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. Using the estimated model, I conduct a decomposition analysis between 1970 and 1995, two years with similar real house prices but substantially different probabilities of marital transitions. I find that the change in marital transitions accounts for 29% of the observed increase in the homeownership rate of single households. Also, I show that incorporating the change in divorce risk helps generate the observed decrease in married households' housing asset share. By extending the period of analysis to include the housing price boom in the mid-2000s, I demonstrate that the continuing decrease in marriage contributes to an approximately 7% increase in the homeownership rate for young singles.

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1 Introduction

Marriage and divorce are intimately linked to housing and portfolio decisions (Lauster and Fransson, 2006, Smits and Mulder, 2008, Love, 2010). Noticeably, the prospects of marriage and divorce have changed vastly over the past decades. 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. Yet, during this period, the aggregate homeownership rate stayed roughly constant until the house price boom started (Chambers et al., 2009, Acolin et al., 2016). These two observations seem difficult to reconcile at first sight. However, 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. 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. Such quantitative development is important as a building block for counterfactual analysis and for evaluating various policies. For instance, the effectiveness of reforms such as the US 2017 tax reform regarding property taxes and mortgage deductibility may vary according to different marital prospects.

Let me explain the basic 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. In addition, knowing that a married couple pool their assets, a single person whose prospect of marriage is promising will save less. This free-riding incentive discourages savings, which makes it less likely for the single person to be a homeowner. Since it is more difficult to split a house than liquid assets such as checking accounts, a married couple will invest less 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 postulate a life-cycle model of single and married households that face age-dependent marital transition shocks. Given that the model closely fits the life-cycle profiles of housing decisions in the baseline year 1995, I conduct a counterfactual analysis of varying the underlying marital transition probabilities to reflect risks in different time periods. This allows me to quantify the extent to which marital transitions account for housing decisions and to evaluate the relative importance of alternative factors including financial constraints, labor market uncertainty, and spousal labor productivity.

To control for a potential confounding effect from housing price change, my analysis starts with a comparison of the years 1970 and 1995. 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. Then I extend the analysis to cover the housing boom periods in the mid-2000s to study whether the continuing change in marital transitions still matters.

Similar to Cubeddu and Ríos-Rull (2003) and Fernández and Wong (2014), I treat marriage and divorce as age-dependent exogenous shocks that households face. Furthermore, this enables me to maintain simplicity and clarity in my decomposition analysis of shutting down each channel associated with housing decisions. This approach is in a similar vein to the vibrant literature that has found it useful to treat employment status or earnings as exogenous shocks. If marriage and divorce are modeled as endogenous decisions, then some underlying shocks that drive these complex decisions should be modeled instead, which is beyond the scope of this paper. 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 when he/she gets married. Likewise, a married couple sell their owned house when they get divorced.[2]

In addition, I model the following features to reflect other competing factors that could account for housing decisions: (i) Owned housing, which is modeled over a discrete housing size grid, can serve as a collateral for borrowing. This is useful to isolate the role of relaxed borrowing constraints on lumpy housing decisions. (ii) Households face idiosyncratic labor productivity shocks. This enables me to analyze how households adapt their housing investment to increasing earnings risk.

[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] This is empirically supported by the fact that, 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 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).

(iii) Each household member decides how much to work. As a spouse's labor productivity increases, the model generates an increase in spousal labor supply while allowing for a household head to adjust labor supply accordingly.

I estimate the model parameters using a limited information Bayesian method to match the moments from the cross-section data of 1995, the benchmark year for my analysis. This paper is the first to apply this estimation method to a life-cycle model, which has the advantage of explicitly incorporating prior beliefs and combining them with the data's variation. The model closely fits the life-cycle profiles of homeownership, housing asset share, and labor force participation across marital status observed in the data. The estimated parameters inform me about the substitutability of renting and owning a house, utility from home production, economies of scale within marriage, and cost associated with labor supply. Then, I conduct a decomposition analysis to quantify how much of the change in housing decisions between 1970 and 1995 can be additionally accounted for by the change in the likelihood of marital transitions. These two years are treated as steady states with the same housing prices, but very different marriage and divorce prospects.

First, I find that the change in the likelihood of marital transitions accounts for 29% of the observed increase in single households' average homeownership rate. This channel is useful to generate a homeownership rate for singles aged 25 to 30 that was much lower in 1970 compared to 1995. I also incorporate other changes in key drivers of housing decisions studied in the literature: borrowing constraints, earnings risk, and spousal labor productivity. When combined, these channels account for 45% of the observed change. The comparison with the marital transition channel, which accounts for 29% of the change, demonstrates that the change in marital transitions is quantitatively of comparable importance to the changes in borrowing constraints, earnings risk, and spousal productivity.

