A House Without a Ring: The Role of Changing Marital Transitions in Housing Decisions

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Abstract

This paper shows that the evolving likelihood of marriage and divorce is an essential factor in accounting for the changes in housing demand over time in the United States. I build a life-cycle model with housing decisions where single and married households face age-dependent exogenous marital transition shocks. I estimate the model to match key life-cycle profiles for the year 1970 and use it to generate the prediction for the year 1995 by applying several structural changes that potentially affect housing decisions. In addition to relaxed downpayment constraint, the declined likelihood of marriage is shown to be a key driver to generate the increase in young singles' homeownership and housing asset share. In contrast, the increased divorce likelihood contributes to predict the decline in housing variables for married couples. Its effect is of a similar magnitude with the influence of the increased house price.

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1 Introduction

The average homeownership rate of married couples is significantly higher than that of single households. Over the past decades, the fraction of single households increased substantially as the prospects of marriage and divorce changed vastly. For instance, the average marriage probability for singles between ages 25 and 64 fell by more than 30%, and the average divorce probability more than doubled from the 1970s to the 1990s. One would expect a substantial drop in the aggregate homeownership rate with the increase in the fraction of singles, but the aggregate homeownership rate stayed roughly constant until the house price boom started in the mid 2000s (Chambers et al., 2009, Acolin et al., 2016). Although this seems puzzling at first sight, this happened because the homeownership rate of single households rose as their fraction increased in the economy. A closer look at the homeownership rate and the composition of assets conditional on marital status reveals a major shift: non-elderly singles were much more likely to be homeowners, while young couples were less likely to lock their assets in housing.

This paper builds and estimates a structural life-cycle model to understand these observations conditional on marital status. Little attention has been paid in the macroeconomic literature to these "within-group" changes since they were masked by little change in the aggregate housing demand. This paper shows that the changes in marital prospects can account for the fact that singles became more likely to purchase houses, while married households put fewer assets into housing. Hence, this paper offers a quantitative framework with marital transitions that complement other potential channels such as borrowing constraints and labor market uncertainty to explain the evolution of aggregate housing demand during the last decades.

Let me explain the intuition on how the risk of family formation and dissolution is linked to housing decisions. If one gets married, he/she may want to live in a bigger house or live in different neighborhoods to incorporate his/her spouse's preferences. Hence, if a forward-looking single person is likely to get married soon, he/she will wait to buy a house with a spouse because transaction costs make it costly to sell or resize a house. Likewise, since it is more difficult to split a house than liquid assets such as checking accounts, a married couple is less likely to invest in housing out of total assets if their chances of divorce are high.

To quantify the effect of the change in marital transitions on the change in homeownership and housing asset share, I focus on the two years 1970 and 1995 before the housing boom started. I pick 1970 as a representative period of high marriage and low divorce risks for two reasons. First, it is hard to get information on households' portfolios with data prior to 1970. I use an underexplored data set, the historical Survey of Consumer Finances (SCF), and an imputation strategy to link these data and the Panel Study of Income Dynamics (PSID). Second, a number of changes happened after 1970 in social norms associated with marriage and divorce. One leading example is the legalization of no-fault divorce over the 1970s, in which the dissolution of a marriage does not require proof of wrongdoing by either spouse.[1] As a period of low marriage and high divorce risks, I choose 1995, since it is prior to the house price increase that started in the late 1990s.

I postulate a life-cycle model of single and married households that face age-dependent marital transition shocks similar to Cubeddu and Ríos-Rull (2003) and Fernández and Wong (2014). This enables me to maintain clarity in my decomposition analysis of turning on each channel associated with housing decisions.[2] Taking into account the prospects of marriage and divorce, households decide how much to consume, rent, save in non-housing and housing assets, and work. Owned housing incurs substantial transaction costs whenever it is sold or its size is adjusted. Since a house one bought as a single person is likely to be a bad match for the married couple, it is modeled to be sold with high probability when he/she gets married. Likewise, most married couples sell their owned house when they get divorced. The probability of selling home with marital transitions is disciplined by the empirical counterpart observed in the data.[3]

In addition, the model has ingredients to reflect other structural changes that could influence housing decisions. Owned housing serves as a collateral for borrowing and relaxation of the downpayment constraint can be captured by changing a single tightness parameter in the model. Households face idiosyncratic labor productivity shocks. By increasing the variance of the associated idiosyncratic process, I can analyze how households adapt their housing investment to increased labor market uncertainty. Over the period of interest, spousal labor

[1] California first enacted no-fault divorce in 1969. By late 1983, all states except for South Dakota and New York legally allowed no-fault divorce. It is still controversial whether this law raised divorce rates (Friedberg, 1998; Wolfers, 2006). Instead of taking a stand on its causal effect, I interpret the legalization of no-fault divorce as a signal of change in social norms about marriage and divorce.

[2] If marriage and divorce are modeled as endogenous decisions, then some underlying shocks that drive these complex decisions should be modeled instead. It goes beyond the scope of this paper. More discussion on the assumption of exogenous marital transitions is provided in Section 6.

[3] Although some couples move in to the home that one partner already has, they tend to sell the house and move to another one within 5 years of marriage, which is the unit of my model period (Speare, 1970; Speare and Goldscheider, 1987; Deurloo et al., 1994). Likewise, divorcees are likely to move to a new house since the house bought as a married couple would not meet their needs after divorce (South et al., 1998).

participation increased significantly. To be able to reflect this change, each household member is modeled to decide how much to work. As a spouse's labor productivity increases and fixed cost of participation falls, the model generates an increase in spousal labor supply. I can study how this change affects household income and housing decisions. Married households' marginal utility from consumption and housing services is modeled to vary based on the effective household size with children over the life-cycle. This allows me to study the effect of declined fertility on housing decisions. I compute the life-cycle profiles of household decisions from the stationary equilibrium given prices such as non-housing asset return and house price. These values are calibrated to reflect prices of different periods.

I estimate the model parameters using a limited information Bayesian method to match the moments from the cross-section data of 1970, the benchmark year for my analysis.[4] The model closely fits the life-cycle profiles of homeownership, housing asset share, and labor force participation across marital status observed in the data. Then I conduct counterfactual analysis to quantify the explanatory power of the marital transition channel while controlling for other potential channels that affect housing decisions. Alternative channels considered in this paper include financial constraints, labor market uncertainty, spousal labor productivity, fertility, non-housing asset return, and house price. I first apply structural changes between 1970 and 1995 one at a time to study each channel's effect on homeownership and housing asset share. Then I show the prediction of the model when all channels reflect the year 1995's changes and compare it to the data.

First, the model is able to account for a significant fraction of the increase in young singles' homeownership (about 60% of the data's change for the age group 25-29, and about 33% of that for the age group 30-34). The changes in marital prospects and downpayment constraint induce singles to own home more. Hence, they are key factors to predict the increase in singles' homeownership that is consistent to what happened between 1970 and 1995.[5] The marital transition channel plays a bigger role for the age group 25-34 whereas the relaxed downpayment constraint influences more the age group 35-44. In addition, the model's prediction for the increase in singles' housing asset share explains more than half (53%) of the data's change averaged over age 25-44 (whose value is 6.9 percentage

[4]Prior beliefs play an explicit role in the Bayesian approach. I use uniform priors in this paper so that the non-uniform shape of posterior density clearly illustrates that data variations are informative of the estimated parameters. I leave for future research what informative priors to impose for different parameters of interest in a life-cycle model.

[5]The other factors either play a negligible role (e.g. reduced fertility) or exert downward pressure on singles to decrease their homeownership (e.g. heightened labor market risk, higher house price).

point). For this age group, the relaxed downpayment constraint alone predicts an increase by 5 percentage points whereas the change in marital transitions predicts an increase by 4 percentage points on average. The downpayment constraint predicts a higher increase for the share variable because it induces both extensive and intensive margin adjustments in household portfolios whereas the effect of marital transition shocks is mostly associated with the extensive margin.

In addition, the model correctly predicts the decline in homeownership for young married households. For instance, the average decline in homeownership predicted by the model for the age 25-39 is close to the average decline observed in the data (-2.7 percentage points vs. -3 percentage points). The drivers that exert negative effects on couples' housing demand include changes in marital transitions, fertility, non-housing asset return, and house price. To be specific, the marital transition channel alone predicts a decline in housing asset share by 2 percentage points on average for the age group 25-44. Its effect is of a similar magnitude with the influence of the increased house price. It is shown that the change in marital transitions is one of the key ingredients to correctly forecast the decline in housing asset share in 1995.

This paper contributes to several distinct strands of the literature. First, it is related to the literature on housing in macroeconomics, of which Davis and Van Nieuwerburgh (2015) and Piazzesi and Schneider (2016) give a nice and extensive overview. My paper is closely related to a stream of quantitative papers that analyze portfolio choice with illiquid housing over the life-cycle (Cocco, 2005; Yao and Zhang, 2005; Fernández-Villaverde and Krueger, 2007; Kaplan and Violante, 2014; Chang et al., 2018; Nakajima and Telyukova, 2020). My paper builds on these papers while modeling transaction costs that arise in times of marital transitions, which affects the decisions of forward-looking households.

Second, this paper demonstrates the importance of changes in idiosyncratic risk on aggregate variables, which is also emphasized in the literature. For instance, idiosyncratic income shocks are analyzed to affect various aggregate variables such as income and consumption inequality (Blundell et al., 2008; Heathcote et al., 2010), output and associated welfare (Low et al., 2010), and homeownership (Díaz and Luengo-Prado, 2008). My paper studies the aggregate implication of marital transition risk and earnings risk whose stochastic nature changes over the life-cycle. Borella et al. (2021) emphasize that marriage tends to be ignored in macroeconomics but is helpful in fitting aggregate labor market outcomes and savings. In a similar spirit, my paper studies the effect of marital transition risk and earnings risk for homeownership and portfolios of couples and singles using a structural model.

Finally, this paper contributes to the literature that analyzes the importance of marital transitions for households' decisions.[6] Few recent papers attempt to study housing decisions in the presence of marital transitions. Fisher and Gervais (2011), for example, generate the decrease in the aggregate homeownership of the young by a trend of marrying later and having more singles in the economy. In contrast to my model, their framework cannot replicate the increase in young singles' homeownership rate observed in the data. Fischer and Khorunzhina (2019) study the role of divorce risk by comparing the simulated life-cycle profiles of housing decisions for those with and without divorce risk. I attempt to link my model to the historical data to quantify how much of the change in marital prospects can account for the change in housing decisions. To the best of my knowledge, my paper is the first study to quantify this effect with estimation using micro data.

The rest of the paper is organized as follows. Section 2 describes the data and establishes the empirical facts. Section 3 outlines the model, and Section 4 explains how the parameters are estimated and provides the model fit. Section 5 shows the decomposition analysis, which quantifies how much of the change in housing decisions can be accounted for by the change in the likelihood of marital transitions between 1970 and 1995. Section 6 provides discussion on the assumptions adopted in this paper and some other potential channels left for future research. Section 7 concludes.

2 Data

In this section, I illustrate the data sources used to construct the life-cycle profiles of housing variables in 1970 and 1995. I chose 1970 and 1995 as two periods with similar house prices,[7] but with substantially dissimilar likelihood of marital transitions. The year 1970 was chosen as a representative period with high marriage and low divorce probabilities.[8] If we look

[6]This includes various non-housing decisions such as savings and female labor supply (Cubeddu and Ríos-Rull, 2003; Mazzocco et al., 2013; Fernández and Wong, 2014; Voena, 2015), fertility and child investment (Brown et al., 2015), and portfoilo choice without housing (Love, 2010).

[7]For example, Corbae and Quintin (2015) call the period 1940-1998 as the period with intermediate, "normal" house price level. I include the time-series of the real house price index in Appendix A.3. In the decomposition analysis of Section 5 I consider the increase in house price by 6% as one structural change for the year 1995 compared to 1970.

[8]I only treat legally-married couples as married households. Cohabitation was uncommon in 1970 and in 1995. For instance, Stevenson and Wolfers (2007) report that cohabitation rate among adults was 2.9 percent based on the 1995 Current Population Survey.

at the time series data,[9] the marriage rate showed a local peak in 1970 and started to fall from then on. In contrast, with the legalization of no-fault divorce, the divorce rate surged throughout the 1970s.[10] The year 1995 was chosen as the representative period with high divorce and low marriage probabilities. It is suitable to analyze periods before the start of the housing price boom in the late 1990s, a trend that continued until the Great Recession.

2.1 Data to construct life-cycle profiles in 1995

I use the 1995 Survey of Consumer Finances (SCF) data, which is conducted every three years and is available from the Federal Reserve's website. This data is a repeated cross-section that provides detailed information on households' portfolio choices as well as their demographic characteristics such as age and marital status.

To be consistent with my model, I categorize assets into either housing or non-housing assets.[11] The SCF also provides information on mortgages and home equity lines of credit, which can be used to construct the net value of housing assets. I construct the variable *housing asset share* as the net value of housing assets divided by total assets, including both housing and non-housing assets.[12] The life-cycle profile of this unconditional share still preserves a hump shape. The variable *homeownership* is defined as a dummy variable whose value is one if a household holds a positive amount of housing assets. Regarding a household's labor supply, I use the employment status and the weekly hours of work reported in the SCF data.

2.2 Data to construct life-cycle profiles in 1970

I use two data sources to construct life-cycle profiles for the year 1970. First, I use the 1970 Survey of Consumer Finances. These data are accessible via the Inter-University Consortium

[9]Source: Centers for Disease Control and Prevention National Center for Health Statistics (CDC NCHS).

[10]See Voena (2015) for the overview of US divorce laws and for the literature review.

[11]The description of how each variable is constructed is provided in Appendix A.1. I do not model risky financial assets additionally since most of young households, who I conjecture are subject to substantial marital transition risk, do not hold risky financial assets. Ameriks and Zeldes (2004) report the average share of assets held in equity-based accounts to be around 6% for age 25-44 in 1995.

[12]To avoid selection issue, I focus on the unconditional share that combines the information about participation rate and conditional housing asset share when matching the model output to the data in Section 4. I validate the model fit for (untargeted) conditional share of housing assets and study how a mechanism of the model operates along extensive vs. intensive margin in Section 5.

for Political and Social Research (ICPSR), whereas the SCF data since 1983 are available from the Federal Reserve's website. I use the raw data downloaded from ICPSR and construct the variables of interest as outlined in Appendix A.1. The value of using the historical SCF data before 1983 has recently been highlighted by Kuhn et al. (2020), and my paper is also in line with their attempt to incorporate these data to answer a question that has not been answered: how much of the change in homeownership and housing asset share can be accounted for by the change in marital transition probabilities?

However, there is a challenge to answering this question because the number of observations of single households in the 1970 SCF is too small due to the high marriage rate. This results in a very jagged life-cycle profile for single households. To obtain more observations that can inform me about homeownership rate and housing asset share in 1970, I use data from the Panel Study of Income Dynamics (PSID), which is the longitudinal household survey that has been administered since 1968.

Despite the larger number of observations in the 1970 PSID, it does not provide enough information on households' non-housing asset composition, which is essential information to construct the housing asset share variable. Therefore, I use a cross-imputation strategy similar to Blundell et al. (2006) to obtain a relation between housing assets and non-housing assets from the 1970 SCF data and impute the missing non-housing assets for the PSID sample using the fitted regression. The cross-imputation is done as follows: using the 1970 SCF sample, I first add 1% of the average net value of housing to each household i's net value of housing, denoted by $\textit{net value of housing}_{i,SCF}$. This is done to secure more observations used in the regression of log-log specification. I regress this logged net value of housing on the logged non-housing asset with various controls included in X_i,

$$\log(\textit{net value of housing}_{i,SCF}) = X'_{i,SCF}\beta + \gamma \log(\textit{non-housing asset}_{i,SCF}) + u_{i,SCF}.$$

By using the estimated coefficients $(\widehat{\beta}, \widehat{\gamma})$ and assuming that the relation between variables will be the same between the different data sets, I can obtain the cross-imputed value of non-housing assets in the PSID data for household i as

$$\widehat{\textit{non-housing}}\ \textit{asset}_{i,PSID} = \exp\left(\frac{\log(\textit{net value of housing}_{i,PSID}) - X'_{i,PSID}\widehat{\beta}}{\widehat{\gamma}}\right).$$

Using the imputed non-housing asset value and the observed housing asset value, I construct the housing asset share for household i in the PSID. In Appendix A.1, I show that the regression applied to the 1970 SCF data to obtain the estimates $(\widehat{\beta},\widehat{\gamma})$ has the adjusted R-squared close to 0.8 (Table A-2). Also, I show that the mean, the median, and the standard deviation of the imputed housing asset share of the PSID data are close to those observed in the SCF data (Table A-1).

2.3 Life-cycle profiles in 1970 and 1995

I construct the life-cycle profiles of single and married households in 1970 and 1995. Making use of an underexplored data set, the historical Survey of Consumer Finances data, I provide the empirical facts on how the life-cycle profiles of housing-related variables changed across different marital statuses, which has not been documented before. Understanding how aggregate housing demand changed across marital statuses is important because many tax and subsidy policies are designed separately for single and married households.

