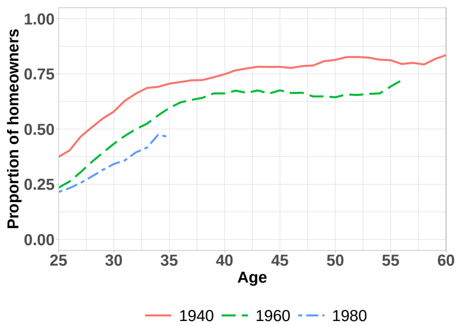

Figure 24: Homeownership, by cohort, sample including SEO and immigrants

In this sample period, the PCE implies overall lower cumulative inflation than the CPI and, therefore, implies that median and average earnings of younger cohorts have grown more than with the CPI. However, because cross-sectional inequality within a cohort-age cell is not affected by the choice of deflator, the facts regarding changes in the distribution of earnings that lie at the core of this paper are unchanged when considering the PCE.

Figure 25 shows median and average earnings by cohort, for male and head and spouse earnings. Deflating with the PCE increases the differences between cohorts, particularly for household earnings, which implies that it acts in the opposite direction as the inclusion of a broader sample described in Appendix C.1. Naturally, the choice of deflator does not affect earnings inequality within age and cohort, nor measures of earnings risk, nor homeownership.

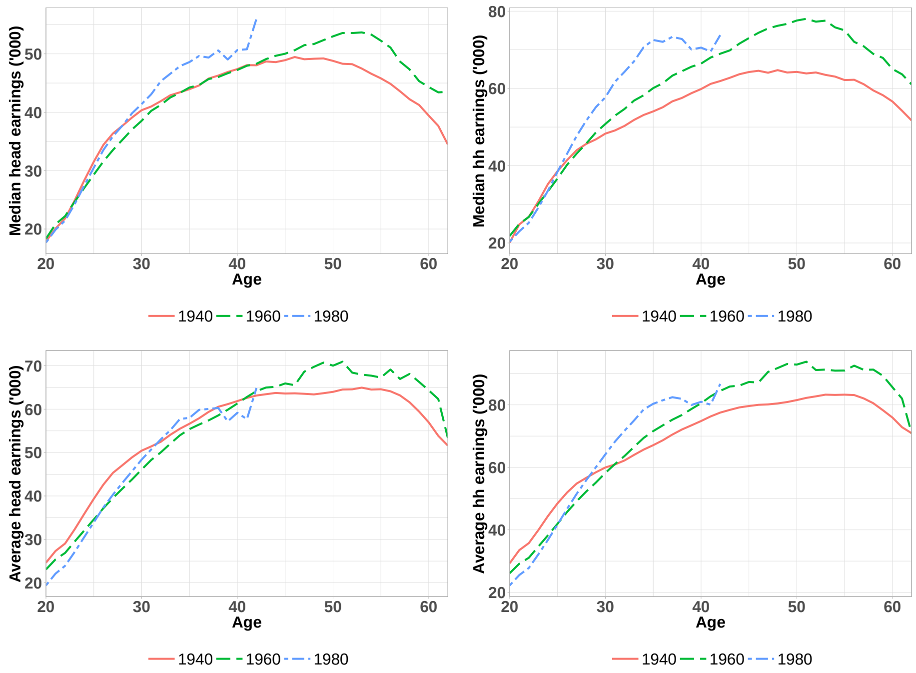

Figure 25: Median (top) and average (bottom) earnings, 2013 dollars. Left: household heads, right: households. PCE-deflated sample.

C.3 Marital dynamics and family composition

Figure 26 compares the profiles in Figure 1 with those for married households. While it is clear that family composition affects the profiles for the first ten years of age, and that earnings inequality is lower in the more homogeneous sample of married couples, the main picture is pretty similar, which suggests that there are differences in labor earnings across cohorts, particularly in distributional terms, which are not fully explained by the differential timing of marriage.

Figure 27 shows that there are also large differences in homeownership over different cohorts if we restrict the sample to married households or to households with children, which provides additional evidence to suggest that earnings dynamics are relevant over and above changes in family composition. Naturally, in these selected samples homeownership tends to be larger than in the general population.

Additionally, the main hypothesis proposed in this paper (changes in the earnings distribution and earnings risk affecting homeownership) can also partially operate via later marriage and/or fertility decisions.

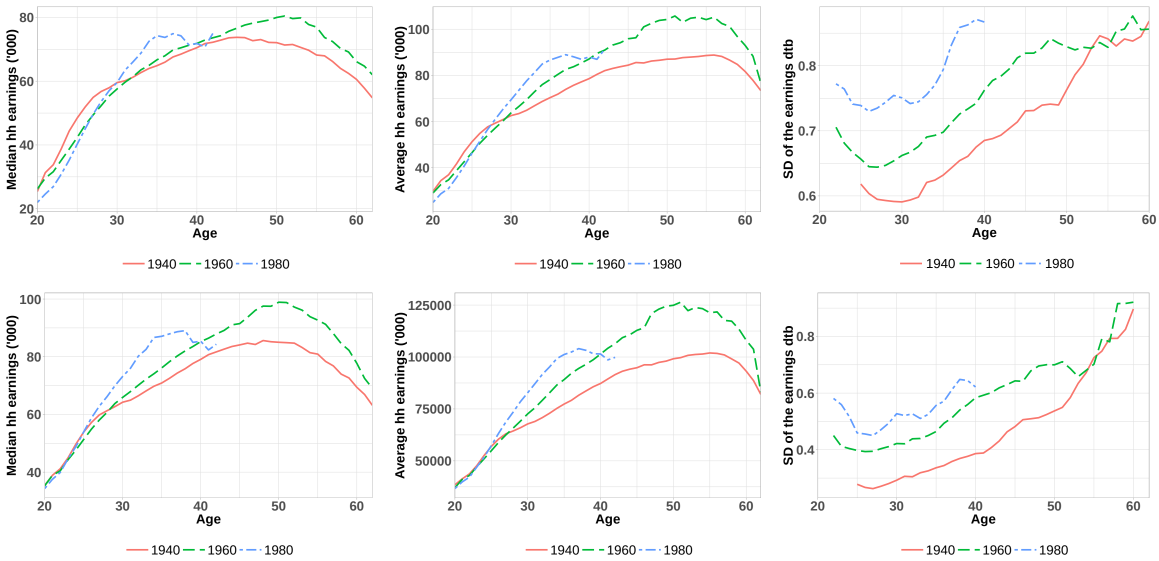

Figure 26: Changes in the earnings distribution over the generations. Top: household earnings; bottom: household earnings for married households. Left: median earnings; center, average earnings; right: standard deviation of the log earnings distribution.