Second, in the data, the average share of assets held in housing by married households declined by 11% between 1970 and 1995. The model can only reproduce this decline if the changes in marital transitions are included. In their absence, the other drivers predict an increase in this share, again demonstrating the crucial importance of this channel for observed trends in households' housing decisions. It is worth noting that the decline in the housing asset share is more noticeable for young married couples. The marital risk channel, which is pronounced for early stages of the life-cycle, is particularly useful to generate the behavior of young couples. One may argue that enhanced financial asset market accessibility and technology would help generate the drop in housing asset share. If so, it would be more likely to affect middle-aged people who hold more financial assets in their portfolio.

It is then an obvious question whether marital transitions, which have continued to change, still play a role in explaining the evolution of housing variables in recent years when house prices have changed dramatically. Guerrieri and Uhlig (2016) provide a nice survey on the literature analyzing housing boom-bust periods in association with credit markets. To incorporate the changing house prices, I model house price as a stochastic shock similar to Corbae and Quintin (2015). I also include a belief shock on appreciation to generate the surge in homeownership during the boom. I simulate the homeownership rate with changing house prices, beliefs on appreciation, credit constraints, and wages. These changes are set to mimic the recent boom in the housing market in the mid-2000s, in addition to the continuing change in marital transitions.

The model cannot simulate households to own more housing when I only apply the more expensive house price during the boom. However, the reduction in marriage and divorce probabilities observed in the data between 1995 and the mid-2000s increases single households' homeownership rate by 6.8%. The changes in credit constraints, wages, and beliefs on appreciation were often suggested as drivers for the homeownership increase during the boom, which is also supported by my paper. It is worth noting that the change in marital transitions contributes to replicating the homeownership increase for young singles even when the house price was expensive. In contrast, the change in marital transition probabilities decreases married couples' homeownership rate by 3.2% during the boom, whose force is masked by the other factors pushing up the homeownership rate during the boom.

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. This captures the friction from the particular nature of housing investment in that becoming married or divorced would make the house owned prior to the change in marital status unsuitable.

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. (2018) 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 aggregate implication of marital transition risk and earnings risk for homeownership and households' portfolios over time. Furthermore, I study how the change in marriage and divorce probabilities affects these housing variables differently between single and married households.

Finally, this paper contributes to the literature that analyzes the importance of marital transitions for households' decisions. 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). 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 on housing decisions by comparing the simulated life-cycle profiles 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 to calibrate and estimate the parameters 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 extends the framework to incorporate the changing house prices to study the housing boom period in the mid-2000s. 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. It is worth noting that the real house price was quite stable between the two years.[3] To control for this confounding factor, I chose 1970 and 1995 because house prices were similar in level, but the likelihood of marital transitions differed substantially. The year 1970 was chosen as a representative period with high marriage and low divorce probabilities. If we look at the time series data,[4] 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.[5] The year 1995 was chosen as the benchmark period with high divorce and low marriage probabilities. It is suitable for the analysis in that it is after the housing recession in 1990 and

[3] See Corbae and Quintin (2015) for the time series of the real house price index. The price to rent ratio also shows a similar trend as reported in Gallin (2008).

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

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

before the start of the housing price boom in the late 1990s, a trend that continued until the Great Recession.

I cover different time periods in the separate sections. In Section 5, I conduct a decomposition analysis between 1970 and 1995 to study how much of the change in marital transition probabilities can explain the change in housing decisions, controlling for house price. However, house price increased dramatically over the early 2000s. In addition, the marital transition probabilities continued to change, although the magnitude of change became small. In Section 6, I extend my analysis and study the implication of marital transition probabilities for housing decisions under changing house prices.

2.1 Data to construct life-cycle profiles in 1995

I use the 1995 Survey of Consumer Finances (SCF), which is conducted every three years and is available from the Federal Reserve's website. These data are 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.[6] 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. Then 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. I focus on the unconditional share, which combines the information about participation rate and conditional housing asset share. 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 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. The value of using the historical SCF data before 1983 has recently been highlighted by Kuhn et al. (2018), and my paper is also in line with their attempt to

[6] The description of how each variable is constructed is provided in Appendix A.

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 us 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 $\textit{net value of housing}^{\dagger}_{i,SCF}$. This is done in order 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,

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

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, we can obtain the cross-imputed value of non-housing assets in the PSID data for household i as

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

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 Table 10 in Appendix A, I show that the regression applied to the 1970 SCF data to obtain the estimates $(\widehat{\beta}$,$\widehat{\gamma})$ has an adjusted R-squared close to 0.8. 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.