Between 1970 and 1995, I control for potential composition changes from education and financial assets by regression analysis that filters out changes in conditional mean accounted for by these factors.[13] Figure 1 shows the change in homeownership rate and housing asset share over time depending on marital status. First, single households' homeownership rate increased significantly between the two years, especially from age 25 to 44. This is also the case for single households' housing asset share. For the married, the homeownership rate fell slightly between 1970 and 1995 for younger households. Interestingly, the housing asset share was significantly higher in 1970 compared to 1995 for younger married households.

Many papers have attempted to explain the pattern that married households are more likely to be homeowners than single households. In addition to this observation from the cross-section, I aim to account for the within-group change in housing variables over time; first, the increase in single households' homeownership rate,[14] and second, the decrease in the married households' housing asset share. I highlight that it is important to focus on heterogeneity in terms of marital status in understanding the changes in housing decisions over time. Then I argue that the likelihood of household formation and dissolution plays a major role in generating these changes over time. If a single person is likely to marry soon, he/she will wait to buy a house with a spouse because it is costly to sell or resize a

[13] The life-cycle profiles of housing-related variables before filtering out composition changes and the regression results to control for composition effects are presented in Appendix A.2.

[14] The increase in homeownership is observed for both single men and women. I do not differentiate gender in this paper and pool all the observations together to study the increase in singles' homeownership rate.

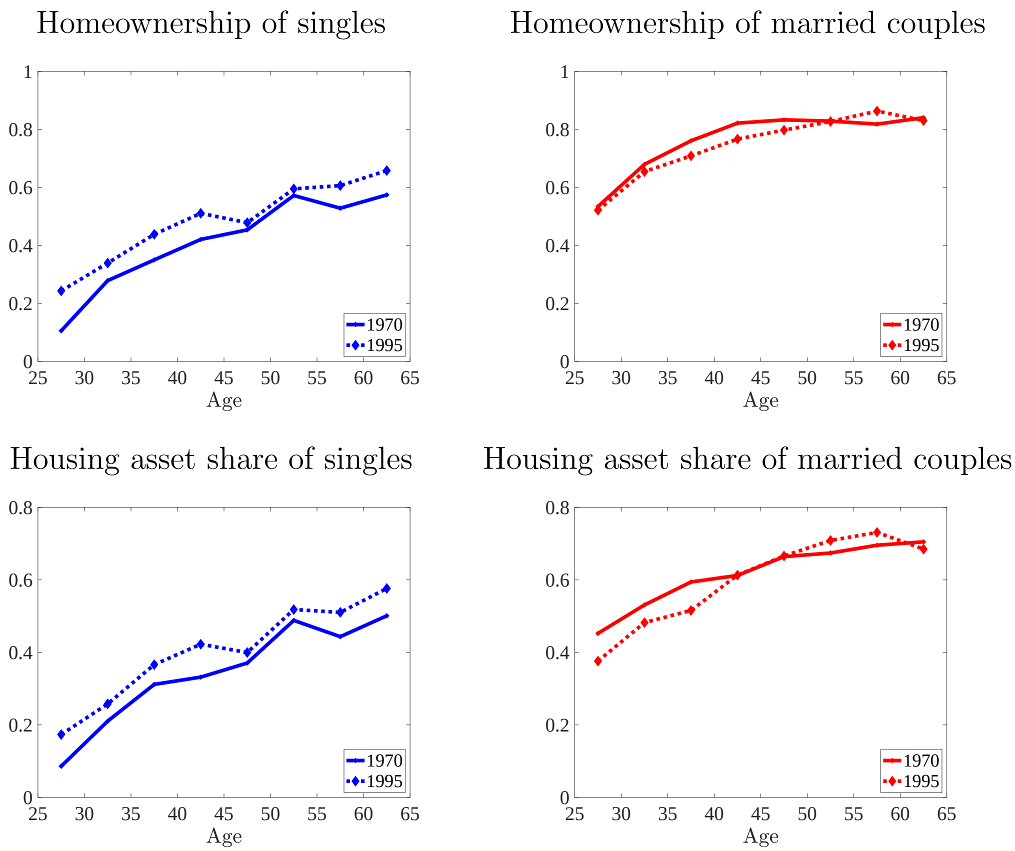

Figure 1: Homeownership rate and housing asset share

Notes: The average homeownership rate and the average housing asset share across different age groups. The solid lines are constructed from the 1970 data and the dashed lines are from the 1995 data. The x-axis stands for the age of household head. These life-cycle profiles are constructed after filtering out composition changes from education and non-housing assets with the regression analysis.

house. This may explain why single households' homeownership rate increased, as they were less likely to marry.[15] In addition, a married couple who are likely to get divorced will tilt their portfolio away from the housing asset, since it requires a large transaction cost when liquidation happens with a divorce. To formalize this conjecture and quantify how much of the change in marital transition probabilities can account for the change in housing variables in comparison to other potential factors, I need a structural model.

[15] In addition, the expectation regarding a potential spouse could play a role for a single's savings pattern. When a single person expects to marry up or when marriage occurs at later ages to a spouse with more assets, prospect of marriage may create a free-riding problem that produces disincentive to savings. The model in Section 3 includes the distributions over a potential spouse's assets and labor productivity.

3 Model

I develop a life-cycle model of single and married households that face age-dependent marital transition shocks. Similar to the approach of Cubeddu and Ríos-Rull (2003) and Fernández and Wong (2014), marital status is treated as exogenous in order to build a computationally tractable model of heterogeneous households and to conduct a decomposition analysis by feeding in the marital transition probabilities observed from the data.[16] When making decisions, households will take into account the probability of getting married or divorced.

Households decide how much to consume, rent, save in non-housing and housing assets, and how many hours to work. A finite number of housing sizes are available to own. Owning a house is advantageous, since it yields a higher service flow than renting and it serves as collateral for borrowing. However, it incurs substantial transaction costs whenever its size is adjusted. Housing is a highly idiosyncratic investment, so a change in status is likely to make the house owned prior to the change no longer suitable. For example, when you are single, you do not know what type of house your future spouse may like. When you get married, you learn how your spouse values the jointly owned home. The house you purchased when single is likely to be ill-suited for a married couple. Housing allocation rule in times of getting married or divorced is modeled to replicate housing transaction of individuals around marital transitions observed in the data.

Households face non-insurable idiosyncratic labor productivity shocks and idiosyncratic housing depreciation/appreciation shocks. The framework is a partial equilibrium model in which households face the following given prices: wage, savings interest rate, borrowing interest rate, and common house price.

Preference - Single agent. A single agent's utility is specified by

$$u(c,s,l) = \frac{(c^{\alpha}s^{1-\alpha})^{(1-\sigma)}}{1-\sigma} - B_s \frac{l^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}} - \phi \cdot I(l>0) + uhp(l),$$

where $c \geq 0$ is consumption and $s \geq 0$ is housing service. The service is defined as $s = m + \zeta(h) \cdot h$, where m is from rented housing and $\zeta(h) \cdot h$ is from owned housing. $\zeta(h)$ is a

[16] Although people choose which type of family arrangement they live in, this paper treats it as an exogenous shock stochastically generated by an underlying probability distribution. On the other hand, there are a few recent papers that endogenize households' marital decisions in different contexts (Mazzocco et al., 2013; Voena, 2015; Low et al., 2018; Reynoso, 2019). I provide more discussion on the assumption of exogenous marriage and divorce in Section 6.

size-dependent function of owned housing

$$\zeta(h) = \left(\zeta_1 + \zeta_2 \frac{h - h_{min}}{h_{max} - h_{min}}\right),$$

where h_{min} is the smallest non-zero size of owned housing and h_{max} is the biggest size. ζ_1 is the service gain of owning h_{min}-sized housing compared to renting. ζ_2 reflects the marginal gain for larger houses. $\zeta(h)$ is assumed to be greater than 1 to reflect that owned housing is preferred to rented housing.[17]

On top of the change in marital transitions, there were substantial changes in earnings risk and in the labor market environment between 1970 and 1995. Since I want to incorporate these changes into the decomposition analysis in Section 5, I build a model with endogenous labor supply. This will allow me to study how housing decisions as lumpy investments change according to how agents adjust their labor supply in response to various idiosyncratic shocks. l stands for labor supply associated with disutility from working B_s and the fixed cost of labor market participation ϕ. Also, there is utility from home production

$$uhp(l) = \begin{cases} 0 & \text{if one works} \\ \omega_{uhp} & \text{if one does not work.} \end{cases}$$

The utility from home production while working is normalized to be zero. The parameter ω_{uhp} is identified from ϕ, since I adopt a different functional form for the married agent's utility from home production.

Preference - Married agents. Within a married household, there is a head and a spouse. They differ in terms of labor productivity denoted by y for the head and $\widetilde{y}$ for the spouse. This can be interpreted as each member of the household taking on a role depending on comparative advantage in house management.

A married head's utility u^{head} and a married spouse's utility u^{spouse} are specified below:

$$u^{\text{head}}(c, s, l, \widetilde{l}) = \varphi_j \frac{\left((\gamma_e c)^{\alpha}(\gamma_e s)^{1-\alpha}\right)^{1-\sigma}}{1-\sigma} - B_m \frac{l^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}} - \phi \cdot I(l > 0) + uhp(l, \widetilde{l})$$

$$u^{\text{spouse}}(c, s, l, \widetilde{l}) = \varphi_j \frac{\left((\gamma_e c)^{\alpha}(\gamma_e s)^{1-\alpha}\right)^{1-\sigma}}{1-\sigma} - \widetilde{B}_m \frac{\widetilde{l}^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}} - \widetilde{\phi} \cdot I(\widetilde{l} > 0) + uhp(l, \widetilde{l}),$$

[17]One could modify the owned house more easily to cater to one's needs. Also, there could be a moral hazard issue with leasing agents, which makes renting less favorable, as pointed out in Postlewaite et al. (2008).

where $c, s \geq 0$ is joint consumption and joint housing service. γ_e is a parameter that transforms joint objects into per capita terms. If γ_e is greater than 0.5, it captures economies of scale in consumption and service flow provided by marriage. φ_j allows for the marginal utility of consumption and housing service to differ over the life-cycle. $\varphi_j > 1$ could result from the joy of having a partner or children. Both the head and the spouse are constrained to enjoy equal consumption and housing service.

l is labor supply of the head and $\widetilde{l}$ is labor supply of the spouse. Labor supply is associated with disutility from working $B_m, \widetilde{B}_m$ and the fixed cost of working $\phi, \widetilde{\phi}$. The married agent's utility from home production is defined as

$$uhp(l, \widetilde{l}) = \begin{cases} 0 & \text{if both work} \\ \frac{\omega_{uhp}}{n_\psi} & \text{if only one spouse works} \\ \omega_{uhp} & \text{if no one works,} \end{cases}$$

where n_ψ reflects whether home production technology is increasing returns to scale or not.[18] In an extreme case where $n_\psi = 1.0$, having two people stay at home and do the housework generates the same utility as having one person do so.

3.1 Problem of the single household at the terminal age

This section describes the recursive formulation of the single household's problem at the terminal age J. The value function depends on the following state variables: age J, total asset a, housing asset h, and labor productivity y. Households face an exogenously given wage w, a risk-free savings interest rate r, a borrowing interest rate r^H, and a common housing price P^H. To simplify the notation, I denote the vector of all the state variables as $X_J^s = [J, a, h, y]$.

$$V^s(X_J^s) = \max_{c,m,b',h',l} u(c, s, l) + \beta V^{s,fin}(b', h')$$

$$s.t. \qquad c + m + b' + P^H h' = wyl + a - \Phi(h', h)$$

$$c \geq 0, \quad s \geq 0, \quad b' \geq 0.$$

[18]This is different from leisure complementarity that induces married couples to participate less in the labor force (to enjoy leisure together). For married households, with increasing returns to scale home production, wives with lower labor productivity tend to stay home whereas heads participate in the labor force.

$\Phi(h', h)$ is the asymmetric transaction cost associated with an illiquid housing asset. Similar to Yang (2009), it is defined as

$$\Phi(h', h) = \begin{cases} \kappa_b P^H h' + \kappa_s P^H h & \text{if } \ h' \neq h \\ 0 & \text{if } \ h' = h, \end{cases}$$

where $\kappa_b < \kappa_s$. Households are borrowing-constrained at the terminal age, which is captured by non-housing asset b' being non-negative.

The objective is to maximize the combination of current period utility and the discounted continuation value of the remaining life. $V^{s,fin}(b', h')$ is the continuation value after age J, for 4 more periods where the household consumes the constant amount of $A \equiv (b' + P^H h')\frac{1-\beta}{1-\beta^4}$.[19] The amount A is obtained by assuming that the discount factor during retirement is equal to $\frac{1}{(1+r)}$. This can be considered as submitting $(b' + P^H h')$ and entering a retirement community, which provides in return a constant flow of utility in the future. The continuation value in this case is written as

$$V^{s,fin}(b', h') = \frac{1-\beta^4}{1-\beta} \cdot \frac{A^{(1-\sigma)}}{1-\sigma}.$$

3.2 Problem of the married household at the terminal age

A married household's problem at age J depends on one more state variable compared to their single counterparts, since we also need to consider the labor efficiency shock $\widetilde{y}$ of a spouse. Similarly, I denote the vector of all the state variables as $X^m_J = [J, a, h, y, \widetilde{y}]$.

A married household solves a joint problem that maximizes the average utility with equal weights. In other words, a marriage is a contract to obey the decision of a utilitarian social planner maximizing the average utility. The average utility at the current period is

$$u(c, s, l, \widetilde{l}) = \frac{u^{\text{head}}(c, s, l, \widetilde{l}) + u^{\text{spouse}}(c, s, l, \widetilde{l})}{2}$$

$$= \varphi_j \frac{\left((\gamma_e c)^{\alpha}(\gamma_e s)^{1-\alpha}\right)^{1-\sigma}}{1-\sigma} - \frac{1}{2}\left(B_m \frac{l^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}} + \widetilde{B}_m \frac{\widetilde{l}^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}}\right) - \frac{1}{2}\left(\phi \cdot I(l > 0) + \widetilde{\phi} \cdot I(\widetilde{l} > 0)\right) + uhp(l, \widetilde{l}).$$

[19] I keep the retirement period simple without having any shocks as in Fernández and Wong (2014). The specification I use for the continuation value plays a similar role as commonly-used bequest utility. I provide more discussion on this in Section 6.

Then the problem solved by the married household is

$$V^m(X_J^m) = \max_{c,m,b',h',l,\widetilde{l}} u(c,s,l,\widetilde{l}) + \beta V^{m,fin}(b',h')$$

$$s.t. \quad c + m + b' + P^H h' = w(yl + \widetilde{y}\widetilde{l}) + a - \Phi(h',h)$$

$$c \geq 0, \quad s \geq 0, \quad b' \geq 0.$$

The household's labor income includes both the head's and the spouse's labor income. The choice variables are analogous to the single household's problem except that the married household also needs to decide the labor supply of the spouse $\widetilde{l}$.

The continuation value $V^{m,fin}(b',h')$ is analogous to the single household's case. The household does not face a marital transition shock at the terminal age J. Each member of the household is assumed to identically evaluate the joint consumption amount $A = (b' + P^H h')\frac{1-\beta}{1-\beta^4}$ provided by the retirement community. There is efficiency gain γ_e in consumption from marriage. The continuation value then becomes

$$V^{m,fin}(b',h') = \frac{1-\beta^4}{1-\beta} \cdot \varphi_J \frac{(\gamma_e A)^{(1-\sigma)}}{1-\sigma}.$$

3.3 Problem of the single household at the non-terminal age

The expected value should take into account the marital shock. I denote the vector of all the state variables as $X_j^s = [j,a,h,y]$. The single household's problem at age $j < J$ is written as follows:

$$\begin{aligned} V^s(X_j^s) = \max_{c,m,b',h',l} \Big\{ u\big(c,s,l\big) \; + \beta \Big[& q_{ss,j} \cdot \mathbb{E}V^s\big(j+1,a',h',y'\big) \\ & + q_{sm,j} \cdot p_{liquidate} \cdot \mathbb{E}V^m\big(j+1,(a'+\widetilde{a}') - \kappa_s P^H(h'+\widetilde{h}'),0,y',\widetilde{y}'\big) \\ & + q_{sm,j} \cdot (1-p_{liquidate}) \cdot \mathbb{E}V^m\big(j+1,(a'+\widetilde{a}') - \kappa_s P^H min\{h',\widetilde{h}'\}, max\{h',\widetilde{h}'\},y',\widetilde{y}'\big)\Big]\Big\} \end{aligned}$$

$$s.t. \qquad c + m + b' + P^H h' = wyl + a - \Phi(h',h)$$

$$a' = (1 + r(b'))b' + P^H(1-\delta')h', \quad \text{where} \quad r(b') = \begin{cases} r & \text{if } b' \geq 0 \\ r^H & \text{otherwise} \end{cases}$$

$$c \geq 0, \quad s \geq 0, \quad b' \geq -\eta P^H h', \quad b' \geq -\nu wyl \quad \text{with} \;\; 0 \leq \eta \leq 1 \text{ and } 0 \leq \nu \leq 1.$$

A single person stays single with age-dependent probability $q_{ss,j}$. Then the expected value is based on the current period savings and housing choice in addition to future labor efficiency. The single household gets married with probability $q_{sm,j}$. This renders the continuation value equal to the average utility from the marriage arrangement. It is assumed that one gets married to a spouse of the same age group.[20] In addition to parsimonious marital transition probabilities that depend on age, a single agent takes into account his/her expectation about the potential spouse's distribution with respect to total asset $\widetilde{a}'$, housing asset $\widetilde{h}'$, and labor efficiency $\widetilde{y}'$.