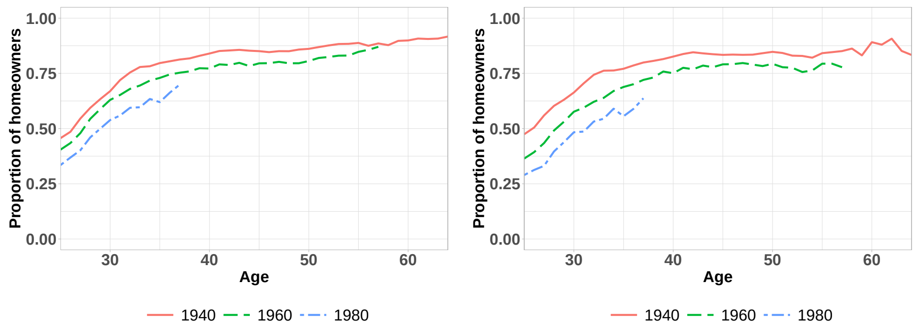

Figure 27: Homeownership by cohorts, PSID data. Left, sample restricted to married couples; right, sample restricted to households with at least one child.

C.4 Education

As shown in the previous section, the gap in homeownership rates is not driven by pure compositional effects due to later marriage or childbearing. The same is true for the case of education. As Figure 28 shows, the drop in homeownership rates has happened both for non-college graduates and for college graduates. The drop is more salient for households whose head does not have college education, which have lower homeownership rates throughout. Although education is not explicit in the model, it captures these differences to the extent that they are embedded in household income.

Given that there has been an increase in the number of college graduates, who are also more likely to be homeowners, if anything changes in education would be a force in the opposite direction to my main results and increase the homeownership rates of the youngest cohort. Additionally, highly educated people display higher homeownership rates even at age 25, thus suggesting that their delayed entry to the labor market is not the key driver of the results either.

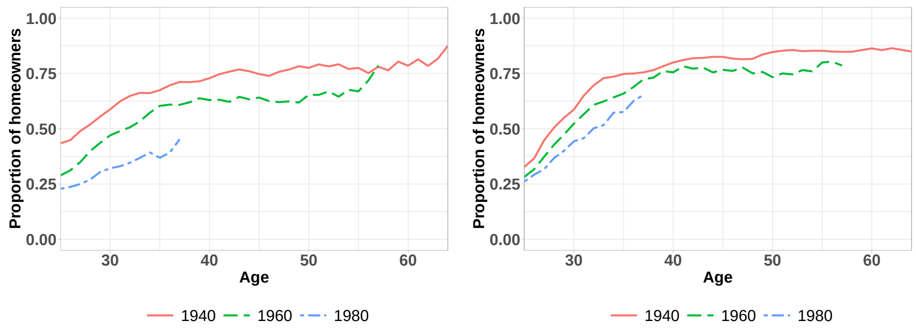

Figure 28: Homeownership by cohorts, PSID data. Left, high school graduates and lower education; right: college graduates

C.5 Geographical differences

The PSID has limited geographical information about households. Thus, in order to disaggregate the drop in homeownership rates between rural and urban areas, I turn to IPUMS data (Ruggles, Flood, Goeken, Grover, Meyer, Pacas and Sobek, 2020) from the American Community Survey and other comparable historical samples. The data for older generations is noisier, given that the data is only available every 10 years before 2000, but it also shows an intergenerational drop in homeownership rates which is broadly consistent with PSID evidence (Figure 29). This drop is true for both urban and rural areas (Figure 30). In the framework in this paper, increased urbanization is reflected in higher average house prices faced by households. To the extent that this is driven by transformations in the labor market, the main message in the paper still holds true. However, an interesting future avenue for research could add geographical heterogeneity to this framework, and explicitly study the role of urbanization.

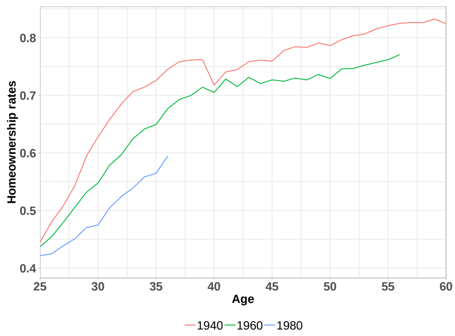

Figure 29: Homeownership rates by age and generation, IPUMS data

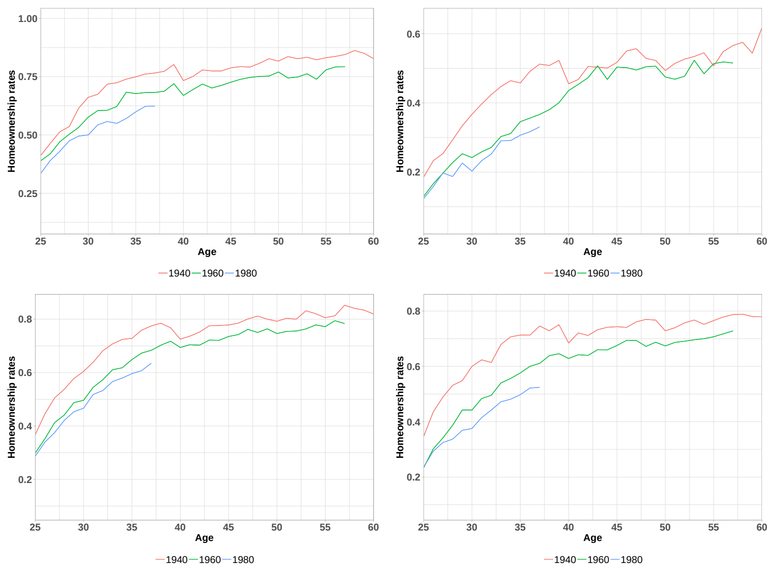

Figure 30: Homeownership rates by age and generation, IPUMS data. Top left: not in metropolitan area; top right: in central/principal city; bottom left: not in centra/principal city; bottom right: intermediate status.