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.

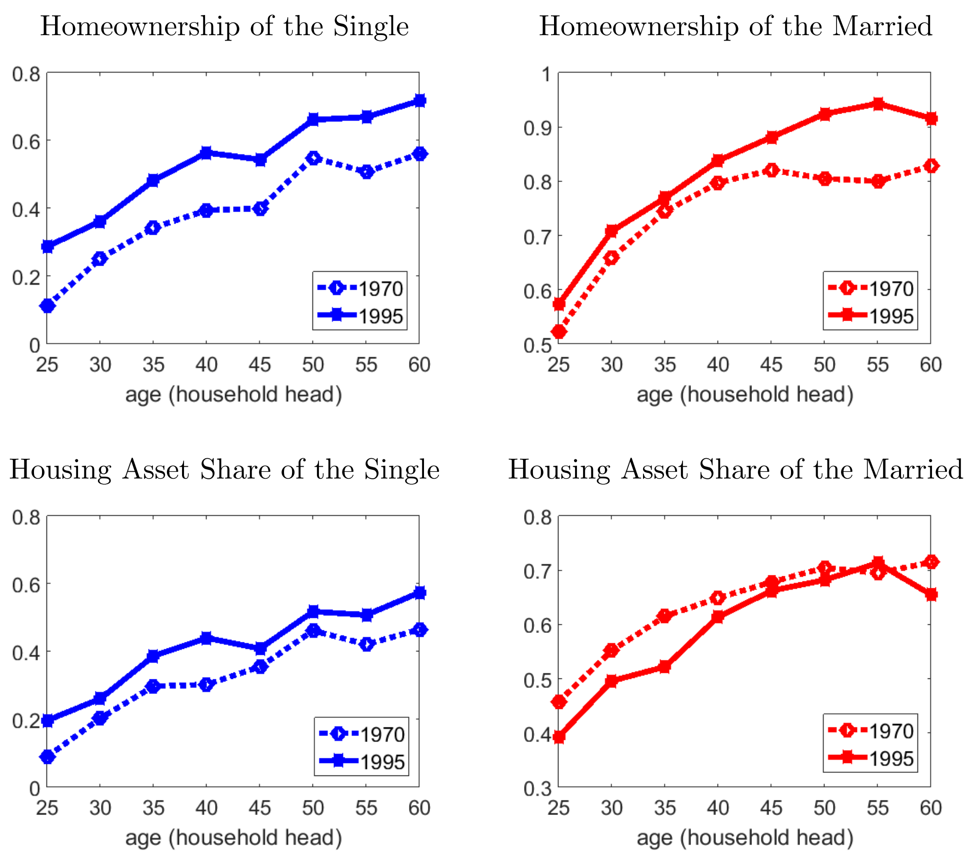

Figure 1: Homeownership Rate and Housing Asset Share

Notes: The average homeownership rate and the average housing asset share across different age groups. The dotted lines are constructed from the 1970 data and the solid lines are from the 1995 data. The x-axis stands for the age of household head. Housing asset share is defined to be the net housing value divided by total assets.

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 across all age groups between the two years. This is also the case for single households' housing asset share.

Since the pattern of change is qualitatively similar for the two housing variables, I focus on the change in homeownership in the following sections.

For the married, the homeownership rate did not change significantly between 1970 and 1995 for younger households from age 25 to age 44.[7] In contrast, the homeownership rate increased significantly for older married households. Given that the main channel of interest — the change in the likelihood of marriage and divorce — matters mostly for the young, it is not expected to explain the increase in the homeownership rate for older people. What explains this change is left for future research. Interestingly, the housing asset share was higher in 1970 compared to 1995 for younger married households.[8] I focus on this change in portfolio share of young married couples instead of the change in homeownership rate.

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, 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 house. Furthermore, the prospect of marriage creates a free-rider problem that discourages single people from saving, which makes it less likely for them to be homeowners. This may explain why single households' homeownership rate increased, as they were less likely to marry. 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, I need a structural model.

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

[7]The null hypotheses of equal means are not rejected under the 5% significance level for the age groups 25-29, 30-34, 35-39, and 40-44.

[8]The null hypotheses of equal means are rejected under the 5% significance level for age groups 25-29 and 35-39 and rejected under the 10% significance level for age group 30-34 (p-value = 0.07).

marital transition probabilities observed from the data.[9] 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 would 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. Hence, it is modeled that the owned house is sold and the associated transaction cost arises in times of getting married or divorced.