To have random matching is computationally costly with rational expectation since consistency is required between the potential spouse's distribution of assets and the equilibrium distribution of assets of singles. Instead, I decide to model the expectation with bounded rationality as follows: assume that the potential spouse's housing asset distribution $\Omega_j(\widetilde{h})$ depends on age j. Since I know the homeownership rate of singles over the life-cycle from the data, I can incorporate this information to discipline $\Omega_j(\widetilde{h})$ such that

$$\begin{aligned}
\Omega_j(\widetilde{h} = 0) &= 1 - \text{homeownership rate at age } j \\
\Omega_j(\widetilde{h} = h_{min}) &= \text{homeownership rate at age } j,
\end{aligned}$$

where h_{min} is the minimum non-zero housing asset level.[21] Since the homeownership rate is increasing with age, a younger single is more likely to meet a spouse without housing assets. Similarly, I use the age-dependent empirical distributions of non-housing assets $\widetilde{b}$ from the data of single households. This induces the distribution over total asset $\widetilde{a}$ coupled with $\Omega(\widetilde{h})$. Furthermore, I model one's labor efficiency y and a potential spouse's labor efficiency $\widetilde{y}'$ as jointly normal random variables that have the empirical correlations across different age groups reported in Borella et al. (2021).[22] For example, the correlation is set to be 0.33

[20] This is consistent with the empirical fact that the average age differential of a married couple was less than 5 years in 1970 and in 1995.

[21] Since the model will be estimated with the moments including the life-cycle profile of the homeownership rate of single households, the potential spouse's housing asset distribution used to form expectation will be consistent with the ownership in equilibrium. However, the consistency over housing asset levels is not guaranteed. Even though I forgo some accuracy, the potential spouse's housing asset distribution captures the reality in that single homeowners tend to own a small house.

[22] Given jointly normal random variables X and Y with parameters $\mu_X, \sigma_X^2, \mu_Y, \sigma_Y^2$ and correlation ρ, we get the conditional normal distribution $Y|X = x$ with

$$E[Y|X = x] = \mu_Y + \rho\sigma_Y \frac{x - \mu_X}{\sigma_X}, \quad Var(Y|X = x) = (1 - \rho^2)\sigma_Y^2.$$

for the age group 25-34 and 0.23 for the age group 45-54.

Housing allocation rule in times of marital transitions is modeled as follows: once a single person gets married, the couple have to sell either part or all of housing assets they accumulated while single and pay the associated transaction costs. The prohibitive transaction costs could also reflect potential moving or relocation costs associated with marriage. $p_{liquidate}$ denotes the probability of selling all home in the event of marital transitions. I calibrate $p_{liquidate}$ so that it reflects the empirical fact that most married households (80-90%) resize or buy a new house within 5 years after getting married (Speare, 1970; Speare and Goldscheider, 1987; Deurloo et al., 1994). With probability $(1 - p_{liquidate})$, the couple keep the bigger house between h' and $\widetilde{h}'$. The smaller house is liquidated with transaction costs. With the remaining wealth after combining two people's assets and selling off the houses owned before marriage, the married couple can choose a new level of housing asset in the next period to maximize the average utility. It is worth noting that there is no margin of disagreement when the couple solve a joint problem.

Households receive the idiosyncratic shock δ on top of the common house price P^H. Depending on the shock, the total asset a household carries to the next age differs. I assume that δ is uniformly distributed on $[\underline{\delta}, \bar{\delta}]$. If $\underline{\delta} < 0$ and $\bar{\delta} > 0$, the shock covers both depreciation and appreciation. Also, households at the non-terminal age have access to collateralized borrowing. η captures the tightness of the collateralized borrowing constraint $b' \geq -\eta P^H h'$. That is, $(1 - \eta)$ reflects the downpayment constraint requirement. The borrowing interest rate r^H is given to be higher than the savings interest rate r.[23] Lastly, households are subject to the loan-to-income (LTI) requirement in each period. It is assumed that households cannot borrow more than ν fraction of their labor income, i.e., $b' \geq -\nu w y l$.

3.4 Problem of the married household at the non-terminal age

The married household solves a joint problem that maximizes the average utility. The married household's problem with $X_j^m = [j, a, h, y, \widetilde{y}]$ is written as follows:

[23]This could be from financial intermediation or from default risk. I treat this borrowing rate to be exogenous instead of endogenizing it. For endogenizing the borrowing rate by explicitly modeling short-term or long-term mortgages, see Jeske et al. (2013) and Favilukis et al. (2017).

$$
\begin{aligned}
V^m(X_j^m) = \max_{c,m,b',h',l,\widetilde{l}} \Big\{ & u\big(c,s,l,\widetilde{l}\big) \; + \beta\Big[q_{mm,j} \cdot \mathbb{E}V^m\big(j+1,a',h',y',\widetilde{y}'\big) \\
& + q_{ms,j} \cdot p_{liquidate} \cdot \mathbb{E}V^s\big(j+1, 0.5(a' - \kappa_s P^H h'), 0, y'\big) \\
& + q_{ms,j} \cdot (1 - p_{liquidate}) \cdot \frac{\mathbb{E}V^s\big(j+1,0.5a',h',y'\big) + \mathbb{E}V^s\big(j+1,0.5a',0,y'\big)}{2} \Big] \Big\}
\end{aligned}
$$

$$
s.t. \qquad c + m + b' + P^H h' = w(yl + \widetilde{y}\widetilde{l}) + a - \Phi(h',h)
$$

$$
a' = (1 + r(b'))b' + P^H(1-\delta')h', \quad \text{where} \quad r(b') = \begin{cases} r & \text{if } b' \geq 0 \\ r^H & \text{otherwise} \end{cases}
$$

$$
c \geq 0, \quad s \geq 0, \quad b' \geq -\eta P^H h', \quad b' \geq -\nu(wyl + w\widetilde{y}\widetilde{l}) \;\text{ with }\; 0 \leq \eta \leq 1 \text{ and } 0 \leq \nu \leq 1.
$$

The choice variables are analogous to the single household's problem except that the married household needs to make an additional decision on spousal labor supply $\widetilde{l}$ given the spouse's labor productivity $\widetilde{y}$. In addition, the LTI requirement is associated with household labor income. ν captures the tightness of LTI requirement $b' \geq -\nu(wyl + w\widetilde{y}\widetilde{l})$.

With probability $q_{mm,j}$, the married household stays married to the same spouse. It is not possible to be married to different spouses for two consecutive periods.[24] With probability $q_{ms,j}$, the married household becomes divorced.[25] With this status change, the divorced single agent becomes egoistic and his/her labor productivity is again distributed over the support of y. With probability $p_{liquidate}$ of selling home in the event of marital transitions, the joint house h' is sold and the associated cost is paid. This attempts to mirror the reality that over 80% of divorcees move within 5 years since divorce (South et al., 1998; Sullivan, 2007). After this transaction, the remaining joint assets are equally divided between the

[24]If there were reshuffling of spouses (remarriage), the value in remarriage would be lower than the value of continuing current marriage since the remarried spouse is less favorable (Becker et al., 1976; Becker et al., 1977) and housing is likely to be liquidated with costs as divorce happens before remarriage. Consequently, introducing remarriage will deliver similar results to those from the model that neglects remarriage.

[25]Although I do not make distinction between never-married singles and divorcees in the model, agents who face divorce shocks are more likely to be homeowners than never-married singles. Divorcees with more assets are likely to be homeowners as they become single again. Also, some of the divorcees are modeled to keep the house. This assumption is consistent with the data pattern that the average homeownership rate of divorcees is higher than that of never-married singles.

couple.[26] With probability $(1 - p_{liquidate})$, h' is kept by one of the spouses after divorce. Under this scenario, it is equally likely whether a divorcee gets h' or not. And the joint assets during marriage is equally divided as denoted by $0.5a'$. Each spouse has the same outlook on the future, which eliminates the margin of disagreement.

3.5 Shocks

A labor efficiency shock y at age j is modeled to be a combination of the age trend $\chi(j)$ from Hansen (1993) and an idiosyncratic shock x of AR(1) after taking the log.

$$y = \chi(j)x, \quad \log(x') = \rho_x \log(x) + \epsilon^x, \quad \epsilon^x \sim N(0, \sigma_x^2) \quad \text{i.i.d.}$$

Idiosyncratic depreciation/appreciation shock δ is uniformly distributed with lower bound $\underline{\delta}$ and upper bound $\bar{\delta}$, $\delta \sim U[\underline{\delta}, \bar{\delta}]$. Additionally, households face the age-dependent marital transition shocks with the associated probabilities $q_{ss,j}, q_{sm,j}, q_{ms,j}$, and $q_{mm,j}$.

4 Estimation of model parameters

I set parameters of the model in two ways. First, some parameters are set by using parameter values in the literature or by using the estimates from the data without relying on the dynamic model. Then the remaining parameters are estimated using a limited information Bayesian approach, which matches the life-cycle profiles from the data and those generated from the model. I estimate the parameters for the baseline year 1970.

4.1 Externally set parameters

Demographics and endowments. Individuals start their lives at age 25 and retire at age 65. One model period corresponds to 5 years as in Fernández and Wong (2014), implying that non-retired individuals live for 8 periods. There is no mortality shock during these periods. Once they retire, households receive a fixed amount of payment for 20 more years before they die with certainty. I use the observed asset distribution of households aged 20 to 24 in the 1970 SCF data to determine initial asset distribution in the model.

[26] There can be other ways of dividing joint assets after separation or divorce. Voena (2015) studied how various divorce laws on property division affect couples' intertemporal decisions.

Preferences. The discount factor β is set to be 0.97 in annual terms. I set the coefficient of relative risk aversion σ to 5. The Frisch elasticity γ is set to be 0.5 following the macro estimates of γ as reviewed in Keane and Rogerson (2015).

Labor productivity. Labor productivity consists of two parts: a life-cycle component and an idiosyncratic shock. The life-cycle component $\chi(j)$ is set to match the estimates of Hansen (1993). The idiosyncratic shock follows AR(1) after taking the log. I set $\rho_x = 0.93$ and $\sigma_x = 0.23$ in annual terms similar to the estimates from Borella et al. (2021) and Fernández and Wong (2014). For the married spouse, the process is modeled with $\rho_{\tilde{x}} = 0.92$ and $\sigma_{\tilde{x}} = 0.25$. The spouse's process is less persistent with a higher standard deviation as reported in Chang and Kim (2006).[27]

Marriage-related parameters. The scale parameter n_ψ of home production is set to be 1.34 for the married household as in Fernández-Villaverde and Krueger (2007). To construct the life-cycle profile of φ_j, I rely on the OECD household member weight as in Pizzinelli (2018) and the average number of children across age groups in the 1970 Census data.

Age	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
φ_j	1.15	1.29	1.37	1.39	1.28	1.13	1.0	1.0

Table 1: Values for φ_j

The probabilities $q_{sm,j}$ of getting married at age j are computed by a similar logistic regression as in Borella et al. (2021).[28] Age and squared age are used as regressors.[29] Cohort or time effect is not controlled for.[30] For the 1970 probabilities, the PSID data from 1970

[27]For robustness check, I set the same values for persistence coefficient and standard deviation of innovation for heads and spouses by using ρ_x and σ_x. As females are subject to lower volatility in labor productivity, spousal labor participation slightly increases. But the housing decisions of married couples show little change and the overall fit of the life-cycle profiles do not change much.

[28]The probabilities $q_{sm,j}$ of getting married at age j are estimated as $q_{sm,j} = Prob(Married_{j+1} = 1|Married_j = 0, Z_j) = F(Z_j'\beta_m)$ where F denotes the standard logistic function and Z_j includes age j and squared age. The probability of getting divorced $q_{ms,j}$ is analogously defined.

[29]I do not control for geographic location which is not publicly available from the data. In the literature, Ziliak (2018) reports that marriage rates decreased from 1970 to 1995, and the decrease was steeper for those in rural areas. Divorce rates increased over the same time period, and the increase was slightly more steeper for those in urban areas. Despite the differences in terms of magnitude, people in both urban and rural areas became less likely to get married and more likely to get divorced from 1970 to 1995.

[30]I provide the marital transition probabilities with cohort effects considered in Appendix A.4. Also, I report the estimation uncertainty associated with marital transition probabilities in Appendix A.5.

to 1974 are used. For 1995, the data from 1995 to 1999 are used. Since there are fewer divorces than marriages, I also rely on the divorce probabilities computed from the Divorce Registration Area (DRA) data reported in Clarke (1995). For instance, the age-dependent probabilities of getting divorced $q_{ms,j}$ of 1995 are computed as the average of the probabilities in Clarke (1995) and the probabilities computed by a logistic regression using the PSID data from 1995 to 1999 with age and squared age controlled for.

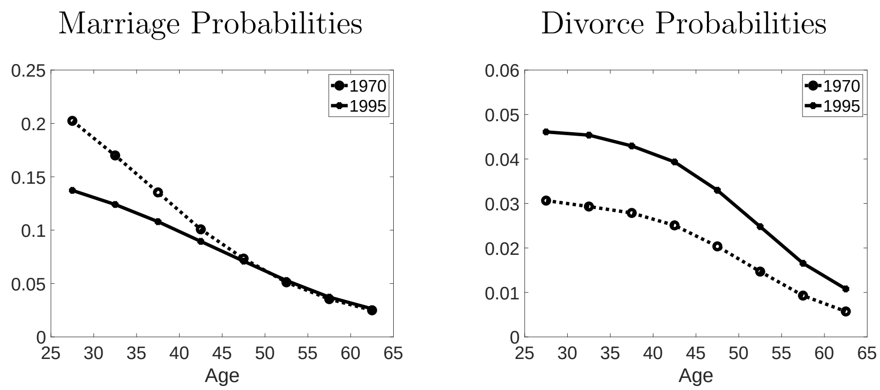

Figure 2: Marriage and divorce probabilities

Borrowing constraint, loan-to-income requirement, and prices. Households are subject to a collateralized borrowing constraint where the parameter η captures how relaxed the constraint is. I set $\eta = 0.65$ that is similar to the value in Bullard (2012). The loan-to-income (LTI) requirement is introduced to hold each period in the model. ν is calibrated to be 3.0, the same value as in Pizzinelli (2018), so that the average loan-to-income ratio is 0.66 as reported in Iacoviello (2008). The interest rate for savings is set to be 0.02 and the interest rate for borrowing is set to be 0.075 per annum. This borrowing rate is calibrated based on the 30-year fixed rate mortgage in the early 1970s reported by Freddie Mac.

Housing-related parameters. For the transaction cost of owned housing, similar to Gruber and Martin (2003) and Yang (2009), I set that 3% of the home value is paid when buying and 8% is paid when selling. The probability $p_{liquidate}$ of selling all home in the event of marital transitions is set to be 0.85 to reflect the empirical fact that over 80% of married couples and divorcees move within 5 years since marital transitions (Speare, 1970; Speare and Goldscheider, 1987; Deurloo et al., 1994; South et al., 1998; Sullivan, 2007).[31] Lastly, housing depreciation/appreciation shock is modeled to be uniform between $\underline{\delta}$ and $\bar{\delta}$. I set

[31]Parameters such as housing transaction costs and frequency of home sales around marital transitions are set to be consistent with the empirical patterns reported in the literature. It is important to fix these pa-

$\underline{\delta} = -0.04$ in annual terms, which is close to the average price increase for 10 major US metropolitan areas (Composite 10) from the Case-Shiller house price index.[32] I set $\bar{\delta} = 0.03$ per annum, whose value is similar to the 2.5th percentile of price change for all states from 1987 to 1994. The common house price P^H is calibrated to match the rent-price ratio of 5 percent as reported in Davis et al. (2008) for period 1960-1995.

Table 2 summarizes the externally set parameters in annual terms.