C.6 Earnings process, fit of variances

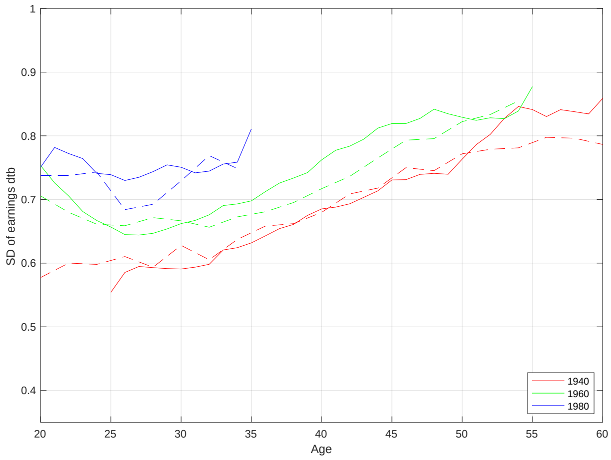

Figure 31: Variance of log earnings over the life cycle, PSID data vs model-implied

C.7 Earnings process, additional Figures

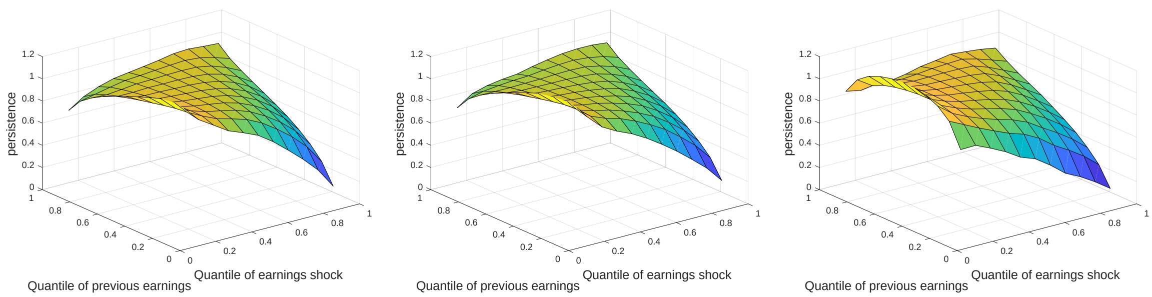

Figure 32: Nonlinear persistence, by cohort. Top left: 1940s; top right: 1960s; bottom: 1980s. All ages

C.8 Portfolio composition, additional Figures

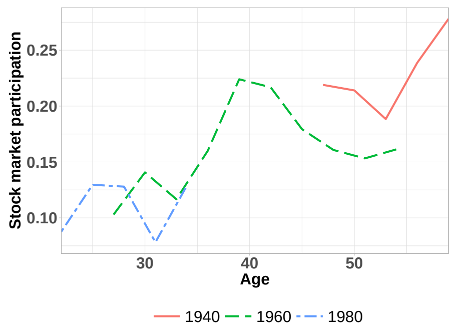

Figure 33: Direct stock market participation, three generations. SCF data.

C.9 Equivalence scales by generation

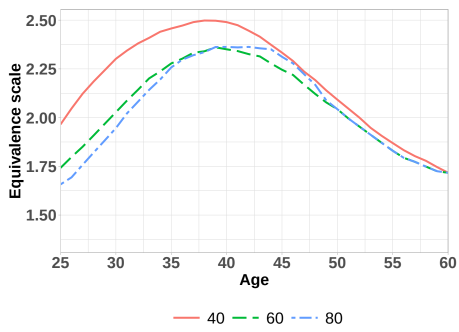

Figure 34: Average OECD equivalence scale, by cohort

D Model, additional results and descriptions

D.1 Adjusting housing prices

I compute the results in which housing prices are left free to adjust as a response to policy changes or earnings counterfactuals in the following way:

First, I begin by defining the *baseline stock of housing* H_t^s as the total number of houses that are occupied by thier owners, which is equivalent to the number of households that live in owner-occupied housing. In order to aggregate across cohorts, I simulate a total of 31 birth-year cohorts (born in all even years from 1930 to 1990), and I attribute the earnings process of the 1940s cohort to the group 1930-1949, the earnings process of the 1960s cohort to the group 1950-1969, and the earnings process of the 1980s cohort to the group 1970-1990. Like in the main experiment, each birth cohort experiments aggregate shocks as they happened in the data in each calendar year, that corresponds to a specific age for each of the 32 cohorts.

Given that I do not have information on the earnings processes of the relevant years for the cohorts born before 1930s, I make the simplifying assumption that their home-ownership profiles are not impacted by any of the changes introduced in the paper and they hold a constant amount of housing. The impact of this assumption would depend on the reaction of these non-modelled cohorts, but it is only particularly restricting for the earlier cohorts when they are relatively young. Additionally, for this experiment I assume that households are born with zero initial wealth.

Thus, H_t^s is computed as summarized in Equation 37, where I am aggregating over all households i that belong to each of these 31 birth-year cohorts. I then assume that, at given prices p_t^h, H_t^s is the total amount of housing supplied for these cohorts; which implies that p_t^h is the price that clears the market given housing supply and demand.

$$\int_i H_i^d(p_t^h) = H_t^s \tag{37}$$

Then, I am interested in computing how the quantities of housing bought by each of the different cohorts change as external factors, such as the earnings process, change. A change in the earnings process will induce a change in the housing demand functions H_i^{d*} for each household. To which extent this gets translated into changes in quantities exchanged and changes in prices depends on the elasticity of housing supply.