Households face non-insurable idiosyncratic labor productivity shocks and idiosyncratic housing price shocks. The framework is a partial equilibrium model in which households face the following exogenous prices: wage, savings interest rate, borrowing interest rate, and common house price. For now, the common house price is set to be fixed to analyze the steady states. In Section 6, the common house price will be modeled as a stochastic shock to study more recent periods with changing house prices.

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.[10] $\zeta(h)$ is a 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

[9] 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. For example, see Low et al. (2018) and Reynoso (2019).

[10] The available sizes of rented housing are modeled to be smaller than those of owned housing. The sizes of rented housing are also defined over a discrete grid.

larger houses. $\zeta(h)$ is assumed to be greater than 1 to reflect that owned housing is preferred to rented housing.[11]

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 hours 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:

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

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

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.

[11] 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).

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. 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 $X_J^s = [J, a, h, y]$.

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

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

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

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

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

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 $A \equiv (b' + P^H h')\frac{1-\beta}{1-\beta^4}$. 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 $X_J^m = [J, a, h, y, \widetilde{y}]$.

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

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

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

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

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

It is worth noting that there is no margin of disagreement between the spouses.

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

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:

$$V^s(X_j^s) = \max_{c,m,b',h',l} \Big\{ u\big(c, s, l\big) \;\; + \beta\big[q_{ss,j} \cdot \mathbb{E}V^s\big(j+1, a', h', y'\big)$$

$$+ q_{sm,j} \cdot \mathbb{E}V^m\big(j+1, (a' + \widetilde{a}') - \kappa_s P^H(h' + \widetilde{h}'), 0, y', \widetilde{y}'\big)\big]\Big\}$$

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

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

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

The single household's value function depends on the same state variables as in the terminal period's problem. 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. This is consistent with the empirical fact that the average age differential of a married couple is 3.8 years in 1995, which is less than the 5-year model period. When computing the expected value, we need to consider 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

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

where h_{min} is the minimum non-zero housing asset level.[12] Since the homeownership rate is increasing with age, a younger single is more likely to meet a spouse without housing assets. Using this distribution, the mean of housing assets in equilibrium turns out to be close to the mean of the potential spouse's housing assets. I assume perfect sorting in terms of non-housing asset $\widetilde{b}$, which induces the distribution over total asset $\widetilde{a}$ coupled with $\Omega(\widetilde{h})$. Simplifying the sorting pattern with respect to non-housing assets is based on the empirical observation that housing assets account for the biggest part of most households' portfolios. For instance, more than 65% of the net worth of the median household from the Survey of Consumer Finances data is in owned housing. Lastly, I assume the potential spouse's labor efficiency is distributed according to the stationary distribution of labor efficiency $\widetilde{y}$.

Once a single person gets married, the couple not only have to sell the housing assets they accumulated while single, but they also have to pay the transaction costs of doing so. Although this setting simplifies the reality, it still captures the fact that most married households (80-90%) resize or buy a new house within 5 years after getting married (Speare and Goldscheider, 1987; Deurloo et al., 1994). The prohibitive transaction costs could also reflect potential moving or relocation costs associated with marriage. 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 house price 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 price 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.[13]

[12] 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.

[13] This could be from financial intermediation or from default risk. I treat this borrowing rate to be exogenous

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:

$$V^m(X_j^m) = \max_{c,m,b',h',l,\widetilde{l}} \Big\{ u\big(c, s, l, \widetilde{l}\big) \; + \beta \Big[q_{mm,j} \cdot \mathbb{E}V^m\big(j+1, a', h', y', \widetilde{y}'\big)$$

$$+ q_{ms,j} \cdot \mathbb{E}V^s\big(j+1, 0.5(a' - \kappa_s P^H h'), 0, y'\big) \Big] \Big\}$$

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

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

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

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 $\widetilde{y}$.

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. In other words, there is no reshuffling of spouses. With probability $q_{ms,j}$, the married household becomes separated or divorced. With this status change, the divorced single agent becomes egoistic and his/her labor productivity is again distributed over the support of y. So each spouse has the same outlook on the future, which eliminates the margin of disagreement. Upon separation, the joint house is sold and the associated cost is paid. After this transaction, the remaining joint assets are equally divided between the couple.[14]

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.

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

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).

[14] 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.

Idiosyncratic house price shock δ is modeled to be 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 $q_{mm,j}$. The common house price P^H is set to be fixed to analyze 1970 and 1995 as two steady states. However, this will be extended to model time-varying house prices over the 2000s as a stochastic shock. The parameterization of each shock will be covered in the following section.