Parameter	Description	Calibration
β	discount factor	0.97
σ	risk aversion coefficient	5.0
γ	Frisch elasticity	0.5
ρ_x $(\rho_{\tilde{x}})$	AR(1) coefficient	0.93 (0.92)
σ_x $(\sigma_{\tilde{x}})$	standard deviation of innovation	0.23 (0.25)
n_ψ	scale in home production	1.34
η	collateralized borrowing constraint	0.65
ν	loan-to-income constraint	3.0
$(r,\ r^H)$	savings/borrowing interest rate	(0.02, 0.075)
$(\kappa_b,\ \kappa_s)$	buying/selling home transaction cost	(0.03, 0.08)
$p_{liquidate}$	probability of selling home with marital transitions	0.85
$(\underline{\delta},\ \bar{\delta})$	bounds on appreciation/depreciation	(-0.04, 0.03)

Table 2: Externally set parameter values

4.2 Estimated parameters

Estimation method. I estimate the remaining parameters that are model-specific (hence hard to calibrate externally) and interact with key endogenous decisions on housing and labor supply. I use a limited information Bayesian approach (Kim, 2002; Christiano et al., 2010; Fernández-Villaverde et al., 2016). Structural estimation such as mine has advantages for several reasons. First, I can discipline estimation with various moments of interest. Since I want my model to be able to account for households' housing and labor supply decisions,

rameters in order not to use arbitrary values to fit the observed housing decisions. I provide some robustness analysis on transaction costs and home transaction frequency in Appendix A.10 and A.11.

[32]Given that major metropolitan areas tend to experience sharper housing price increases, I use the average of Composite 10 as the upper bound. Composite 10 includes Boston, Chicago, Denver, Las Vegas, Los Angeles, Miami, New York, San Diego, San Francisco, and Washington, D.C.

I use the relevant life-cycle profiles of homeownership rates, housing asset share, and labor force participation rates across single and married households. Second, I am able to learn the uncertainty associated with the parameters in contrast to calibration. For instance, I can construct a credible set for each parameter of interest. I can also quantify the uncertainty in the life-cycle profiles induced from the parameter estimates. Lastly, one could incorporate prior beliefs to a limited information Bayesian procedure. I use uniform priors in order to be analogous to the simulated method of moments. Also, this is useful to check whether there is sufficient variation in the data to learn about parameters given diffuse uniform priors. If the micro data evidence or the previous literature helps to form more informative priors, these beliefs could be incorporated. This point will be clear in the following explanation of a limited information Bayesian procedure.

Let Θ denote the parameters of interest and $\hat{\mathbf{m}}$ denote the vector of M empirical moments from the data for estimation. Kim (2002) shows that the likelihood of $\hat{\mathbf{m}}$ conditional on Θ is approximately

$$f(\hat{\mathbf{m}}|\Theta) = (2\pi)^{-\frac{M}{2}}|S|^{-\frac{1}{2}} \exp\left[-\frac{1}{2}\left(\hat{\mathbf{m}} - \mathbf{m}(\Theta)\right)' S^{-1}\left(\hat{\mathbf{m}} - \mathbf{m}(\Theta)\right)\right],$$

where $\mathbf{m}(\Theta)$ is the model-generated moments under parameter Θ, and S is the covariance matrix of $\hat{\mathbf{m}}$. The covariance matrix S is often unknown but can be replaced by a consistent estimator of it, which can be obtained through bootstrap.

Bayes' theorem tells us that the posterior density $f(\Theta|\hat{\mathbf{m}})$ is proportional to the product of the approximate likelihood $f(\hat{\mathbf{m}}|\Theta)$ and the prior $p(\Theta)$:

$$f(\Theta|\hat{\mathbf{m}}) \propto f(\hat{\mathbf{m}}|\Theta)p(\Theta),$$

and we can then apply the standard Markov Chain Monte Carlo (MCMC) techniques such as the Metropolis-Hastings algorithm to obtain a sequence of random samples from the posterior distribution. More details on the algorithm are provided in Appendix A.6.

Identification. The moments used in the estimation include 1970's life-cycle profiles for homeownership rates, housing asset share, and labor force participation rates for single and married households, respectively. The intercept in the service gain of owned housing ζ_1 is identified from the levels of homeownership rate whereas the slope ζ_2 is identified from variation in housing asset share over the life-cycle. Without the utility from home production ω_{uhp}, the model has difficulty in having married household heads to work more than singles on average. Hence, ω_{uhp} is identified from the gap in the labor force participation between married heads of households and singles. The economies of scale parameter γ_e is identified from the gap in housing asset shares between married couples and singles. Preference parameter α that aggregates consumption and housing services is obtained from the overall levels of housing asset share and parameters on fixed cost of working $\phi, \widetilde{\phi}$ are from the overall levels of labor force participation. Lastly, parameters on disutility of working $B_s, B_m, \widetilde{B}_m$ are identified from how labor supply decreases over the life-cycle.

Estimation results. Table 3 reports the posterior mean and the 95% credible intervals of parameters from the Bayesian estimation, together with the uniform priors. Uniform prior belief does not favor certain values over others within the support. This belief would be updated with the curvature provided by the difference between the moments from the data and those from the model. Given this prior specification, this procedure can be considered as pseudo-likelihood estimation in classical inference.

		Posterior Distribution		Uniform Prior
Parameter	Description	Mean	95% Interval	[Min, Max]
ζ_1	service flow from owned housing (intercept)	1.053	[1.016, 1.085]	[0.01, 1.5]
ζ_2	service flow from owned housing (slope)	0.192	[0.167, 0.221]	[0.0, 1.0]
ω_{uhp}	utility from home production	12.870	[10.886, 14.018]	[0.0, 100.0]
γ_e	economies of scale within marriage	0.533	[0.519, 0.539]	[0.5, 1.0]
α	aggregator for consumption and housing	0.653	[0.641, 0.663]	[0.5, 0.999]
B_s	disutility of working (single)	20.234	[17.316, 23.111]	[0.01, 50.0]
B_m	disutility of working (married head)	0.755	[0.144, 2.187]	[0.01, 50.0]
$\widetilde{B}_m$	disutility of working (married spouse)	73.346	[71.393, 74.230]	[50.0, 100.0]
ϕ	fixed cost of working (single, married head)	45.231	[39.968, 59.012]	[0.0, 100.0]
$\widetilde{\phi}$	fixed cost of working (spouse)	31.122	[26.781, 36.521]	[0.0, 100.0]

Table 3: Estimated parameters

One advantage of estimation is that I can characterize the uncertainty associated with each parameter. The parameter estimates inform me about interesting aspects in life, including economies of scale within marriage, utility from home production, and the cost of labor supply. The credible set for γ_e is much narrower than the prior's and it does not include 0.5 (which means no economies of scale) supporting the existence of economies of scale within marriage. The utility from home production ω_{uhp} is estimated to be significantly positive. This gives incentive for some singles and married spouses (since they have lower productivity than married heads) not to work. With this in effect, married spouses' fixed cost of working $\widetilde{\phi}$ is estimated to be smaller than that of married heads. In Appendix A.6, the marginal distributions from posterior draws are shown to be non-uniform by combining the uniform prior with the data's variation.

4.3 Model fit

Figure 3 shows the model fit for the 1970 data. The figures in the left column include the model-generated life-cycle profiles obtained by using the posterior mean estimates reported in Table 3 compared to the data counterparts. The model does a great job of matching the life-cycle profiles of homeownership rates and housing asset share depending on marital status. Also, it matches the labor force participation of married household heads well. The model captures the labor force participation rates over the life-cycle of singles and married spouses, although the model over-predicts the labor supply during the young ages.

The in-sample fit is also analyzed by the posterior predictive checks reported in the right column in Figure 3. I simulate the life-cycle profiles for 100 different posterior draws that are equally distanced over the sampler. From Figure 3 based on the posterior mean, I observe some gaps between the model-generated life-cycle profiles and the data's. The hairlines generated from the predictive checks allow me to see whether these discrepancies are big or not given the uncertainty involved. For example, the life-cycle profiles of homeownership rates are quite precisely estimated, whereas there is more uncertainty associated with the spousal labor supply profiles. In addition, the hairlines for housing variables are more spread out for younger ages compared to older ages. Hence, the estimation procedure provides measures of uncertainty and some insights that one would not otherwise get with calibration.

Lastly, the model is validated with some unmatched moments. The wealth-to-income ratio in the model is 2.1 which is close to the value 2.4 from Kuhn et al. (2020) for the year 1970. This moment is associated with both endogenous decisions regarding housing and labor supply. Hence, it is reassuring that the baseline model generates a sensible value for the wealth-to-income ratio. To avoid selection issue, I target unconditional means of housing asset share over the life-cycle in the estimation. As a model validation, I check the model fit for the life-cycle profiles of conditional housing asset share excluding zeros and the life-cycle profiles of total assets. These results are reported in Appendix A.7.

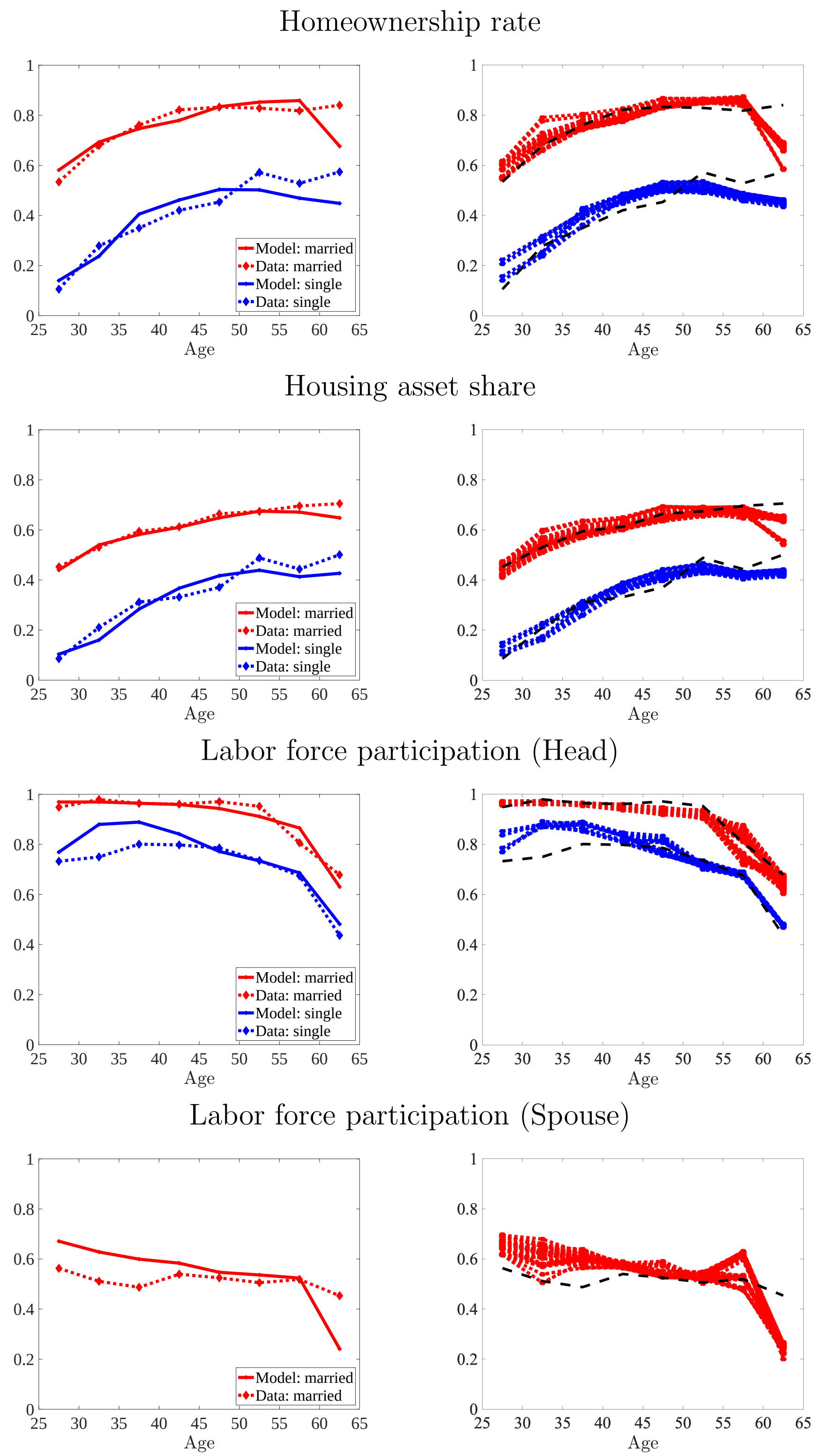

Figure 3: Life-cycle profiles (data *vs.* model)

Notes: Life-cycle profiles of homeownership, housing asset share, and labor force participation from the model and those from the data. (Left column) The model-generated life-cycle profiles are obtained with the posterior mean estimates. (Right column) The model-generated life-cycle profiles represented by the hairlines are with 100 different posterior draws that are equally distanced over the sampler. These predictive checks are compared to the black dashed lines that represent the data counterparts.

5 Findings

Given the estimated model, I can study the impact of marital transition probabilities to account for the change in housing variables. In addition to this change in marriage and divorce probabilities, other structural changes that may be key drivers of households' housing decisions occurred. The goal of this section is to quantify the explanatory power of the main channel while controlling for other changes that affect housing decisions studied in the literature.[33] I first apply structural changes between 1970 and 1995 one at a time to study each channel's effect on homeownership and housing asset share. These results are reported in Table 4. Then I show the prediction of the model when all channels reflect the year 1995's changes and compare it to the data in Table 5. Since marital transitions, which is the channel of interest in this paper, happen relatively early in life, I focus on the age groups from 25 to 44 years in this section.[34]

5.1 Impact of structural changes between 1970 and 1995

Marital transition probabilities. I use the age-dependent marriage and divorce probabilities as in Figure 2. The baseline life-cycle profiles are generated by using the marriage and divorce probabilities in 1970. In this decomposition exercise, I feed in the probabilities in 1995 instead, holding the other things fixed at the values of the baseline.

Homeownership rate of young singles become higher with lower marriage probabilities of 1995. It is because that the expected return on housing goes up as it is less likely to incur the transaction costs of selling or resizing associated with marital transitions. On the other hand, married households own home less with higher divorce probabilities of 1995. For both single and married households, it is worth noting that the gap between the baseline homeownership rate and the counterfactual one closes as I look at older ages. This captures the fact that the difference in marital transition probabilities between 1970 and 1995 is more

[33] A simple back-of-the-envelope calculation is often useful, but ex ante it is difficult to tell whether the result remains the same in an environment with endogenous responses of agents and market interactions without building and solving a structural model. Even if it may turn out that the significance of a mechanism based on the counterfactual analysis is similar to the back-of-the-envelope calculation, it does not mean that having a structural model is not meaningful. For example, the model sheds light on endogenous reactions of households given a change, which cannot easily be captured by a regression analysis or simpler calculations.

[34] The results from decomposition analysis and model prediction for all age groups from 25 to 64 years old are provided in Appendix A.8.

conspicuous for those in their 20s or 30s. Similarly, housing asset share of young singles increases whereas that of young married couples decreases. These adjustments in portfolios are mostly driven by the extensive margin (transitions from non-homeowners to homeowners or vice versa).[35]

	Age group					Age group				
Single households	25-29	30-34	35-39	40-44	25-44	25-29	30-34	35-39	40-44	25-44
	Homeownership					Housing asset share				
Baseline	14.0	23.7	40.5	46.1	31.0	10.3	16.0	28.3	36.7	22.8
Marital transitions	8.4	8.7	1.2	0.9	4.8	4.6	7.3	3.5	1.1	4.1
Downpayment constraint	5.4	5.5	4.8	4.7	5.1	6.1	5.4	4.2	4.9	5.1
Labor market volatility	0.1	-6.6	-13.0	-4.9	-6.1	0.0	-2.9	-6.6	-3.4	-3.2
Spousal labor participation	0.0	-0.1	-0.5	0.0	-0.1	0.0	-0.0	-0.5	-0.4	-0.2
Fertility	0.0	-0.0	-0.0	0.0	0.0	0.0	-0.0	0.0	0.0	0.0
Non-housing asset return	-0.2	-1.7	-2.2	-1.9	-1.4	-0.3	-1.8	-2.4	-2.7	-1.8
Housing price	-2.0	-2.2	-1.1	-1.8	-1.7	-1.9	-2.1	-1.3	-1.7	-1.6
	Age group					Age group				
Married households	25-29	30-34	35-39	40-44	25-44	25-29	30-34	35-39	40-44	25-44
	Homeownership					Housing asset share				
Baseline	58.1	69.3	74.6	77.9	69.9	43.9	53.9	58.1	61.0	54.2
Marital transitions	-4.8	-2.2	-1.9	-1.3	-2.5	-3.1	-2.1	-1.5	-1.4	-2.0
Downpayment constraint	1.7	1.9	2.0	2.2	1.9	2.8	2.9	4.0	4.8	3.6
Labor market volatility	1.0	0.0	0.8	2.2	1.0	-0.4	-0.6	-0.7	0.4	-0.3
Spousal labor participation	10.0	7.0	6.4	5.9	7.3	6.9	4.7	4.1	3.6	4.8
Fertility	-2.5	-0.0	0.0	0.0	-0.6	-1.1	-0.1	-0.0	0.0	-0.3
Non-housing asset return	-5.4	-3.2	0.5	2.2	-1.4	-3.6	-2.6	-0.7	0.2	-1.6
House price	-6.5	-2.8	-2.0	-1.4	-3.1	-3.6	-2.7	-1.6	-1.2	-2.2

Table 4: Effect of structural changes on housing decisions

Notes: The rows named "Baseline" show the housing variables under the 1970 baseline. In comparison to the baseline, the other rows show the incremental changes (in percentage points) obtained from applying structural changes in 1995. For instance, the rows "Marital transitions" show the effect of changing marital transition probabilities from the 1970's values to the 1995's values, holding everything else the same as the baseline.