The main results in the paper are computed under the assumption that housing supply is fully elastic at given prices, and that prices would not respond to changes in the earnings process. I first compute the exact opposite case (all adjustments happening via prices), and then show an intermediate case in which the elasticity of housing supply is nonzero but finite. For all three cases, I begin by computing housing demand functions for each household, dependent on housing prices, at the new, counterfactual earnings process H^{d*}.

Assuming a fully inelastic housing supply implies fixing H_t^s at every year t and finding p_t^{h*} such that Equation 38 holds. I do so sequentially for $t = 1, \ldots, Y$, where Y is the total amount of years in the simulation, and to that extent the model continues to capture history dependence of past prices. Furthermore, the slow-moving nature of these changes and the definition of H_t^s, which captures cyclical variations which the model is attributing to housing supply or other non-modelled factors, implies that the housing growth aggregate state is still consistent with the evolution of house prices.

$$\int_i H_i^{d*}(p_t^{h*}) = H_t^s \tag{38}$$

Assuming an elastic housing supply implies, at a given (empirical) housing supply elasticity η, that the price that clears the market $p_t^{h'}$ satisfies:

$$\int_i H_i^{d*}(p_t^{h'}) = H_t^{s'} \tag{39}$$

such that

$$\frac{\frac{p_t^{h'} - p_t^h}{p_t^h}}{\frac{H_t^{s'} - H_t^s}{H_t^s}} = \eta \tag{40}$$

By substituting 40 into 39, one can solve for $p_t^{h'}$ in every period.

These experiments represent an approximation to actual equilibrium determination of housing prices. On the one hand, I do not model the agents that make housing supply decisions and approximate them with an isoelastic function (with elasticity which is either zero or 1.75). On the other hand, from the perspective of households, housing prices are still exogenous shocks with the same process as in the main version of the model. They are not aware that house prices are determined in equilibrium in a way that depends on total housing demand, and they do not perceive that intergenerational changes could be affecting house prices.

Figure 35 shows the results for the case in which housing supply elasticity is assumed to be zero.

E Robustness checks

E.1 Initial zero wealth

Figure 36 shows the fit of the model with respect to homeownership in the case in which I assume that all households are born with zero wealth and recalibrate parameters accordingly. Although the fit of homeownership at earlier ages is not as good, it is still true that the model can reconcile the changes in homeownership rates across generations without resorting to changes in preferences. Table 5 shows that the decomposition of

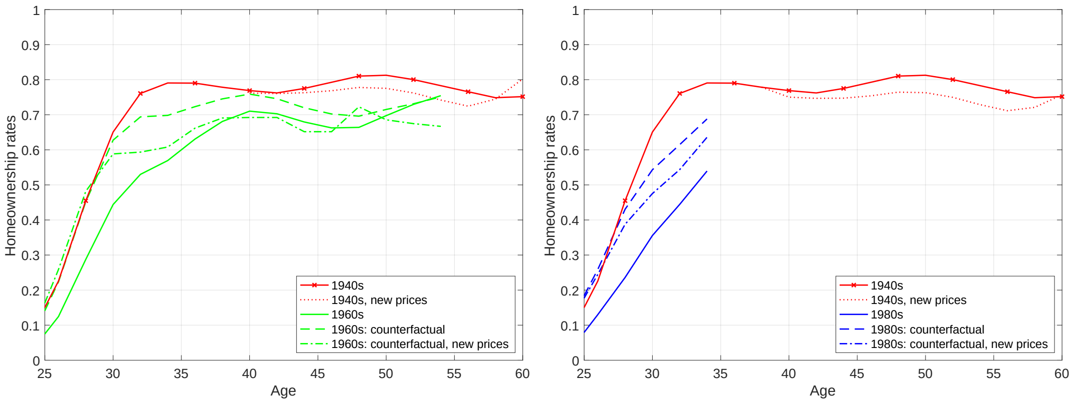

Figure 35: Homeownership by cohorts, benchmark vs. counterfactual earnings processes. Assuming fully inelastic housing supply.

the decrease in homeownership between its different contributing factors is also similar to the main case. Finally, Figure 37 shows that, without taking into account the initial condition, the model underpredicts stock market participation at earlier ages.

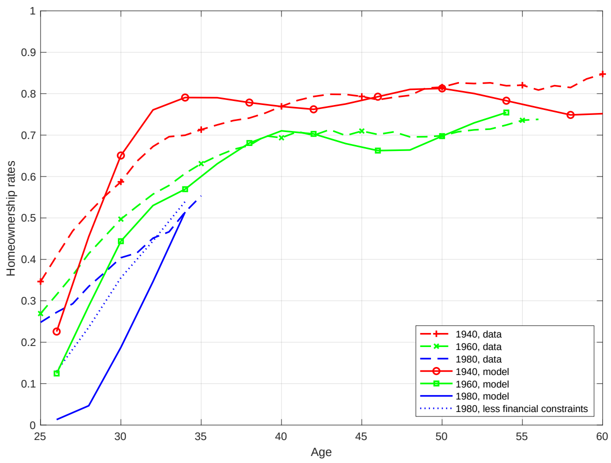

Figure 36: Homeownership by cohorts, data vs. model, relaxation of financial constraints in the early 2000s. Model with zero initial wealth.

1960s generation			
Age	30	40	50
Earnings	66	37	5
initial inequality	62	23	-17
risk	4	14	22
Aggregates	34	63	95
house price trend	73	129	63
histories	-39	-66	32

1980s generation		
Age	30	35
Earnings	51	27
initial inequality	33	8
risk	18	19
Aggregates	104	84
house price trend	90	74
histories	14	10
Financing	-55	-11

Table 5: Contribution of each factor in the change in homeownership with respect to the 1940s generation (% of the change), by age. Model with zero initial wealth.