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 1995 in which the life-cycle profiles could be constructed without the data imputation strategy as in 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, 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 4 more periods before they die with certainty. I use the observed asset distribution of households aged 20 to 24 in the 1995 SCF data to determine initial asset distribution in the model.

Preferences. The discount factor β is set to be 0.94 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 $\rho_x = 0.75$ and $\sigma_x = 0.4$. These values are close to the estimates in Fernández and Wong (2014), which are within the ranges of values in the previous literature (Storesletten et al., 2004; Chang and Kim, 2006).[15] Fernández and

[15] I simulate the process w_t in Fernández and Wong (2014) with $(\rho, \sigma_\eta, \sigma_\epsilon) = (0.969, 0.076, 0.034)$ using

$$w_t = z_t + \eta_t, \quad \eta_t \sim N(0, \sigma_\eta^2), \quad z_t = \rho z_{t-1} + \epsilon_t, \quad \epsilon_t \sim N(0, \sigma_\epsilon^2).$$

Wong (2014) also use a 5-year period. For the married spouse, the process is modeled to be less persistent with a higher standard deviation.

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 used in Pizzinelli (2018) and the average number of children across different age groups in the 1995 Census data.

Age	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
φ_j	1.11	1.23	1.30	1.32	1.22	1.10	1.0	1.0

Table 1: Values for φ_j

The age-dependent marriage probabilities $q_{sm,j}$ are computed by a similar logistic regression as in Borella et al. (2017). Age and squared age are used as regressors. Cohort or time effect is not controlled for. For the 1970 probabilities, the PSID data from 1970 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). The age-dependent divorce probabilities $q_{ms,j}$ of 1995 are computed as the average of the probabilities for 1990 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.

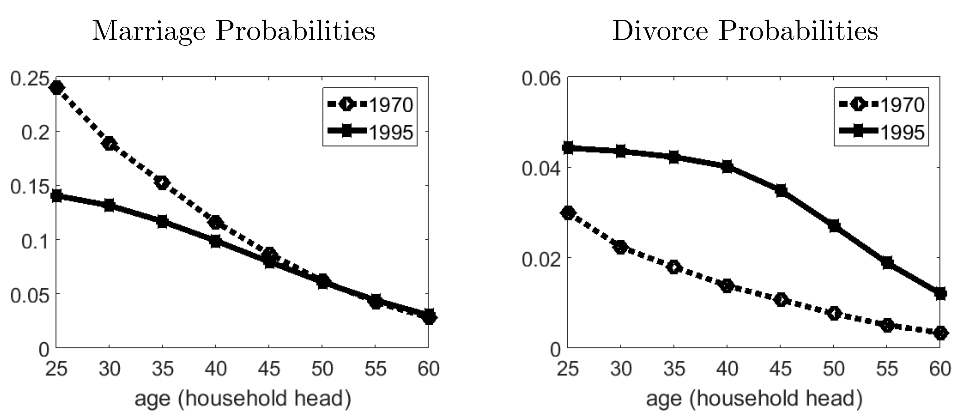

Figure 2: Marriage and Divorce Probabilities

Borrowing constraint and prices. Households are subject to a collateralized borrowing con-

Then I estimate an AR(1) process using the simulated series for 10,000 periods to obtain the persistence parameter $\rho_x = 0.75$. Then I set σ_x to be in the ranges of the previous literature.

straint where the parameter η captures how relaxed the constraint is. I set $\eta = 0.75$, based on the mean loan-to-value (LTV) for prime mortgages from Freddie Mac. The interest rate for savings is set to be 0.02, and the interest rate for borrowing is set to be 0.07 per annum. Hence the net interest margin between savings and borrowing is 0.05, which is close to the value in 1995 from the FRED data.

Housing-related parameters. For the transaction cost of owned housing, I follow Yang (2009) so that 2.5% of the home value is paid when buying and 7% is paid when selling. Lastly, an idiosyncratic house price shock is modeled to be uniform between $\underline{\delta}$ and $\bar{\delta}$. I set $\underline{\delta} = -0.25$, which is close to the average price increase for 10 major US metropolitan areas (Composite 10) from the Case-Shiller house price index.[16] I set $\bar{\delta} = 0.15$, whose value is similar to the 2.5th percentile of price change for all states from 1995 to 1999. The common house price P^H is calibrated to match the price-to-rent ratio. In the decomposition analysis in Section 5, I treat 1970 and 1995 as two steady states with the same common house price but with different marriage and divorce prospects.

Table 2 summarizes the externally set parameters and their sources.