Downpayment constraint. The downpayment constraint was relaxed in 1995 compared to 1970. Fisher and Gervais (2011) point out the average downpayment in the 1990s was about two-thirds of the average value in the 1970s. I change the parameter η accordingly that governs the tightness of the borrowing constraint $b' \geq -\eta P^H h'$.

[35] In other words, the conditional housing asset share (of homeowners) does not change much given the changes in likelihood of marital transitions as reported in Appendix A.8 (Table A-8).

Relaxing the downpayment constraint has a positive effect on homeownership of young single households. For married households, relaxing credit constraints has a positive impact on homeownership but with a smaller magnitude. Housing asset shares change in the same direction: increase for both single and married households. This is in contrast to the effect of changing marital transition probabilities that moves the housing variables of singles and those of married couples in the opposite direction. In addition to the extensive margin, the adjustments in portfolios also involves the changes in intensive margin that homeowners tilt their portfolio further towards housing assets (Table A-8 in the appendix).

Labor market volatility. The increase in labor market volatility is widely documented as in Fisher and Gervais (2011) and Santos and Weiss (2013). The parameters associated with earnings risk are σ_x and $\sigma_{\tilde{x}}$. The parameters for 1995 are set to reflect the 40% increase in volatility from 1970 to 1995 as reported in Fisher and Gervais (2011).

Income risk exerts two opposing forces on homeownership. On the one hand, it is valuable to delay buying a house until a household can afford it due to the large transaction cost and income risk. On the other hand, the increase in idiosyncratic risk raises precautionary savings. These savings can induce more transition from renting to home purchase, thereby increasing the homeownership rate.

Homeownership and housing asset share of singles in their 20s show little change. Negative effect of income risk on homeownership is counteracted by precautionary savings motive that is stronger for young singles. However, at older ages, precautionary savings motive is dominated by the value of delaying the home purchase against labor market volatility. Except for those in their 20s, both homeownership and housing asset share of single households decrease with the increased income risk. For married households, both head and spouse face increased labor market risks that strengthen precautionary savings motive compared to singles. The two opposing forces, stronger precautionary savings motive and avoiding lumpy home purchase with increased risk, seem to cancel out, which results in only small changes in homeownership and housing asset share for married households. In contrast, the conditional asset share falls for married homeowners. They tilt their portfolio to have a smaller share of assets held in illiquid housing. More significant effect of income risk channel appears along the intensive margin for married couples.

Spousal labor productivity and fixed cost of working. From 1970 to 1995, the gender wage gap shrank and the labor force participation of spouses increased substantially. Heathcote et al. (2010) show that the average female wage increased by about 12% from 1970 to

1995 whereas the average male wage does not show a clear increasing pattern. I set the value of $\widetilde{\chi}(j)$ in 1995 to reflect this change while fixing the household head's $\chi(j)$. However, the labor productivity change is not sufficient to generate the observed change in spousal labor force participation. Therefore, I also change the parameter $\widetilde{\phi}$ governing the fixed cost of working. $\widetilde{\phi}$ is set to be lower in 1995 so that the average spousal labor force participation rate matches 0.66 in 1995.[36]

As more spouses participate in the labor force with higher wages, homeownership and housing asset share of married couples increase. Among all the structural changes considered, this channel has the biggest positive effect on the married couples' housing variables. The average homeownership rate of married couples from age 25 to 44 is about 70%, and the change in spousal labor participation channel induces around 10% increase in homeownership rate. A similar magnitude of increase is observed for housing asset share of young couples. As expected, single households' housing variables change little with the change in spousal labor participation.

Fertility. Fertility declined between 1970 and 1995. According to the UN World Population data, the fertility rate for the US was 2.33 births per woman in 1970 and it was 2.01 births per woman in 1995. In the model, φ_j varies over the life-cycle to capture the changing size of married households. When calibrating φ_j, the average number of children across age groups from the 1970 Census data is used. For the decomposition analysis, I reduce it by 15% to reflect the fertility decline in 1995.

Reduction in φ_j decreases the marginal utility of housing services. With 15% reduction in fertility, it is shown that the homeownership rate of married households in their 20s is reduced by 2.5 percentage points. Similarly, housing asset share falls by 1.1 percentage points for couples in their 20s. The change in housing asset share is driven by the extensive margin that young couples in their 20s refrain from home purchase. There is not much change observed for married couples in the other age groups and for single households.

Non-housing asset return. In the model, I only model two types of assets: housing assets and non-housing assets (as safe assets).[37] Between 1970 and 1995, the return on bills and

[36]This counterfactual experiment mimicking the increase in spousal labor participation also generates the fall in married heads' labor force participation as observed in the data: the average labor force participation rate for married heads aged 25-44 falls to 0.92 from 0.96 in the 1970 baseline. This change is similar in magnitude to the data pattern.

[37]I do not model risky financial assets additionally for two reasons. First, the holding of risky financial

government bonds increased whereas the return on housing assets did not show an increasing pattern as reported in Jordà et al. (2019). In order to consider this change in non-housing asset return, I use the interest rate $r = 0.03$ for the year 1995 compared to the baseline value $r = 0.02$ per annum. $r = 0.03$ is close to the risk-free rate for the period 1980-1999 in Caballero et al. (2017) based on the real return on US treasuries.

Increase in non-housing asset return has two opposing effects on housing decisions. Households change their portfolio decision to save more instead of buying houses. However, more savings could induce transition from renting to home purchase. Over the life-cycle, which force dominates the other could differ. Young married households in their 20s and early 30s, especially those who borrow to buy a house under the baseline, defer buying a house since savings return is higher. That is why we see the reduction in young married couples' homeownership until the age 34 and then a small increase in homeownership. A similar pattern is observed for housing asset share where most action is coming from the extensive margin. In comparison, the increase in non-housing asset return is shown to reduce housing demand for single households for the age 25-44. Singles adjust their portfolio to invest in non-housing assets more, which results in the fall in housing variables along both extensive and intensive margin.[38]

House price. House price increases between 1970 and 1995. I consider the 6% increase in house price in the decomposition analysis that is consistent with the data pattern of the Shiller house price index.[39]

The increase in house price makes the smallest house to be owned more expensive. Keeping the same grid for housing, increased house price has a negative effect on housing variables

assets did not change much between 1970 and 1995. For instance, from the Survey of Consumer Finances data, the risky financial asset share including stocks and mutual funds was 0.053 in 1970 and 0.059 in 1995 for the age group 25-44. Also, as reported in Jordà et al. (2019), the average real rates of return on equity shows mean-reverting movements around 8 percent between 1970 and 1995. Since most of young households did not hold risky financial assets and the associated return did not show an increasing trend over the period of study, I do not separately model them as additional assets.

[38]The decrease in conditional share is observed with the change in non-housing asset return as in Table A-8 in the appendix.

[39]According to Corbae and Quintin (2015), the year 1970 and 1995 belong to the "normal house price" regime in contrast to housing boom between 1999 and 2006. Looking at a longer history of the Shiller home price index from the 1950s until right before the housing boom, one could model 1970 and 1995 with the same house price that represents the historical mean over this period. In this case, decomposition analysis regarding house price change is not necessary.

of single and married households. The effect is larger for younger households. As Fisher and Gervais (2011) mention, if I shift the grid for housing to the left by 6% by allowing for individuals to economize on the size of the house under a higher price, then the reduction in homeownership will be negligible since the housing expenditures will be the same regardless of the house price change.

5.2 Model prediction and data

Starting from the baseline that reflects the year 1970's economy, I apply all the structural changes considered above to generate the prediction of housing variables for the year 1995. Table 5 shows the results for homeownership and housing asset share across marital status.

Age	Data			Model			Data			Model		
group	1970	1995	Change	1970	1995	Change	1970	1995	Change	1970	1995	Change
	Homeownership of single households						Housing asset share of single households					
25-29	10.5	24.3	13.7	14.0	22.4	8.4	8.5	17.3	8.7	10.3	17.5	7.2
30-34	27.8	33.9	6.0	23.7	25.7	2.0	21.0	25.7	4.7	16.0	20.7	4.7
35-39	34.9	43.8	8.8	40.5	42.0	1.5	31.1	36.6	5.4	28.3	29.5	1.2
40-44	42.0	51.0	9.0	46.1	51.9	5.8	33.1	42.2	9.0	36.7	38.5	1.7
25-44	28.8	38.2	9.3	31.0	35.5	4.4	23.4	30.4	6.9	22.8	26.5	3.7
	Homeownership of married households						Housing asset share of married households					
25-29	53.3	52.1	-1.2	58.1	54.3	-3.7	45.2	37.5	-7.6	43.9	41.9	-2.0
30-34	67.9	65.4	-2.5	69.3	66.3	-3.0	53.0	48.2	-4.8	53.9	52.0	-1.9
35-39	76.0	70.8	-5.2	74.6	73.2	-1.4	59.4	51.5	-7.8	58.1	57.8	-0.3
40-44	82.1	76.6	-5.5	77.9	80.4	2.4	61.2	61.3	0.1	61.0	62.4	1.4
25-44	69.8	66.2	-3.6	66.9	68.5	-1.4	54.7	49.6	-5.0	54.2	53.5	-0.7

Table 5: Housing decisions in 1970 and 1995 (data *vs.* model)

First, the model is able to account for a significant fraction of the increase in young singles' homeownership (about 60% of the data's change for the age group 25-29, and about 33% of that for the age group 30-34).[40] The model's prediction for the change in singles' housing asset share coincides closely with what happened in reality for young singles younger than 35 years old. For the age group 35-44, the signs of changes in housing decisions are correctly predicted but the explanatory power of the model is smaller. From Table 4, the

[40]My results improve on Fisher and Gervais (2011) that matched the fall in married households homeownership rate but was not able to match the increase in singles' homeownership rate.

main drivers for the increase in singles' homeownership are the changes in marital prospects and downpayment constraint. The marital transition channel plays a bigger role for the age group 25-34 whereas the relaxed downpayment constraint influences more the age group 35-44. For housing asset share of singles of age 25-44, the relaxed downpayment constraint alone predicts an increase by 5 percentage points whereas the change in marital transitions predicts an increase by 4 percentage points on average. The downpayment constraint predicts a higher increase for the share variable because it induces both extensive and intensive margin adjustments in household portfolios whereas the effect of marital transition shocks is mostly associated with the extensive margin.

For married households, the model correctly predicts the decline in homeownership for age 25-39.[41] The average decline in homeownership predicted by the model for the age 25-39 is close to the average decline observed in the data (-2.7 percentage points vs. -3 percentage points). From Table 4, the drivers that exert negative effects on couples' homeownership include changes in marital transitions, fertility, non-housing asset return, and house price. The marital transition channel predicts a decline in homeownership rate by 2.5 percentage points on average for the age group 25-44. The magnitude of the effect of marital transitions is similar to that of increased house price. Furthermore, to correctly forecast the decline in housing asset share, the marital transition channel plays a significant role. In fact, the model is not able to predict the decline in couples' housing asset share when I apply all the changes to mimic the 1995 economy except for the change in marital prospects. The effect of marital transition changes alone on the average housing asset share of age 25-44 is a decline by 2 percentage points that is similar to the prediction by the house price channel. However, it is worth noting that house price channel influences the housing decisions of singles and married households in the same direction whereas the marital transition channel's effect operates in the opposite directions across marital status.

6 Discussion

I provide discussion on the assumptions adopted in this paper and some other potential alternative channels abstracted in the main analysis.

[41] The model's inability to explain the fall in homeownership for the age 40-44 is a concern that future research should address.

Exogeneity of marriage and divorce. I model marriage and divorce as exogenous shocks that households face. This has the limitation of not allowing for the reverse causality (housing decisions affect marital transitions) and for another factor to drive both housing decisions and marital status.[42] An advantage of my approach is that, by keeping marital transitions exogenous, I can build a tractable dynamic life-cycle framework and conduct a straightforward decomposition analysis to compare the effect of marital transition shocks to various other factors that potentially drive housing decisions. Modeling marriage and divorce as exogenous shocks is similarly adopted in Cubeddu and Ríos-Rull (2003) and Fernández and Wong (2014). I improve on previous literature by explicitly modeling marital transitions in a structural model with couples and singles to study their housing decisions although I do not endogenize marriage and divorce as in Mazzocco et al. (2013) and Voena (2015).[43] If I endogenize marriage and divorce, I will need to model underlying structural shocks that affect marital decisions. What underlying shocks to add and how to design a decomposition analysis with time-varying marriage and divorce become less clear.

Marital transition probabilities with cohort effects. In the baseline analysis, the probabilities of getting married and getting divorced are estimated while abstracting cohort effects. I construct the marital transition probabilities with cohort effects in Appendix A.4. These probabilities are constructed so that, for instance, a single individual of the age group 25-29 in 1970 faces the year 1995's marriage probability at the age group 50-54. Compared to the baseline in 1970, the marriage probabilities with cohort effects are lower and the divorce probabilities are higher. With these marital prospects, singles own home more whereas married couples invest less in housing. It is left for future research to study the change in marital transition probabilities and its effect on housing decisions for different cohorts.[44]

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[42]There has been some research on the effect of homeownership on marriage decisions. Recently, Wei et al. (2017) show some evidence that owned housing serves as valuable status good in the marriage market in China. Farnham et al. (2011) raise the possibility that house price changes affect divorces over the recent boom-bust periods. Devising a model to analyze how housing influences marital transitions is an intriguing possibility, but it is beyond the scope of this paper and I leave it for future research.

[43]Mazzocco et al. (2013) and Voena (2015) do not model the life-cycle aspect and do not separate savings in housing and non-housing assets. In addition, they do not attempt to study the effects of different mechanisms on household decisions over time. This may result from these models with limited commitment being computationally demanding and difficult to design a decomposition analysis of competing channels. Although these papers do not focus on explaining changes over time as my paper does, they provide valuable insights on the link between labor supply, savings, and marital decisions.

[44]We could think of constructing the marital transition probabilities for those who were 25-29 years old in 1995. For this cohort's housing decisions over the life-cycle, however, we need data over the 2000s when

Continuation value in retirement. Since the central focus of my paper is the effect of marital transition shock that mostly affects younger households, I keep the retirement period simple without having any shocks as in Fernández and Wong (2014).[45] The continuation value is modeled as $V^{fin}(b', h') = \frac{1-\beta^4}{1-\beta} \cdot \frac{A^{(1-\sigma)}}{1-\sigma}$ with a constant amount of consumption $A = (b' + P^H h')\frac{1-\beta}{1-\beta^4}$. In fact, this specification plays a similar role as commonly-used bequest utility $V^{bequest}(b', h') = \delta_1 \frac{(\delta_2 + (b' + P^H h'))^{1-\sigma} - 1}{1-\sigma}$ where δ_1 is a scale parameter and δ_2 represents the threshold below which the agent does not leave any bequests (De Nardi, 2004; De Nardi et al., 2010; Lockwood, 2018). With the current specification, agents do not deplete all their housing assets although I acknowledge that my model is insufficient to match closely the homeownership rate in the terminal period.

Certain elements of retirement may have changed to affect housing decisions over the life-cycle. Between 1970 and 1995, out-of-pocket medical expenses increased but pension payments increased even more.[46] In Appendix A.12, I conduct a counterfactual analysis in which the increase in pension payments net of medical costs is reflected before computing a constant consumption amount during retirement. Housing demand falls in the terminal period but the magnitude of change in housing variables over the life-cycle turns out to be not so substantial. More thorough exploration for old-age housing decisions is left for future research.

Mobility. The previous literature on life-cycle models with housing has incorporated age-dependent moving probabilities in reduced form.[47] A potential reason for changes in housing demand is that households' likelihood of mobility may have changed. If people move more

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housing boom-bust happened. This topic is beyond the scope of my paper.

[45]They study the life-cycle model of female labor force participation with divorce and wage shocks for the working-age population. Without facing any shocks, retirees make a consumption-savings decisions while receiving a constant pension.

[46]The life expectancy in 1970 was 70.8 years whereas that in 1995 was 75.62 years according to the data from World Bank. This corresponds to an increase in terms of one model period. When I extend the remaining life in retirement to be one period longer for 1995, the life-cycle profiles of homeownership rate do not change much. For this reason, I do not consider the change in longevity.