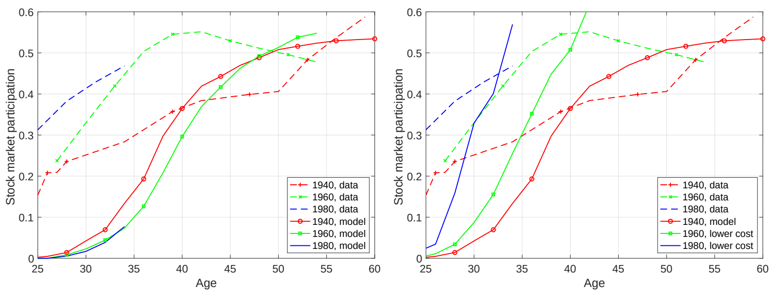

Figure 37: Stock market participation by age and cohort, data vs model. Left: constant participation costs across generations; right: reduction of participation costs across generations. Model with zero initial wealth.

E.2 Empirical initial wealth and inter-vivos transfers

In the main version of the model, I infer the initial wealth of the 1940s generation from its homeownership rates, and keep it constant over the different generations. In this section, I use empirical data on wealth at ages 20-25 instead, complemented with data on transfer receipts from parents and other family members. Figure 38, left panel, shows the empirical initial wealth distribution by cohorts. To the extent that this captures the average level of wealth of 20-25 year olds, it is also capturing any asset that comes from an early inheritance of family gift. However, this might underestimate inter-vivos transfers for two reasons. First, there might be family contributions (e.g. helping with the downpayment of a mortgage) which are not properly captured in the data. Second, these inheritances or family help might happen later than 25, and thus be difficult to separate in the data from wealth accumulation due to individual savings. In order to get an approximate idea of how far this channel could go in explaining the shortcomings of the model with zero initial wealth, I have used SCF data for the 1980s cohort to find out the percentage of people that got a large gift or inheritance before 35 (12.5%) and added its average value (one year of average income) to the top 12.5% of the initial wealth distribution.[38]

Figure 38, right panel, shows the results with the initial wealth distribution, and adding these additional inter-vivos transfers (IW+IV). Effects on homeownership profiles are minor when compared with the version of the model with zero initial wealth. However, the differences with the main version of the model, in which initial wealth positions are consistent with observed homeownership and stock market participation rates, suggest that initial wealth is poorly captured in these surveys, particularly for older generations.

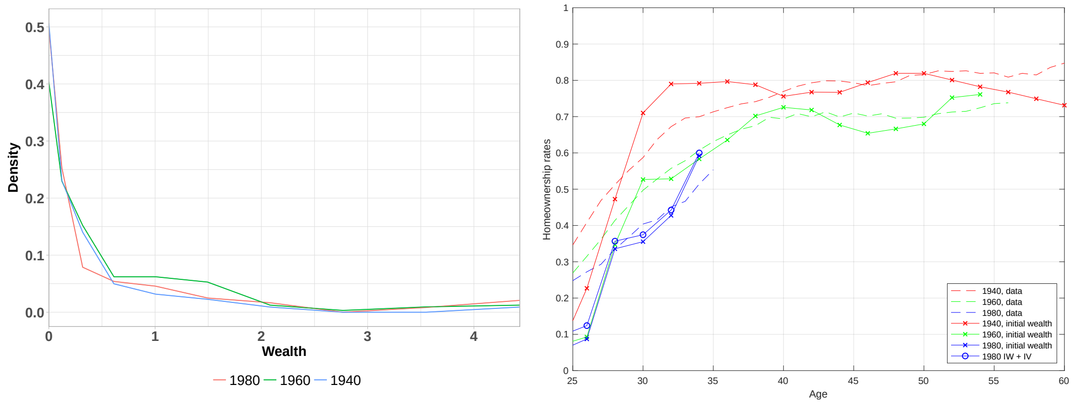

Figure 38: Empirical initial wealth. Left: density of wealth of 20-25 year olds, SCF data, measured as multiples of average income. Zero includes zero or negative. Right: model-implied homeownership with empirical initial wealth

E.3 Canonical process

Figure 39 shows the fit of the life-cycle variances for the canonical process with business cycle variation described in Section 8.1, and Table 6 shows its estimated parameters.

The estimates for the 1940s cohort are more precisely estimated and thus as expected (variances are larger in recessions than in expansions). For the 1960s cohort, the difference between expansions and recessions is quite imprecisely estimated, but the model

[38] This is an approximation, given that without a panel component it is not possible to find the joint distribution of (future) gift receipts and wealth.

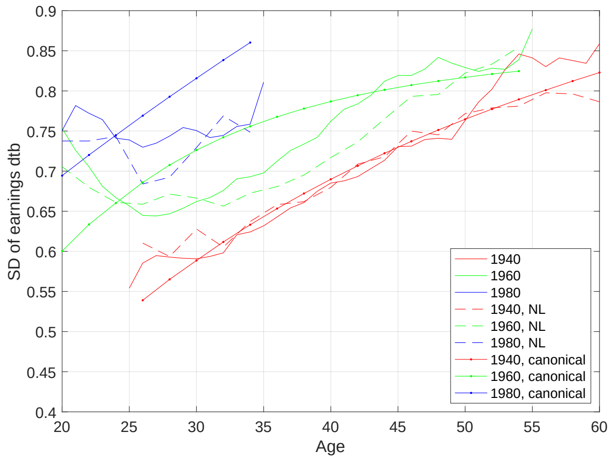

Figure 39: Variance of earnings over the life cycle. Sold lines: data; dashed lines: NL process; dash-dot lines: canonical process

Cohort	ρ	$\sigma^2_{r,c}$	$\sigma^2_{b,c}$	σ^2_{ϵ}
1940	1.0	0.0155	0.0118	0.32
1960	0.99	0.0010	0.0198	0.35
1980	0.45	0.5796	0.6259	0.0001

Table 6: Parameter estimates, business-cycle varying canonical process

succesfully replicates the higher level of earnings inequality that the cohort faces. Finally, for the 1980s cohort there are very few years of observations - whilst the process matches the variance profiles well, the persistence parameters and the variances for shocks are very noisily estimated.