Parameter	**Value**	**Source**
Preference		
β	0.94	—
σ	5.0	—
γ	0.5	Keane and Rogerson (2015)
Labor Productivity		
$\chi(j)$	—	Hansen (1993)
ρ_x $(\rho_{\tilde{x}})$	0.75 (0.73)	Fernández and Wong (2014)
σ_x $(\sigma_{\tilde{x}})$	0.4 (0.42)	Chang and Kim (2006)
Marriage		
n_ψ	1.34	Fernández-Villaverde and Krueger (2007)
φ_j	—	Pizzinelli (2018), Census
$q_{sm,j},\ q_{ms,j}$	—	Divorce registration area (DRA) data, PSID
Borrowing Constraint		
η	0.75	Freddie Mac mean LTV for prime mortgages
$(r,\ r^H)$	(0.02, 0.07)	Net interest margin of banks (FRED)
Housing Market		
$(\kappa_b,\ \kappa_s)$	(0.025, 0.07)	Yang (2009)
$(\underline{\delta},\ \bar{\delta})$	(-0.25, 0.15)	Case-Shiller house price index

Table 2: Externally Set Parameter Values

[16] 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.

4.2 Estimated parameters

I estimate the remaining parameters using a limited information Bayesian approach as in Christiano et al. (2010) and Fernández-Villaverde et al. (2016). Structural estimation such as mine has advantages for several reasons. First, we 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, 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 confidence interval or 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 advantage of a Bayesian approach is that I can explicitly incorporate prior beliefs and combine them with information from the data. A limited information Bayesian procedure is closely related to the simulated method of moments, but it has the advantage of adding prior beliefs from micro data evidence or the previous literature. As a special case, a Bayesian inference becomes analogous to a classical inference if one chooses uniform priors as I do in this paper. But one can use informative priors and also check how robust the choice of priors is. This will be clear in the following explanation of a limited information Bayesian procedure.

I denote the data moments to match as $\widehat{\psi}$. The goal is to choose a parameter vector θ to make the model-simulated moments $\psi(\theta)$ be as close as possible to $\widehat{\psi}$. The approximate likelihood of $\widehat{\psi}$ is written as

$$f(\widehat{\psi}|\theta) = \left(\frac{1}{2\pi}\right)^{\frac{M}{2}} |\bar{V}|^{-\frac{1}{2}} \times \exp\left[-\frac{1}{2}\big(\widehat{\psi} - \psi(\theta)\big)'\bar{V}^{-1}\big(\widehat{\psi} - \psi(\theta)\big)\right],$$

where M is the number of moments in $\widehat{\psi}$ and $\bar{V}$ is obtained by a bootstrap approach with N_B bootstrap samples as

$$\bar{V} = \frac{1}{N_B}\sum_{b=1}^{N_B}(\psi_b - \bar{\psi})(\psi_b - \bar{\psi})',$$

where ψ_b stands for the moments from the b-th bootstrap sample and $\bar{\psi}$ is the mean of ψ_b for $b = 1, \ldots, N_B$. To provide context, there are not many observations for middle-aged and elderly singles. This procedure will choose to weight more young singles' moments if they show lower variance.

The Bayesian posterior of θ conditional on $\widehat{\psi}$ is derived as

$$f(\theta|\widehat{\psi}) = \frac{f(\widehat{\psi}|\theta)p(\theta)}{f(\widehat{\psi})},$$

where $p(\theta)$ denotes the priors on θ and $f(\widehat{\psi})$ denotes the marginal density of $\widehat{\psi}$, where $f(\widehat{\psi}) = \int f(\widehat{\psi}|\theta)p(\theta)d\theta$. Then I characterize the posterior density using the Random-Walk Metropolis Hastings sampler with the objective function

$$g(\theta) \equiv \log f(\widehat{\psi}|\theta) + \log p(\theta).$$

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:

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

Table 3 shows the parameters to be estimated and their priors. I use the uniform priors for all the parameters. This reflects the fact that the 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.

Parameter	**Distribution**	**Support**	**Description**
ζ_1	Uniform	[1.0, 1.5]	Service flow from owned housing (intercept)
ζ_2	Uniform	[0.0, 1.0]	Service flow from owned housing (slope)
ω_{uhp}	Uniform	[0.0, 2.0]	Utility from home production
γ_e	Uniform	[0.5, 1.0]	Economies of scale within marriage
α	Uniform	[0.4, 0.9]	Aggregator for consumption and housing
B_s	Uniform	[10.0, 100.0]	Disutility from working (single)
B_m	Uniform	[10.0, 100.0]	Disutility from working (married head)
$\widetilde{B}_m$	Uniform	[10.0, 100.0]	Disutility from working (married spouse)
ϕ	Uniform	[0.0, 2.0]	Fixed cost of working (head)
$\widetilde{\phi}$	Uniform	[0.0, 2.0]	Fixed cost of working (spouse)