[47]In Appendix A.9, I postulate a simple model with moving probabilities and compare the outputs from this model to the results in the main text. Under the simpler model without marital transitions, singles are subject to moving shock and there is no buffer provided by pooled assets with a potential spouse. In this regard, investing in home while being single is less attractive under the simpler model. In contrast, the model with moving probabilities deliver higher homeownership rate and housing asset share for married couples. This is because assets are not destructed by half as in the case of divorce and the economies of scale within marriage is still kept with moving.

frequently and each moving involves spending in home transaction costs, this will lower homeownership. However, the CPS Geographical Mobility report documented that the probability that an individual moves did not change much between 1970 and 1995.[48] That is why I do not consider the likelihood of mobility as one of key structural changes happened over the period of interest.

However, starting from late 1990s, interstate migration of working-age adults has declined as documented in Kaplan and Schulhofer-Wohl (2017) and Guler and Taşkin (2018). Guler and Taşkin (2018) report that the dual earner moving rate dropped by 50% whereas the drop in single earner moving was 39% from 1981 to 2012. How the change in mobility affects housing demand in more recent periods is left for future research.

Confounding reforms. Some important bills related to housing decisions were passed between 1970 and 1995 that are abstracted in the paper. First, the 1986 tax reform regarding mortgage interest deductibility shifted the incentives to take up mortgages. Other changes were also made to the tax code in 1986 that lowered incentive to own home. For example, Poterba (1992) states that the marginal tax rates declined substantially for high-income individuals which lowered the benefits to the mortgage interest tax deduction. In this regard, it is unclear how the tax reform in 1986 changed the housing demand. This issue is beyond the scope of this paper and I leave this question to future research.[49]

The Equal Credit Oppotunity Act (ECOA) was related to the relaxation of LTI constraint for married couples and may have improved labor supply incentives for spouses. In my model, the LTI constraint is written as $b' \geq -\nu(wyl + w\widetilde{yl})$ combining both spouses' labor income. When I conduct a counterfactual experiment to relax the LTI constraint by multiplying 2 in front of wife's labor income in the spirit of ECOA, this barely change married couples' housing variables. For instance, homeownership rate increases by 0.2 percentage points for the age group 25-29.[50] Hence, I decide to abstract this reform from my analysis.[51]

[48]An individual's moving probability from the previous year was 22% in the mid 1970s and 20% in the mid 1990s.

[49]Gervais (2002) shows that the removal of mortgage interest deductibility induces only a small change in aggregate homeownership rates. This is because mortgage interest deductions represent only a small fraction of one's tax burden.

[50]This result is in line with Bottazzi et al. (2007) where the simulated homeownership rates show only modest increases even with substantial relaxation in LTI constraint (when $\nu = 3$ changed to $\nu = 10$ for example).

[51]I do not have long-term mortgages in my model and they may have different implications for housing decisions with the confounding reforms. I leave this as an open question to be explored in future research.

Inheritances or gifts from parents. As discussed in Wolff (1999), the primary recipients of inheritances or gifts are of age from 45 years old. Since the 1980s with seminal papers such as Kotlikoff and Summers (1981) and Modigliani (1988), how much inheritance matters for wealth accumulation has been controversial. Recently, Alvaredo et al. (2017) study the evolution of the share of inherited wealth in aggregate private wealth in the US, and the share of inherited wealth is shown to change little over the 1970-1995 period. Hence, I abstract from these intergenerational gifts or transfers in my analysis.

7 Conclusion

The prospects of marriage and divorce have changed dramatically over the past decades. For instance, the average marriage probability for singles between ages 25 and 64 fell by more than 30%. The average divorce probability more than doubled from the 1970s to the 1990s. Yet, during this period the rate of homeownership remained roughly constant, which seems puzzling given that marriage and divorce are linked to housing and portfolio choices. By closely looking at the homeownership rate and the composition of assets conditional on marital status, this paper uncovers a major shift in housing demand and further shows that the evolving likelihood of marriage and divorce is an essential factor in explaining how housing decisions have changed in the United States.

I study two representative years — 1970 and 1995 — when real house prices were similar in level but the marriage and divorce probabilities differed substantially. Comparing these two years, the micro data show that single households' homeownership increased for all age groups and young married households' housing asset share decreased. I conjecture that these changes in housing variables could be affected by the change in the likelihood of marital transitions. A single person who is likely to get married soon will wait to buy a house with a spouse because it is costly to sell or resize a house. For a married couple, a high probability of divorce will prevent them from investing in housing because it is more difficult to split a house than liquid assets.

To quantify what fraction of the observed change in homeownership and housing asset share can be explained by the change in marital transitions, I build a life-cycle model of single and married households that face age-dependent exogenous marital transition shocks. In times of getting married or divorced, a substantial transaction cost is modeled to arise because housing is a highly idiosyncratic investment, and a marital status change is likely to make the house owned prior to the change no longer suitable. In addition, the model includes features to incorporate a comprehensive list of structural changes in borrowing constraints, earnings risk, spousal productivity, fertility, non-housing asset return, and house price.

I estimate the parameters of the model by a limited information Bayesian method to match the moments from 1970's cross-section data. Then I conduct a decomposition analysis by feeding the 1995's marriage and divorce probabilities to the model. The declined likelihood of marriage is shown to be a key driver to generate the increase in young singles' housing demand. The increase predicted by this channel is close to what the relaxed downpayment constraint channel delivers. In contrast, the increased divorce likelihood contributes to predict the decline in housing variables for married couples. Its effect is of a similar magnitude with the influence of the increased house price. My analysis sheds light on the quantitative significance of the change in marital transition prospects in accounting for the change in housing demand.

Lastly, since marital transitions and housing decisions are complex problems in life, my model abstracts from some interesting dimensions to explore. An advantage of my approach is that, by keeping marital transitions exogenous, I can build a tractable dynamic life-cycle framework and conduct a straightfoward decomposition analysis. This assumption has the limitation of not allowing for the reverse causality (housing decisions affect marital transitions) and for another factor to drive both housing decisions and marital status. It is beyond the scope of this paper and I leave it for future research.

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Online Appendix: The Role of Changing Marital Transitions in Housing Decisions

Minsu Chang

A Data – Further Details

A.1 Variable construction

(1) Year 1995

I use the 1995 Survey of Consumer Finances (SCF) available on the Federal Reserve's website. I drop the observations if the age of the head is less than 25 and more than 65. Since its redesign in 1983, the SCF consists of two samples. The first sample is drawn using area probability sampling of the entire U.S. population based on Census information. The second sample is drawn based on tax information used to identify households at the top of the wealth distribution. This two-frame sampling scheme yields a representative coverage of the entire population, including wealthy households. To get rid of outliers, I drop the observations with total asset level greater than 95% percentile. The following shows how each variable is constructed using the SCF data.

- checking account = X3506 + X3510 + X3514 + X3518 + X3522 + X3526
- savings account = X3804 + X3807 + X3810 + X3813 + X3816
- mutual funds = X3824 + X3826 + X3828 + X3822 + X3830
- stocks = X3915 + X7641
- bonds = X3902 + X3906 + X3908 + X3910 + X7633 + X7634
- life insurance = X4006
- IRA = X3610 + X3620
- certificate of deposit = X3721

- value of housing = X513 + X526 + X604 + X614 + X623 + X716 + X1706 + X1806 + X1906
- mortgages and HELOCs = X1715 + X1815 + X1915 + X805 + X905 + X1005 + X1044 + X1108 + X1119 + X1130 + X1136
- net value of housing = value of housing - mortgages and HELOCs
- total asset = checking account + savings account + mutual funds + stocks + bonds + life insurance + IRA + certificate of deposit + net value of housing
- homeownership dummy = 1 if value of housing > 0
- housing asset share = $\begin{cases} \text{net value of housing/total asset} & \text{if total asset} > 0 \\ 0 & \text{if total asset} = 0 \end{cases}$

(2) Year 1970

Survey of Consumer Finances (SCF). I use the 1970 Survey of Consumer Finances (SCF) that was conducted by the Economic Behavior Program of the Survey Research Center at the University of Michigan. The raw data can be downloaded from the Inter-University Consortium for Political and Social Research (ICPSR), at the Institute for Social Research in Ann Arbor. The historical survey contains the variables that are used to construct housing asset share and homeownership rate. It also includes demographic information including age, sex, marital status, and educational attainment. The historical SCF sample before 1983 is not supplemented by the second sample, so wealthy households are likely to be under-represented. Similar to the re-weighting procedure described in Kuhn et al. (2018), I identify the observations belonging to the top 5% of the total asset distribution. Then I increase the survey weights for these households so that 2% of wealthy households are added to the original sample. The remaining weights are adjusted. Once this is done, I drop the observations with a total asset level greater than 95% percentile under the new weights. The following shows how each variable is constructed with this data.

- checking account = V334
- savings account = V333

- mutual funds = V335
- stocks = V336
- bonds = V337 + V338
- life insurance = V275
- certificate of deposit = V332
- net value of housing = V150 + V339 - V340
- total asset[52], homeownership dummy, housing asset share are analogously defined as with the 1995 SCF.

Panel Study of Income Dynamics (PSID). The Panel Study of Income Dynamics (PSID) data is the longitudinal household survey. The 1970 PSID data does not provide a detailed breakdown of households' portfolios into different assets. However, the net value of housing can be constructed as V1122-V1124 and a homeownership dummy can be set to 1 if V1122$>$ 0. Non-housing asset is required in order to construct housing asset share variable. To do so, I use the cross-imputation strategy as described in Section 2.2. Table A-1 shows the summary statistics from the data sets in 1970 and 1995.

[52] There is no IRA variable for 1970. Traditional IRA was introduced with the Employee Retirement Income Security Act of 1974 (ERISA) and made popular with the Economic Recovery Tax Act of 1981.

Panel A. Mean of variables

	Year 1970		Year 1995
Variables	PSID	SCF	SCF
Marriage rate	0.75	0.78	0.55
Age of head	43.82	43.88	42.61
Age of spouse	39.9	40.36	40.64
Education of head	4.26	4.24	4.41
Housing asset share	0.54*	0.54	0.49
Homeownership rate	0.67	0.66	0.66
Employment rate (head:M)	0.94	0.9	0.84
Employment rate (head:S)	0.69	0.67	0.72
Employment rate (spouse:M)	0.52	0.51	0.66
Weekly hours worked (head:M)	43.31	43.67	40
Weekly hours worked (head:S)	27.89	29.44	32.13
Weekly hours worked (spouse:M)	17.68	8.47	25.69
Number of observations	3267	1764	2408

Panel B. Moments of housing asset share

Housing asset share (Year 1970)	PSID	SCF
Mean	0.54*	0.54
Median	0.73*	0.71
Standard Deviation	0.44*	0.41

Table A-1: Summary statistics (1970 vs. 1995)

Notes: M stands for married and S stands for single. Education of the head is a categorical variable (1: 0-5 grades, 2: 6-8 grades, 3: 9-11 grades, 4: 12 grade/ complete high school, 5: complete college, 6: post graduate studies). The value with asterisk(*) is obtained from cross-imputation similar to Blundell et al. (2006).

	(1)	(2)	(3)	(4)
Marital status dummy	0.192***	0.185***	0.192***	0.185***
	(0.067)	(0.069)	(0.067)	(0.069)
Age	0.023***	0.023***	0.023***	0.023***
	(0.003)	(0.003)	(0.003)	(0.003)
Education	0.068***	0.068***	0.068***	0.068***
	(0.015)	(0.015)	(0.015)	(0.015)
Hours worked	0.003*	0.003	0.004*	0.004*
	(0.002)	(0.002)	(0.002)	(0.002)
Homeownership dummy	3.835***	3.832***	3.837***	3.834***
	(0.059)	(0.059)	(0.059)	(0.060)
Non-housing assets	0.131***	0.132***	0.132***	0.133***
	(0.015)	(0.015)	(0.015)	(0.015)
Children dummy	—	0.024	—	0.025
	—	(0.061)	—	(0.061)
Employment dummy	—	—	-0.075	-0.075
	—	—	(0.103)	(0.103)
Constant	-3.098***	-3.124***	-3.067***	-3.094***
	(0.177)	(0.189)	(0.182)	(0.194)
Observations	1570	1570	1570	1570
Adjusted R^2	0.794	0.794	0.794	0.794

Table A-2: Regression Analysis (SCF 1970)

Notes: * p-value $<$ 0.10, ** p-value $<$ 0.05, *** p-value $<$ 0.01. Standard errors are in parentheses.

A.2 Life-cycle profiles in 1970 and 1995 before filtering out composition changes

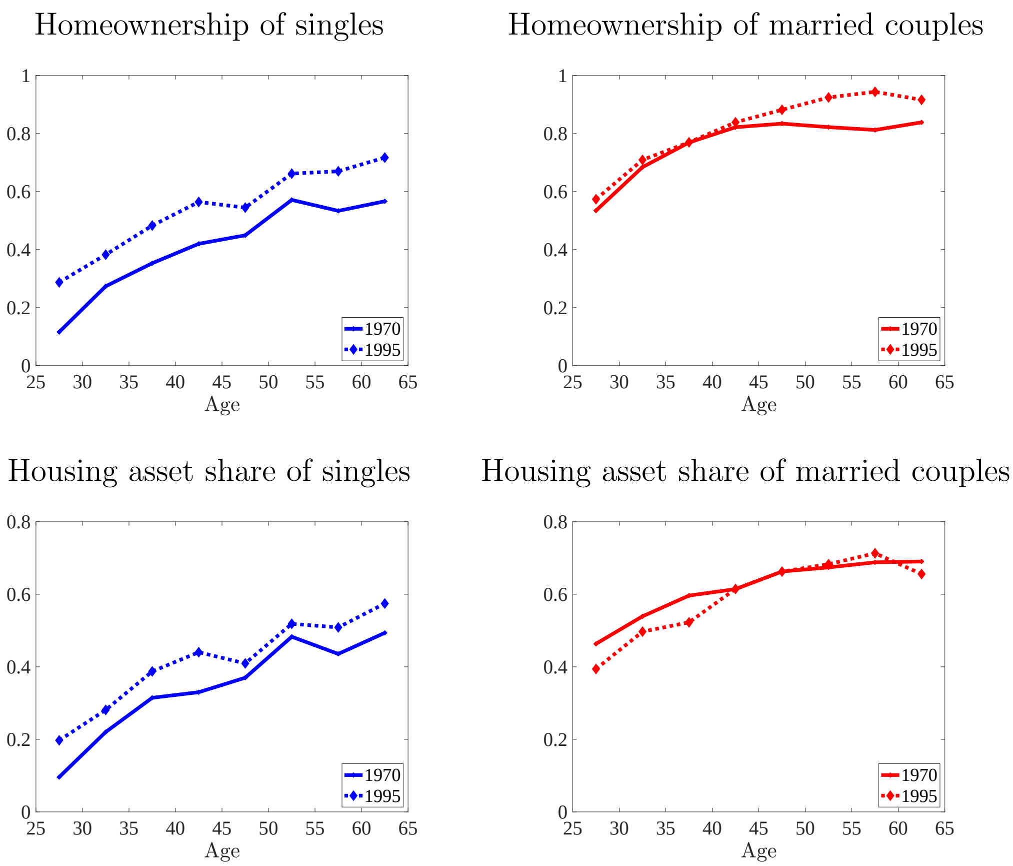

Figure A-1: Homeownership rate and housing asset share

Notes: The average homeownership rate and the average housing asset share across different age groups. The solid lines are constructed from the 1970 data and the dashed lines are from the 1995 data. The x-axis stands for the age of household head.

Figure A-1 shows the life-cycle profiles of homeownership and housing asset share in 1970 and 1995. They are drawn without controlling for potential composition changes from education and assets. In order to control for them, I regress either homeownership or housing asset share on marital status, education of the head, and non-housing assets. Education of the head is a categorical variable (1: 0-5 grades, 2: 6-8 grades, 3: 9-11 grades, 4: 12 grade or complete high school, 5: complete college, 6: post graduate studies.) Non-housing assets is constructed by subtracting net housing value from total assets.

	Dependent variable			
	Homeownership rate		Housing asset share	
	1970	1995	1970	1995
Marriage dummy	0.273***	0.281***	0.225***	0.215***
	(0.026)	(0.018)	(0.023)	(0.016)
Education	0.016***	0.023**	0.010*	0.010
	(0.006)	(0.009)	(0.005)	(0.008)
Non-housing assets	6.43e-06***	1.72e-06***	-6.18e-06***	-1.24e-06***
	(1.19e-06)	(2.09e-07)	(1.03e-06)	(1.85e-07)
Constant	0.352***	0.369***	0.356***	0.353***
	(0.033)	(0.041)	(0.028)	(0.036)
Adjusted R^2	0.0822	0.1331	0.0695	0.0754

Table A-3: Regression results

Notes: * p-value < 0.10, ** p-value < 0.05, *** p-value < 0.01. Standard errors are in parentheses. The Survey of Consumer Finances data is used to generate this table.

Based on these regression results, I obtain the life-cycle profile of each housing variable after filtering out the change in conditional mean accounted for by education and non-housing assets between 1970 and 1995. As a result, I obtain the life-cycle profiles used in the main text displayed in Figure 1.