The canonical process relies on the sequences of variances and autocovariances faced by each of the sub-cohorts that form a broad generation, and thus uses, for example, 122 observations. On the other hand, the NL process relies directly on pairs of observations for earnings in t and $t+1$, and uses 7500 such observations for the 1980s cohort.

E.4 Alternative assumptions for future projections

Figure 40 shows alternative scenarios for the future projections described in Section 7.1. The black solid line represents the case in which the earnings process of the 1980s cohort, rather than reverting back to that of the 1940s and 1960s cohort, stays constant from age 35 onwards. Finally, the black dot-dash line represents the case in which house prices are assumed to become constant with certainty with respect to median income from age 35 onwards. For clarity, confidence bands are not reported. Broadly, the median realization of all of these scenarios implies that households born in the 1980s take longer to buy houses, but eventually reach the homeownership rate of the 1960s generation. However, in a large set of scenarios less than 70% of households own houses at age 60.

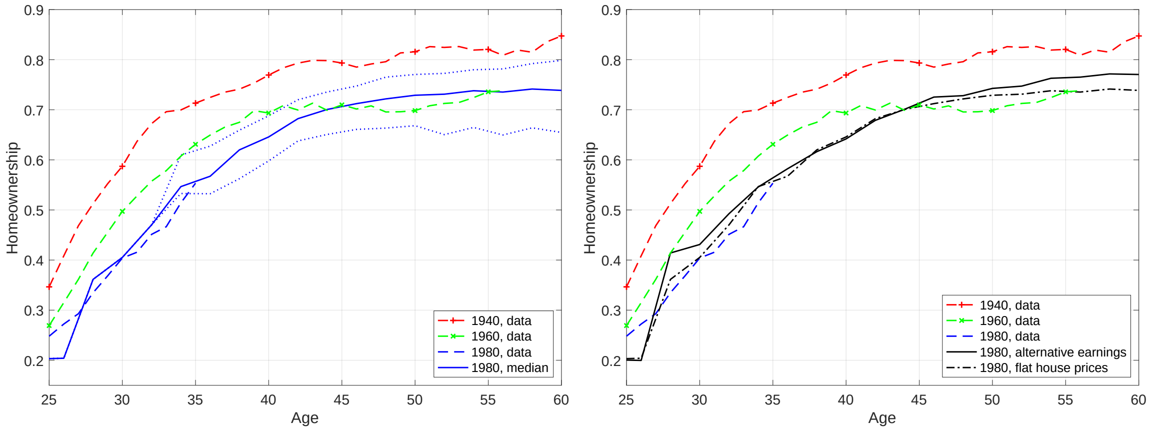

Figure 40: Homeownership: projecting the 1980s cohort into the future

E.5 Equilibrium effects on stock returns

Figure 41 shows to which extent the conclusions in Section 7.1 would vary as a result of possible general equilibrium effects on stock returns induced by the larger accumulation of financial wealth. In both cases, I assume that, once we enter the simulation period, yearly stock market returns fall unexpectedly and persistently by 2% or 4% for each possible realization of the stock state. A reduction of 2% in stock returns still implies that the 1980s cohort accumulates more financial wealth than that of the 1940s - a very significant reduction of 4% is required to make the profiles for both generations comparable. The accumulation of housing wealth is almost unaffected by these potential equilibrium effects.

E.6 Marital dynamics and family sizes

Over the past few decades, marriage rates have fallen, fertility has decreased, and the average age of women at both marriage and first childbearing has steadily increased (Lundberg and Pollak, 2007). These developments offer a possible alternative explanation for the reduction and delay in homeownership.

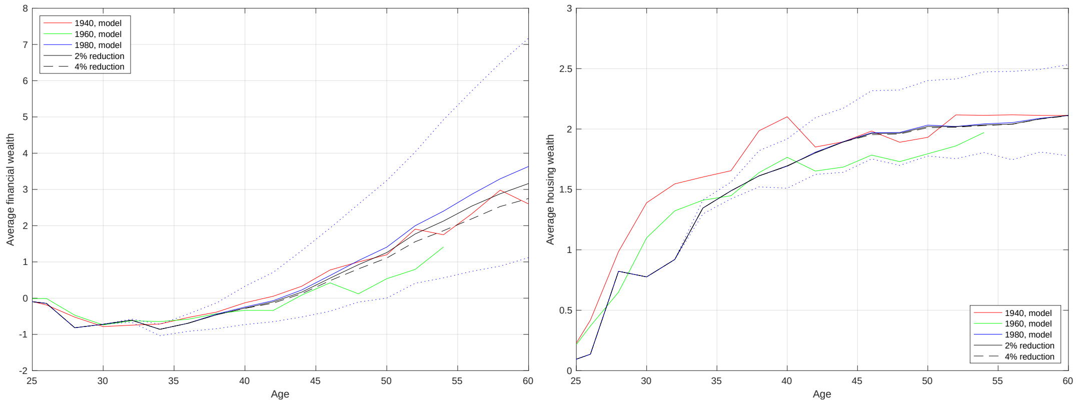

Figure 41: Wealth accumulation: projecting the 1980s cohort into the future. With constant participation costs, comparing different reductions in average stock returns

In the framework proposed in this paper, all of those changes are implicitly considered in the earnings process, which is estimated in all households (married or not) and thus embeds marriage and divorce risk into earnings risk. In order to disentangle these two effects, the left panel Figure 42 replicates the analysis by replacing the earnings process by one estimated only on continuously married couples. Given that this subset of households have on average higher and more stable earnings, their implied homeownership rates within the model are larger. However, differences across cohorts are present in a very similar way. This suggests that, while family dynamics can play a relevant role[39], the increase in inequality and earnings risk seems to be of first order to explain the changes in homeownership. To verify this hypothesis, the right hand side of Figure 42 replicates the counterfactual in which the 1940s earnings process is attributed to younger generations within the subsample of married households. Effects are similar to those in the main results.