Table 3: Priors

The moments used in this procedure include 1995's life-cycle profiles for homeownership rates, housing asset share, and labor force participation rates for single and married households, respectively. Table 4 shows some percentiles from the prior and the posterior distributions. One advantage of estimation is that I can characterize the uncertainty associated with each parameter. By using the 5th percentile and 95th percentile of the posterior draws, I can construct the 90% credible set for each parameter. The parameter estimates inform me about interesting aspects in life, including utility from home production, economies of scale within marriage, and the cost of labor supply. For instance, the credible set of the economies of scale parameter γ_e is much narrower than the prior's, supporting the existence of economies scale within marriage. In Appendix B, the histograms of each parameter's posterior distribution are shown to be non-uniform by combining the uniform prior with the data's variation.

	Prior			Posterior		
Parameter	5%	50%	95%	5%	50%	95%
ζ_1	1.025	1.25	1.475	1.163	1.364	1.480
ζ_2	0.05	0.5	0.95	0.048	0.341	0.938
ω_{uhp}	0.1	1.0	1.9	0.224	1.015	1.858
γ_e	0.525	0.75	0.975	0.558	0.607	0.679
α	0.425	0.65	0.875	0.458	0.538	0.593
B_s	14.5	55	95.5	33.814	48.670	58.964
B_m	14.5	55	95.5	10.731	17.491	46.067
$\widetilde{B}_m$	14.5	55	95.5	19.046	48.318	74.348
ϕ	0.1	1.0	1.9	0.370	1.374	1.932
$\widetilde{\phi}$	0.1	1.0	1.9	0.097	0.827	1.736

Table 4: Prior and Posterior Distributions of Estimated Parameters

Notes: The columns show the 5th, 50th, 95th percentiles of the prior and the posterior distributions.

4.3 Model fit

Figure 3 shows the model fit for the 1995 data. The model-generated life-cycle profiles are obtained by using the posterior median estimates reported in Table 4. 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 household heads well. The model captures the overall life-cycle profile of spousal labor force participation in the data, even though I do not model many other factors that potentially affect spousal labor supply.

The in-sample fit is also analyzed by the posterior predictive checks reported in Figure 4. I simulate the life-cycle profiles for 50 different posterior draws that are equally distanced over the sampler. From Figure 3 based on the posterior median, 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 asset share are more spread out for younger singles compared to older ones. Hence, the estimation procedure provides measures of uncertainty and some insights that one would not otherwise get with calibration.