A.3 House price index

Figure A-2 shows the real home price index by Shiller (2015). Despite some swings from 1970 to 1995, the real home price index seems to be mean-reverting when we look at a longer history from the 1950s.[53] In addition, the index on rent-price ratio stayed quite stable between 1970 and 1995 as reported in Gallin (2008). Hence, I choose 1970 and 1995 as

[53]This reasoning is in line with Corbae and Quintin (2015): the real home price is approximated with three-point process where the 1940-1998 time spans as periods with the intermediate price value. The period between 1999 and 2006 is with the high price and the period between 1920 and 1939 is with the low price.

two periods with similar house prices, but with substantially dissimilar likelihood of marital transitions. In the decomposition analysis of Section 5, I consider the slight increase in house price by 6% as one structural change for the year 1995 compared to 1970.

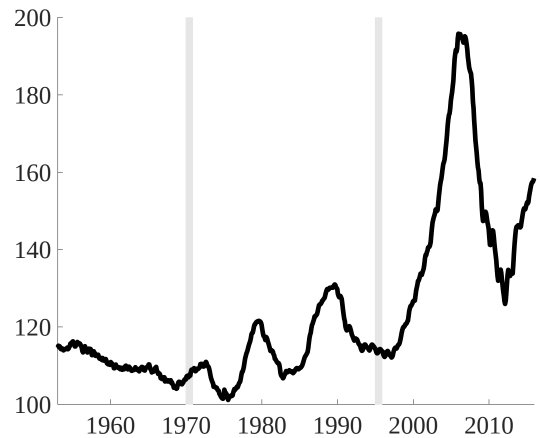

Figure A-2: Real home price index

Notes: The solid line is the real home price index from Shiller (2015). The raw data is available online at http://www.econ.yale.edu/ shiller/data.htm. The shaded gray areas stand for the year 1970 and the year 1995.

A.4 Marital transition probabilities with cohort effects

I construct marriage and divorce probabilities taking into account cohort effects using data until the year 1995. From Figure A-3, the marriage probabilities with cohort effects considered are lower than the baseline probabilities. In contrast, the divorce probabilities are higher when cohort effects are considered. I conduct a sensitivity analysis by feeding in these probabilities (with cohort effects) to the model.[54]

Table A-4 compares the housing variables from the baseline abstracting cohort effects to those from the model with cohort effects. With lower marriage probabilities with cohort effects, singles own home more and housing asset share increases. On the other hand, with higher divorce probabilities with cohort effects, married couples' homeownership rates as well as housing asset share decline.

[54]Since I use the data until the year 1995, I use the age-dependent probabilities from the 1995's cross-section for age groups 50-64.

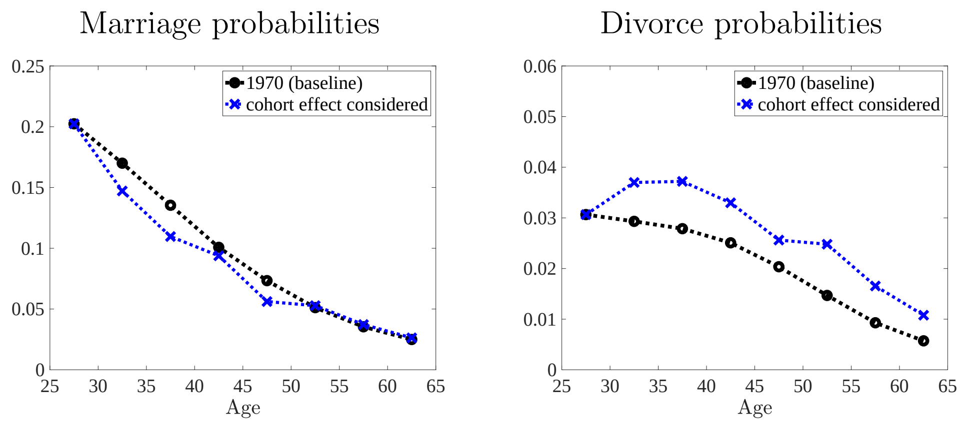

Figure A-3: Marriage and divorce probabilities

Notes: The black dotted lines are the same as the baseline where the cohort effect is abstracted. The blue lines with x-mark denote the probabilities where the cohort effect is considered. In other words, a single individual of the age group 25-29 in 1970 faces the year 1995's marriage probability at the age group 50-54.

	Age group					Age group				
Single households	25-29	30-34	35-39	40-44	25-44	25-29	30-34	35-39	40-44	25-44
	Homeownership					Housing asset share				
Baseline	14.0	23.7	40.5	46.1	31.0	10.3	16.0	28.3	36.7	22.8
Prob. with cohort effects	14.1	25.8	42.6	48.3	32.7	10.3	17.4	30.0	38.3	24.0
	Age group					Age group				
Married households	25-29	30-34	35-39	40-44	25-44	25-29	30-34	35-39	40-44	25-44
	Homeownership					Housing asset share				
Baseline	58.1	69.3	74.6	77.9	69.9	43.9	53.9	58.1	61.0	54.2
Prob. with cohort effects	55.3	68.9	74.2	77.6	69.0	42.4	53.3	57.6	60.6	53.4

Table A-4: Housing decisions from the baseline and from the model with marital transition probabilities with cohort effects

A.5 Marital transition probabilities with confidence bands

Figure A-4 shows the estimated age-dependent marriage and divorce probabilities. The black lines are the mean probabilities used in the main analysis (baseline), and the blue lines show the 95% confidence bands. Still, the decline in marriage probabiltiies for young singles and the increase in divorce probabilities hold with uncertainty in the estimates taken into account.

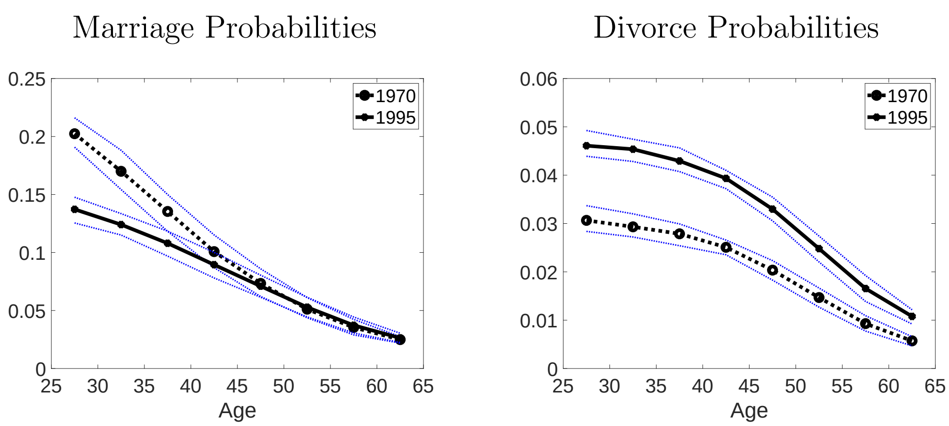

Figure A-4: Marriage and divorce probabilities

Notes: Marriage probability at age t is constructed from $Pr(Married_{t+1} = 1|Married_t = 0, Z_t)$ where Z_t include age and squared age similar to Borella et al. (2021). Divorce probability at age t is from $Pr(Divorced_{t+1} = 1|Married_t = 1, Z_t)$ where Z_t include age and squared age. The blue dotted bands represent 95% confidence bands.

As robustness check, I use the lower bound values in the confidence bands to represent marriage and divorce probabilities (smaller risks faced by households). Compared to the results reported in the main text (Table 4), the baseline values for housing decisions increase for both singles and married couples only slightly. Also, the decrease in marriage probabilities and the increase in divorce probabilities are shown to increase singles' homeownership rate whereas putting the downward pressure for married couples'. The effects of marital transition channel turn out to be similar in magnitude regardless of whether I use the mean probabilities or the lower bounds from the confidence bands.

	Age group					Age group				
Single households	25-29	30-34	35-39	40-44	25-44	25-29	30-34	35-39	40-44	25-44
	Homeownership					Housing asset share				
Baseline	14.2	24.0	41.2	47.2	31.6	10.3	16.2	28.7	37.3	23.1
Marital transitions	8.1	7.5	1.6	1.0	4.5	4.6	6.4	3.2	1.3	3.8
	Age group					Age group				
Married households	25-29	30-34	35-39	40-44	25-44	25-29	30-34	35-39	40-44	25-44
	Homeownership					Housing asset share				
Baseline	58.5	69.8	75.1	78.4	70.4	44.2	54.3	58.5	61.4	54.6
Marital transitions	-5.0	-2.5	-2.0	-1.5	-2.7	-3.2	-2.2	-1.7	-1.6	-2.3

Table A-5: Effect of marital transition probabilities using lower bound values

Notes: The rows named "Baseline" show the values of homeownership rate and housing asset share generated from the model to represent the year 1970. The row named "Marital transitions" show the incremental changes from the baseline when only the marital transitions probabilities are changed to the year 1995's values, holding everything else as the baseline. The marital transition probabilities used are the lower bound values from the 95% confidence bands (blue dotted lines) in Figure A-4.

A.6 Bayesian Estimation

Let Θ denote the parameters of interest and $\hat{\mathbf{m}}$ denote the vector of M empirical moments from the data for estimation. The goal is to choose Θ to make the model-simulated moments $\mathbf{m}(\Theta)$ be as close as possible to $\hat{\mathbf{m}}$. The approximate likelihood is written as

$$f(\hat{\mathbf{m}}|\Theta) = (2\pi)^{-\frac{M}{2}}|S|^{-\frac{1}{2}} \exp\left[-\frac{1}{2}\left(\hat{\mathbf{m}} - \mathbf{m}(\Theta)\right)' S^{-1}\left(\hat{\mathbf{m}} - \mathbf{m}(\Theta)\right)\right],$$

where S is the covariance matrix of $\hat{\mathbf{m}}$. The covariance matrix S is replaced by a consistent estimator $\bar{S}$, which can be obtained through bootstrap. With N_B bootstrap samples,

$$\bar{S} = \frac{1}{N_B}\sum_{b=1}^{N_B}(\hat{\mathbf{m}}_b - \bar{\mathbf{m}})(\hat{\mathbf{m}}_b - \bar{\mathbf{m}})',$$

where $\hat{\mathbf{m}}_b$ stands for the moments from the b-th bootstrap sample and $\bar{\mathbf{m}}$ is the mean of $\hat{\mathbf{m}}_b$ for $b = 1, \ldots, N_B$. The Bayesian posterior of Θ conditional on $\hat{\mathbf{m}}$ is derived as

$$f(\Theta|\hat{\mathbf{m}}) = \frac{f(\hat{\mathbf{m}}|\Theta)p(\Theta)}{f(\hat{\mathbf{m}})},$$

where $p(\Theta)$ denotes the priors on Θ and $f(\hat{\mathbf{m}})$ denotes the marginal density of $\hat{\mathbf{m}}$, where $f(\hat{\mathbf{m}}) = \int f(\hat{\mathbf{m}}|\Theta)p(\Theta)d\Theta$. Then I characterize the posterior density using the Random-Walk Metropolis Hastings sampler with the objective function $g(\Theta) \equiv \log f(\hat{\mathbf{m}}|\Theta) + \log p(\Theta)$.

The proposal covariance-variance matrix Ω_{proposal} is obtained by multiplying a constant c to the diagonal matrix Ω whose elements are equal to prior variances, $\Omega_{\text{proposal}} = c \times \Omega$. As the chain runs, c is updated as in Herbst and Schorfheide (2019) so that the acceptance rate x gets closer to the target 0.25:

$$c' = c \times \left(0.95 + 0.1 \times \frac{e^{16(x-0.25)}}{1 + e^{16(x-0.25)}}\right).$$

Figure A-5 shows the marginal density of each parameter constructed from posterior draws. I use uniform priors in this paper so that the non-uniform shape of posterior density clearly illustrates that data variations are informative of the estimated parameters. Even with non-informative priors, the parameter estimates inform me about interesting aspects in life, including economies of scale within marriage, utility from home production, and the cost of labor supply. More informative priors would sharpen the inference. I leave for future research what informative priors to impose for different parameters in a life-cycle model.

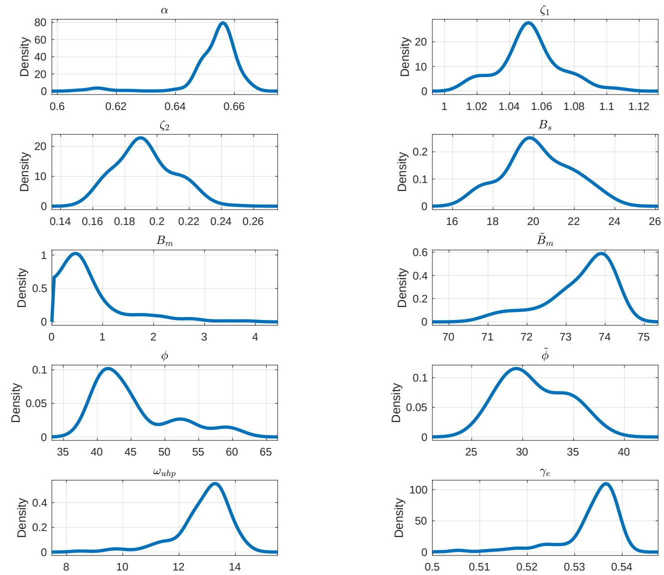

Figure A-5: Posterior density for each parameter

A.7 Model Fit

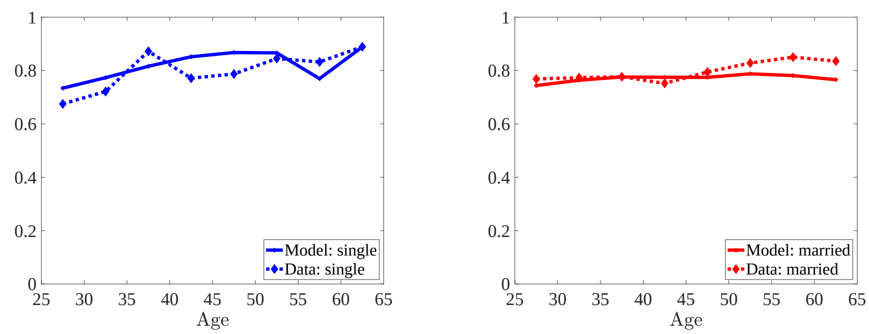

Figure A-6: Model fit for conditional housing asset share

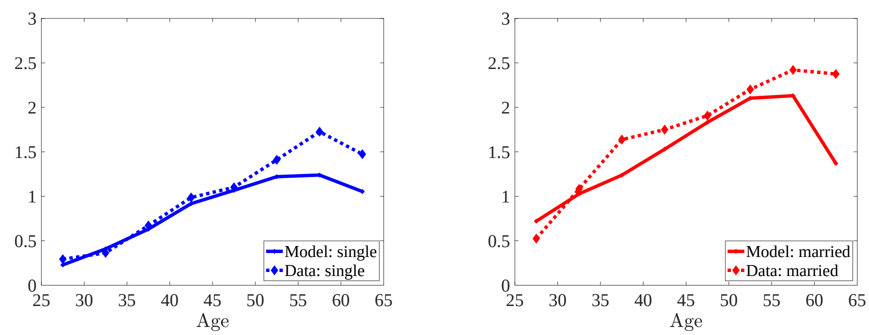

Figure A-7: Model fit for total assets

Notes: The vertical axis is in \$10,000 in 1970.

A.8 Decomposition analysis

	Age group							
Single households	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
Baseline	14.0	23.7	40.5	46.1	50.3	50.2	46.9	44.8
Marital transitions	8.4	8.7	1.2	0.9	0.8	0.9	0.9	0.8
Downpayment constraint	5.4	5.5	4.8	4.7	2.7	-0.5	1.3	-0.3
Labor market volatility	0.1	-6.6	-13.0	-4.9	-4.6	-0.1	0.0	-1.0
Spousal labor participation	0.0	-0.1	-0.5	0.0	0.5	0.7	0.5	0.9
Fertility	0.0	-0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.0
Non-housing asset return	-0.2	-1.7	-2.2	-1.9	-4.5	-3.4	2.6	2.7
House price	-2.0	-2.2	-1.1	-1.8	-2.6	-4.0	-1.1	-1.6
	Age group							
Married households	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
Baseline	58.1	69.3	74.6	77.9	83.4	85.2	85.8	67.6
Marital transitions	-4.8	-2.2	-1.9	-1.3	-1.1	-0.7	-0.4	-0.2
Downpayment constraint	1.7	1.9	2.0	2.2	2.0	2.3	1.7	-3.1
Labor market volatility	1.0	0.0	0.8	2.2	0.9	1.2	0.0	1.2
Spousal labor participation	10.0	7.0	6.4	5.9	2.7	0.9	-2.2	-0.3
Fertility	-2.5	-0.0	0.0	0.0	0.1	0.1	0.1	-0.1
Non-housing asset return	-5.4	-3.2	0.5	2.2	1.7	1.2	-0.5	2.1
House price	-6.5	-2.8	-2.0	-1.4	-1.2	-2.2	-3.2	2.5

Table A-6: Effect of structural changes on homeownership rate

Notes: The rows named "Baseline" show the housing variables under the 1970 baseline. In comparison to the baseline, the other rows show the incremental changes (in percentage points) obtained from applying structural changes in 1995. For instance, the rows "Marital transitions" show the effect of changing marital transition probabilities from the 1970's values to the 1995's values, holding everything else the same as the baseline.