[39] Chang (2018) shows that marital and divorce risk is a relevant force to explain changes in homeownership of singles versus couples.

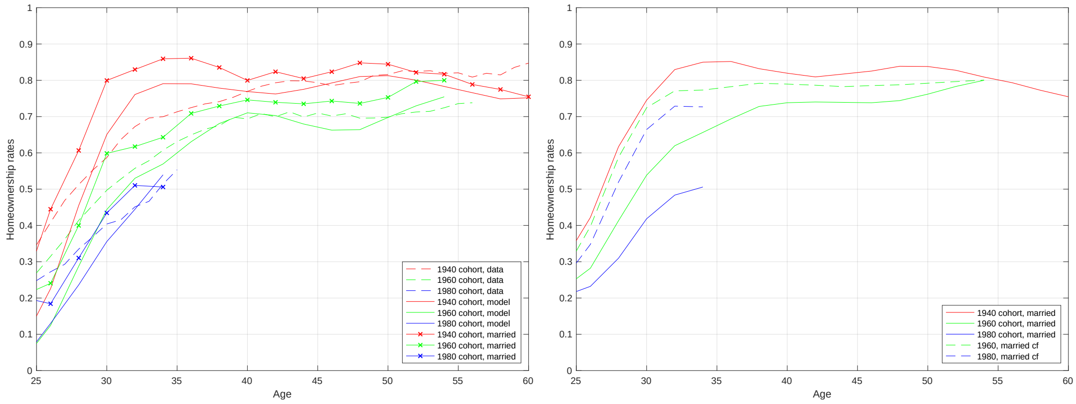

Figure 42: Homeownership by cohorts, married people only.

E.7 Per-period participation costs

There is a long standing discussion in the household finance literature about whether one-off entry costs, which I consider in the main version of this model, or per-period participation costs rationalize better the patterns of stock market participation that we observe in the data. While the former is used in studies like Cocco (2005) or Gomes and Michaelides (2005), Vissing-Jorgensen (2002), Gálvez (2017), or Bonaparte, Korniotis and Kumar (2018), amongst others, find that the latter seems to be the most promising avenue to explain the observed patterns of stock market participation. However, the estimated value for the per-period participation cost is frequently relatively high (for instance, Bonaparte et al. (2018) estimate it to be around 3.2% of average household income every year).

Figure 43 shows the implied profiles for stock market participation, in a recalibrated version of the model that only allows for per-period participation costs that decrease over time. As in previous studies, the estimated cost which is necessary to reconcile low levels of stock market participation is quite high (around 3.5% of average household income for the 1940s cohort), but is lower for younger cohorts.

E.8 Stocks as 401(k)

In order to investigate whether the fiscal incentives associated with IRAs and 401(k)s could be an alternative explanation for the increase in stock market participation, Figure 44 represents the results of a counterfactual exercise in which participation costs are kept constant, but I modify the nature of the financial asset or stock f_t in the model to closely

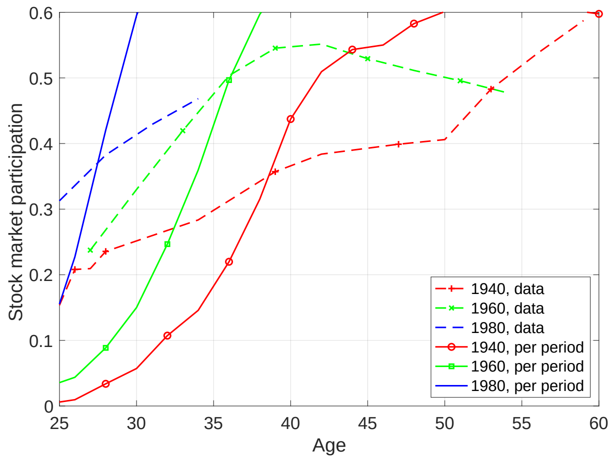

Figure 43: Stock market participation over the life-cycle, by cohorts, case with calibrated per-period participation costs

replicate a 401(k). I keep participation costs constant across generations, but assume that contributions to the account are tax-exempt below a certain limit, the interest it generates is tax free, households pay income tax on all amounts withdrawn, and there are penalties for withdrawal before age 60 (10%).

As a result, households in the model would actually invest less in these accounts. This reaction is related to the illiquidity of 401(k)s, which makes it costly for househols to withdraw from their stocks in response to a bad labor income shock, and suggests that the ease of access and auto-enrolment were the key features that explained the success of these accounts.

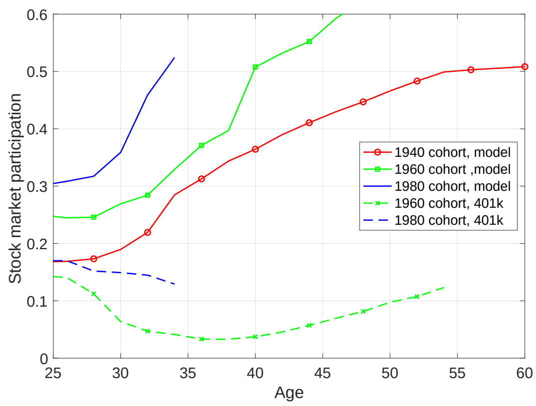

Figure 44: Stock market participation: model with constant participation costs and stocks with 401(k) tax properties

E.9 Local correlation of income shocks and house prices

An additional element that increases the riskiness of housing is the correlation at the local level between house prices and income changes. For instance, in areas that benefit in particular from an expansion it is likely that both incomes and house prices go up. When households incorporate this information into their decision making, it influences both homeownership and portfolio choices.

To approximate this effect, I allow for income shocks to be correlated with housing price shocks at the idiosyncratic level. Given that in the baseline version of the model both are exogenous, this correlation can be directly imposed from data estimates. I rely on Davidoff (2006) for the empirical quantification of this correlation and fix it at 0.29.