	Age group							
Single households	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
Baseline	10.3	16.0	28.3	36.7	41.6	43.8	41.3	42.6
Marital transitions	4.6	7.3	3.5	1.1	0.8	0.6	0.7	0.7
Downpayment constraint	6.1	5.4	4.2	4.9	2.3	-0.7	1.8	0.1
Labor market volatility	0.0	-2.9	-6.6	-3.4	-4.2	-1.4	-0.6	-1.7
Spousal labor participation	0.0	-0.0	-0.5	-0.4	0.2	0.5	0.4	0.8
Fertility	0.0	-0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0
Non-housing asset return	-0.3	-1.8	-2.4	-2.7	-5.9	-4.6	0.8	1.5
House price	-1.9	-2.1	-1.3	-1.7	-2.9	-4.0	-1.3	-2.4
	Age group							
Married households	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
Baseline	43.9	53.9	58.1	61.0	64.8	67.4	67.1	64.8
Marital transitions	-3.1	-2.1	-1.5	-1.4	-1.2	-1.2	-0.9	-1.1
Downpayment constraint	2.8	2.9	4.0	4.8	4.8	5.1	4.8	-1.4
Labor market volatility	-0.4	-0.6	-0.7	0.4	0.6	0.8	0.6	-0.3
Spousal labor participation	6.9	4.7	4.1	3.6	3.6	1.0	-1.3	-0.4
Fertility	-1.1	-0.1	-0.0	0.0	0.1	0.4	0.3	-0.1
Non-housing asset return	-3.6	-2.6	-0.7	0.2	-0.4	-2.3	-2.9	1.0
House price	-3.6	-2.7	-1.6	-1.2	-1.8	-3.4	-1.5	2.8

Table A-7: Effect of structural changes on housing asset share

Notes: The rows named "Baseline" show the housing variables under the 1970 baseline. In comparison to the baseline, the other rows show the incremental changes (in percentage points) obtained from applying structural changes in 1995. For instance, the rows "Marital transitions" show the effect of changing marital transition probabilities from the 1970's values to the 1995's values, holding everything else the same as the baseline.

	Age group							
Single households	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
Baseline	73.4	77.3	81.6	85.1	86.7	86.6	76.9	88.8
Marital transitions	0.0	2.4	1.8	0.6	0.0	-0.1	-0.5	-0.2
Downpayment constraint	9.8	8.7	2.1	0.0	-1.7	-3.4	6.1	-6.2
Labor market volatility	0.1	-0.8	-1.1	-1.8	-4.0	-0.5	0.0	-2.0
Spousal labor participation	0.0	0.0	0.0	-0.1	-0.3	-0.2	-0.1	-0.1
Fertility	0.0	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0
Non-housing asset return	-2.2	-3.1	-3.6	-3.0	-7.5	-2.5	2.9	-1.2
House price	-2.5	-2.4	-3.4	-2.7	-1.5	-0.6	1.9	0.1
	Age group							
Married households	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
Baseline	74.3	76.3	77.5	77.4	77.4	78.7	78.1	76.5
Marital transitions	-0.1	0.4	-0.5	-0.2	-0.4	-0.5	-0.4	-0.3
Downpayment constraint	4.2	4.2	2.7	3.6	4.0	3.9	2.9	-3.3
Labor market volatility	-3.8	-2.3	-1.5	-0.0	-0.4	-0.0	0.3	-0.6
Spousal labor participation	2.6	1.3	0.4	0.1	2.2	0.5	-2.1	1.4
Fertility	0.2	-0.0	-0.1	-0.0	0.0	0.0	0.2	-0.2
Non-housing asset return	-0.8	-0.5	-0.9	-1.7	-2.2	-3.2	-4.3	2.8
House price	2.3	1.1	-0.1	-0.2	-0.6	-2.5	1.1	5.0

Table A-8: Effect of structural changes on conditional housing asset share

Notes: The rows named "Baseline" show the housing variables under the 1970 baseline. In comparison to the baseline, the other rows show the incremental changes (in percentage points) obtained from applying structural changes in 1995. For instance, the rows "Marital transitions" show the effect of changing marital transition probabilities from the 1970's values to the 1995's values, holding everything else the same as the baseline.

	Data			Model			Data			Model		
Age group	1970	1995	Change	1970	1995	Change	1970	1995	Change	1970	1995	Change
	Homeownership of singles						Housing asset share of singles					
25-29	10.5	24.3	13.7	14.0	22.4	8.4	8.5	17.3	8.7	10.3	17.5	7.2
30-34	27.8	33.9	6.0	23.7	25.7	2.0	21.0	25.7	4.7	16.0	20.7	4.7
35-39	34.9	43.8	8.8	40.5	42.0	1.5	31.1	36.6	5.4	28.3	29.5	1.2
40-44	42.0	51.0	9.0	46.1	51.9	5.8	33.1	42.2	9.0	36.7	38.5	1.7
45-49	45.3	47.8	2.4	50.3	55.6	5.2	37.0	39.9	2.8	41.6	44.9	3.2
50-54	57.2	59.4	2.2	50.2	55.0	4.8	48.8	51.8	3.0	43.8	46.3	2.5
55-59	52.8	60.6	7.7	46.9	54.6	7.7	44.3	51.0	6.7	41.3	49.2	7.9
60-64	57.4	65.8	8.3	44.8	50.1	5.3	50.1	57.6	7.5	42.6	46.0	3.4
	Homeownership of married households						Housing asset share of married households					
25-29	53.3	52.1	-1.2	58.1	54.3	-3.7	45.2	37.5	-7.6	43.9	41.9	-2.0
30-34	67.9	65.4	-2.5	69.3	66.3	-3.0	53.0	48.2	-4.8	53.9	52.0	-1.9
35-39	76.0	70.8	-5.2	74.6	73.2	-1.4	59.4	51.5	-7.8	58.1	57.8	-0.3
40-44	82.1	76.6	-5.5	77.9	80.4	2.4	61.2	61.3	0.1	61.0	62.4	1.4
45-49	83.2	79.7	-3.5	83.4	85.9	2.5	66.4	66.6	0.2	64.8	67.2	2.3
50-54	82.8	82.7	-0.1	85.2	86.7	1.4	67.4	70.8	3.4	67.4	70.7	3.2
55-59	81.8	86.3	4.5	85.8	87.6	1.7	69.5	73.1	3.5	67.1	69.5	2.4
60-64	84.0	83.0	-1.0	67.6	72.7	5.0	70.5	68.4	-2.0	64.8	71.0	6.2

Table A-9: Housing decisions in 1970 and 1995

A.9 Comparison to a simple model with moving probabilities

One could model moving probabilities to capture a potential reason for changes in housing demand. If people move more frequently and each moving involves substantial home transaction costs, this could lower homeownership. In this section, I conduct a counterfactual analysis with moving probabilities: the goal is to compare the outputs from a simple model with moving probabilities to those from the baseline model.

The problems for singles and married couples at the terminal age are the same as the baseline. Likewise, the preferences of singles and married households are specified the same way as the baseline as well as the budget constraint, the borrowing constraint, and the LTI constraint. Hence I only state the changes made to the value functions at the non-terminal ages: the expected value should take into account the age-dependent shock of moving with probability $q_{move,j}$ for age j. For both singles and married couples, it is assumed that a household hit by the moving shock sells the owned home and pays the associated transaction costs. The value function of the single household with the state variables $X_j^s = [j, a, h, y]$ is written as follows:

$$V^s(X_j^s) = \max_{c,m,b',h',l} \Big\{ u\big(c, s, l\big) \ + \beta \Big[(1 - q_{move,j}) \cdot \mathbb{E}V^s\big(j+1, a', h', y'\big) \\ + q_{move,j} \cdot \mathbb{E}V^s\big(j+1, a' - \kappa_s P^H h', 0, y'\big) \Big] \Big\}.$$

Likewise, the married household's value function with $X_j^m = [j, a, h, y, \widetilde{y}]$ is written as follows:

$$V^m(X_j^m) = \max_{c,m,b',h',l,\widetilde{l}} \Big\{ u\big(c, s, l, \widetilde{l}\big) \ + \beta \Big[(1 - q_{move,j}) \cdot \mathbb{E}V^m\big(j+1, a', h', y', \widetilde{y}'\big) \\ + q_{move,j} \cdot \mathbb{E}V^m\big(j+1, a' - \kappa_s P^H h', 0, y', \widetilde{y}'\big) \Big] \Big\}.$$

When solving this simpler model, I plug in the same parameter estimates used in the 1970's baseline. For the age-dependent moving probabilities for single households, I use the same values as age-dependent marriage probabilities.[55] It is known that married couples move less

[55] They are very similar to the age-dependent moving probabilities of men who moved to another county

compared to singles. Hence, I set the age-dependent moving probabilities for married couples by multiplying 1/3 to the singles' moving probabilities. This gap is in a similar magnitude to the reported values in Guler and Taşkin (2018) and Alonzo (2022).

	Age group					Age group				
Single households	25-29	30-34	35-39	40-44	25-44	25-29	30-34	35-39	40-44	25-44
	Homeownership					Housing asset share				
Baseline	14.0	23.7	40.5	46.1	31.0	10.3	16.0	28.3	36.7	22.8
Moving probabilities	9.7	12.2	24.0	35.7	20.4	5.9	7.0	14.5	23.6	12.8
	Age group					Age group				
Married households	25-29	30-34	35-39	40-44	25-44	25-29	30-34	35-39	40-44	25-44
	Homeownership					Housing asset share				
Baseline	58.1	69.3	74.6	77.9	69.9	43.9	53.9	58.1	61.0	54.2
Moving probabilities	75.7	77.8	81.3	82.1	79.2	58.9	61.6	64.5	66.4	62.8

Table A-10: Housing decisions from the baseline and from the model with moving probabilities

Table A-10 shows the life-cycle profiles of housing decisions for the age groups from 25 to 44 years. Singles' homeownership and housing asset share from the simple model with moving probabilities are lower than those from the baseline. Under the simpler model without marital transitions, singles are subject to moving shock that involves costly liquidation of home for sure and there is no buffer provided by pooled assets with a potential spouse. In this regard, investing in home while being single is less attractive under the simpler model. In contrast, the model with moving probabilities deliver higher homeownership rate and housing asset share for married couples. Assets are not destructed by half as in the case of divorce and the economies of scale within marriage is still kept with moving. In this regard, housing variables turn out to be higher compared to the baseline.

or state reported in Purcell (2020) for the period 1994-1996. In addition, the CPS Geographical Mobility report documented that the probability that an individual moves did not change much between 1970 and 1995. An individual's moving probability from the previous year was 22% in the mid 1970s and 20% in the mid 1990s.

A.10 Robustness check with $p_{liquidate}$

The higher $p_{liquidate}$ could amplify the riskiness of marriage and divorce when it comes to housing decisions. With $p_{liquidate} = 0.9$, the housing demand is only slightly lower compared to the baseline. The opposite is the case for $p_{liquidate} = 0.8$ that is close to the lower bound value of empirical frequency.

	Age group					Age group				
Single households	25-29	30-34	35-39	40-44	25-44	25-29	30-34	35-39	40-44	25-44
	Homeownership					Housing asset share				
$p_{liquidate} = 0.85$ (Baseline)	14.0	23.7	40.5	46.1	31.0	10.3	16.0	28.3	36.7	22.8
$p_{liquidate} = 0.9$	14.0	23.7	40.4	46.0	31.0	10.3	15.9	28.3	36.6	22.7
$p_{liquidate} = 0.8$	14.1	23.8	40.5	46.2	31.1	10.3	16.0	28.4	36.8	22.9
	Age group					Age group				
Married households	25-29	30-34	35-39	40-44	25-44	25-29	30-34	35-39	40-44	25-44
	Homeownership					Housing asset share				
$p_{liquidate} = 0.85$ (Baseline)	58.1	69.3	74.6	77.9	69.9	43.9	53.9	58.1	61.0	54.2
$p_{liquidate} = 0.9$	57.9	69.0	74.4	77.7	69.7	43.8	53.7	57.9	60.8	54.0
$p_{liquidate} = 0.8$	58.2	69.5	74.8	78.1	70.1	44.1	54.2	58.4	61.2	54.4

Table A-11: Housing decisions from the baseline and from the model with different $p_{liquidate}$

A.11 Robustness check with transaction costs

I conduct a counterfactual analysis with the alternative specification of transaction costs that also entail a fixed component. Let me first revisit the results under the proportional transaction costs as in the main text. The results are reported under the title "Transaction costs (proportional only)" in Table A-12. The counterfactuals are reported under the title "Transaction costs (proportional+fixed)": this stands for the alternative specification where the fixed component corresponding to 3% of the smallest house's value needs to be paid in addition to the proportional transaction costs.[56]

[56]For instance, buying the smallest house will incur 6% of the house value as the total transaction costs. This value is close to costs of employing estate agents, lawyers, surveyors, and other specialists reported in Bottazzi et al. (2007) for the United Kingdom.

Married households	Age group 25-29	30-34	35-39	40-44	25-44	Age group 25-29	30-34	35-39	40-44	25-44
	Transaction costs (proportional only)					Transaction costs (proportional+fixed)				
Baseline	58.1	69.3	74.6	77.9	69.9	53.6	64.6	70.8	74.8	65.9
Marital transitions	-4.8	-2.2	-1.9	-1.3	-2.5	-6.2	-2.8	-2.2	-1.7	-3.2

Table A-12: Effect of marital transition probabilities on homeownership (with different transaction costs)

Notes: The rows named "Baseline" show the homeownership rates under the 1970 baseline. The rows "Marital transitions" show the effect (incremental change in percentage points) of changing marital transition probabilities from the 1970's values to the 1995's values, holding everything else the same as the baseline.

Under the baseline with 1970's marital transition probabilities, the homeownership rate is lower when there is a fixed component to be paid for home transactions. The average homeownership rate for married couples of age 25-44 is about 66% with the fixed component and about 70% without the fixed component. The effect of increased divorce risk on housing decisions is amplified with the fixed component. The magnitude of changes reported in the row "Marital transitions" is shown to be larger under the alternative specification.

A.12 Counterfactual with medical costs and pension payments

Certain elements of retirement may have changed between 1970 and 1995. I conduct a counterfactual experiment to incorporate the change in out-of-pocket medical expenditures and pension payments and compare what differs from the baseline results. Pension payments increased from $7141.7 to $9462.6 (both in 1995 dollars) as reported in Purcell and Whitman (2006). Out-of-pocket medical expenses increased from $792.6 to $1188.99.[57] Combining these two changes, there was $1918.6 increase in the pension payments net of medical expenses. Accordingly, I experiment with the model so that this amount is added to $b' + P^H h'$

[57]Medical spending for people older than 65 increased from $1981.6 to $5284.4 (both in 1995 dollars) as reported in Dickman et al. (2016). The reported out-of-pocket expenses were calculated based on the fraction paid out-of-pocket out of total medical spending reported in De Nardi et al. (2016).

before computing a constant amount of consumption for the continuation value in the terminal period.[58] Table A-13 and Table A-14 show the results from this counterfactual analysis. The homeownership rate and the housing asset share in the terminal period fall slightly. These changes in the terminal period seem to affect the decisions over the life-cycle (such as slight increase in young homeownership rates), but the magnitude of change is not so substantial. More thorough exploration for old-age housing decisions is left for future research.

	Age group							
Single households	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
Baseline	14.0	23.7	40.5	46.1	50.3	50.2	46.9	44.8
Change in medical costs + pension payments	15.4	25.1	41.5	46.8	50.7	50.1	48.9	43.0
	Age group							
Married households	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
Baseline	58.1	69.3	74.6	77.9	83.4	85.2	85.8	67.6
Change in medical costs + pension payments	60.8	70.4	75.4	78.6	83.9	85.7	84.3	65.6

Table A-13: Homeownership from the baseline and from the model with the change in medical costs and pension payments

	Age group							
Single households	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
Baseline	10.3	16.0	28.3	36.7	41.6	43.8	41.3	42.6
Change in medical costs + pension payments	11.6	17.3	29.3	37.5	42.2	43.9	42.3	40.9
	Age group							
Married households	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
Baseline	43.9	53.9	58.1	61.0	64.8	67.4	67.1	64.8
Change in medical costs + pension payments	45.3	55.0	59.0	61.9	65.6	67.6	68.1	64.3

Table A-14: Housing asset share from the baseline and from the model with the change in medical costs and pension payments

[58]I add $3837.2 for married couples.