Figure 45 shows the corresponding homeownership profiles. I perform two experiments. The left hand side panel represents the case in which house prices are expected to be correlated with income, and in which the realizations of house prices are also correlated with the realizations of the income shocks. This induces, unlike in the main case in this paper, housing price heterogeneity within agents living in the same year. Like in the main case, I assume that the average realization of the house price shock is like that observed in the data for that specific year. Homeownership would be lower in this case for all cohorts, particularly for those born in the 1980s, even with looser financial constraints.

The right hand side panel represents the alternative case in which households expect house prices to be correlated with their individual income shock, but where this is not true in realization and house prices are still their corresponding national average. Differences with the previous experiment are minor, which suggests that the key driver for this reduction in homeownership rates are household portfolio decisions rather than changes in the stationary distribution induced by the introduction of house price heterogeneity.

This experiment abstracts from important elements such as endogenous determination of local house prices or endogenous mobility, which are beyond the scope of this project and are left for future research.

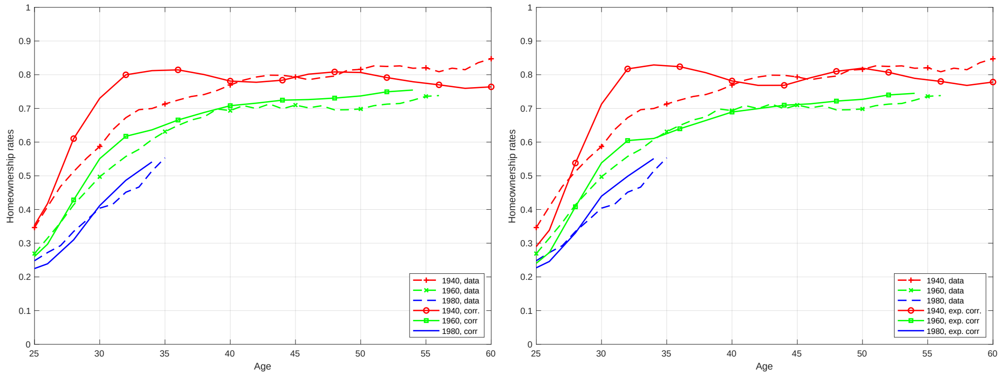

Figure 45: Homeownership by cohorts, local correlation of house price shocks with income. Solid line with crosses: realizations + expectation, dotted line: expectations only

E.10 House sizes

In the main version of the model, households can choose to own two types of housing, which I denote h_1 and h_2. This reflects that houses are lumpy and have limited divisibility, and that frequently households cannot access their optimal house size and quality because it is scarcely available or disadvantageously priced on the market. In this section, I check the robustness of my results with respect to different specifications of house sizes.

The size of the small house h_1 is key for my results, as it conditions who is the marginal person who is indifferent between buying a house and renting, and thus homeownership rates. In current U.S. dollars, for the latest periods in the model, the price of a small house is around \$100,000. Here I argue that there is limited supply of houses below this price, few households actually live in them, and including a smaller small house in the model generates counterfactual implications.

With respect to supply limitations, Falcettoni and Schmitz (2018) argue that regulations and monopoly power have reduced the production of prefab or factory-built houses below its efficient level, thus reducing the number of cheap houses available on the market. In my PSID data, I find that, for the 1980s cohort, only 9.4% of households bought a house with a price lower than h_1, with most of them concentrated nearby.

The left hand side panel of Figure 46 shows the model implications for the case in which the smallest house is 33% smaller and cheaper. Naturally, results are sensitive to this assumption. However, as Figure 47 reveals, this experiment underestimates generational differences by overestimating how many people buy small houses as a reaction to changes in earnings dynamics and housing prices.

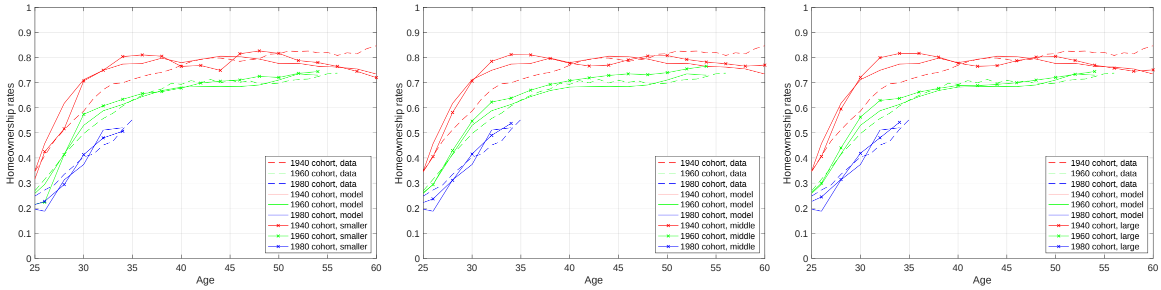

Figure 46: Alternative house sizes, main experiments

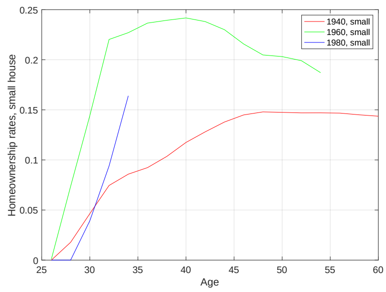

Figure 47: Percentage of households owning the small house by age. Left, robustness check in which it's smaller; right: main results

The central and right panels of Figure 46 show two robustness experiments in which I set the number of housing qualities to $H = 3$. In the middle panel, I do so by allowing for a middle-sized house exactly between the prices of the small house and the big house. In the right hand side panel, I allow for a large house, twice the size of the big one. In all cases I recalibrate housing preference parameters accordingly so that homeownership for the 1940s cohort at age 40 is within the ballpark of the data.

Results are almost identical with either of the $H = 3$ assumptions, thus suggesting that the choice of $H = 2$ is not key in driving the results I obtain. Setting $H = 3$ and allowing for a large house does improve the fit of the model in terms of the portfolio composition of the richest, which slightly underestimates their housing share (see Figure 11).