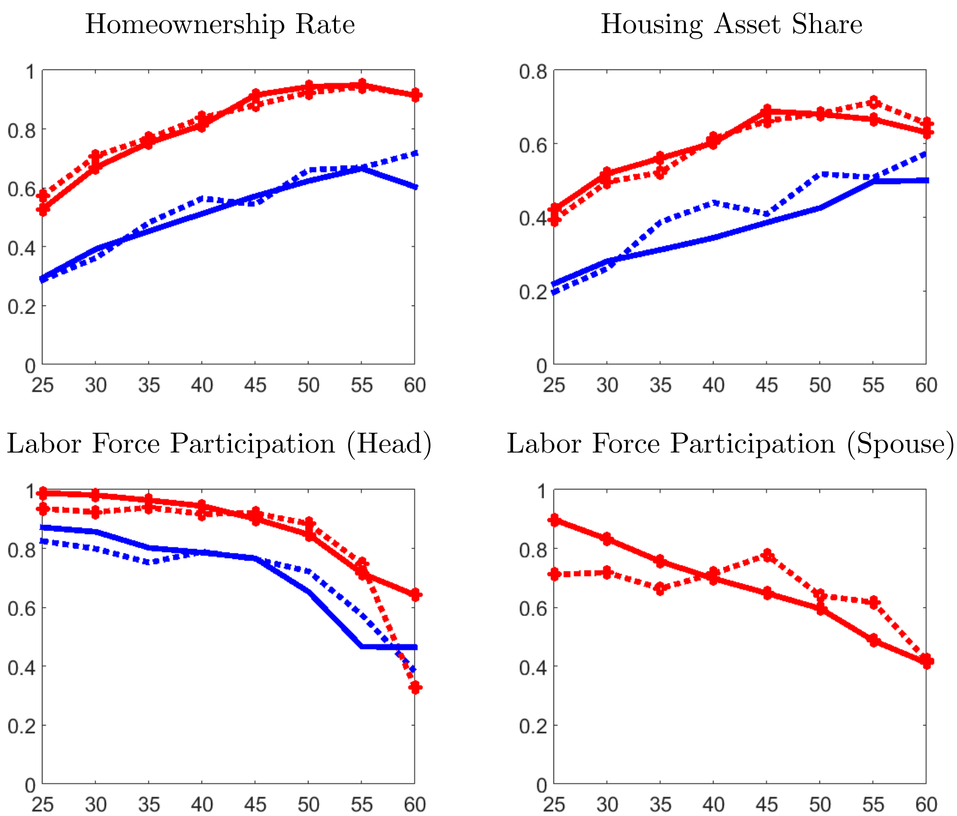

Figure 3: Life-Cycle Profiles: Model *vs.* Data

Notes: Life-cycle profiles of homeownership, housing asset share, and labor force participation from the model and those from the data. The solid lines are obtained from the model given the posterior median estimates. The dotted lines are obtained from the data. The blue lines are for single households and the red lines are for married households.

Lastly, the model is validated with some unmatched moments in Table 5 that are not included in the sampler.

Variable	**Model**	**Data**
Housing wealth to consumption ratio	2.13	2.3
Wealth to income ratio	2.98	3.2
Rent to income ratio	0.23	0.21
Ratio of mean hours worked (Single/Married:Head)	0.81	0.82
Ratio of mean hours worked (Married:Spouse/Married:Head)	0.62	0.66

Table 5: Unmatched Moments: Model *vs.* Data

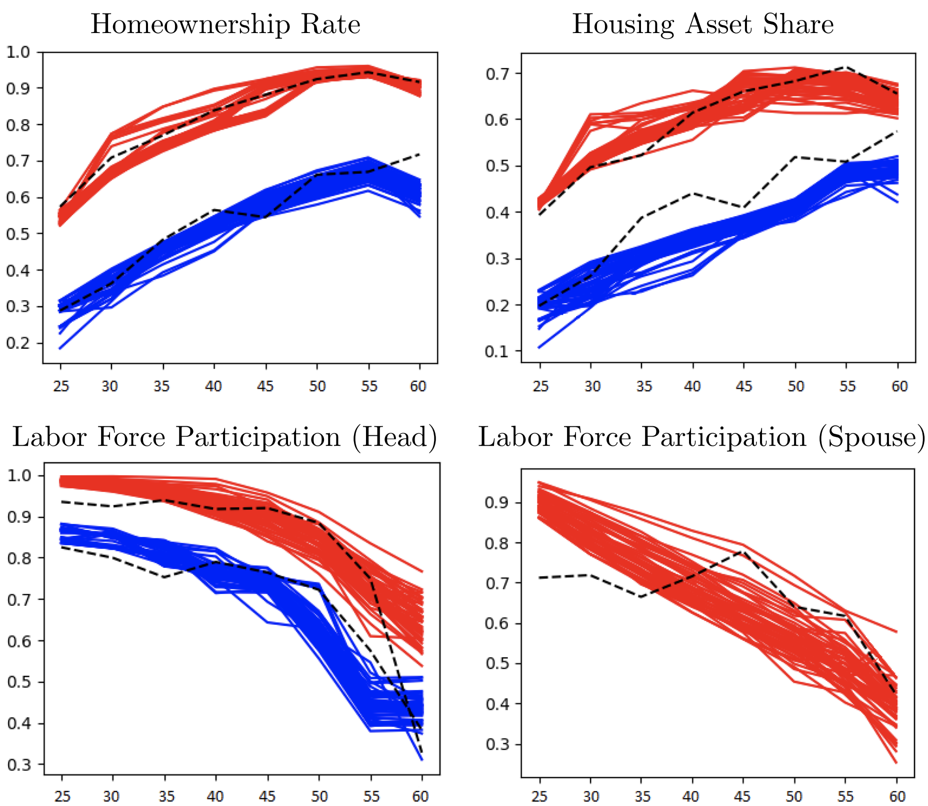

Figure 4: Predictive Checks of Posterior Draws

Notes: Each hairline corresponds to a draw from the posterior distribution. The dotted black lines are the life-cycle profiles from the data. The blue lines are for single households and the red lines are for married households.

5 Decomposition analysis: 1970 *vs.* 1995

Given the model and the parameter estimates, I can answer the main question of how much of the change in marital transition probabilities can account for the change in housing variables. In addition to this change in marriage and divorce probabilities, other 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. The structural model serves as a playing field to generate counterfactual housing variables as the changes in marriage and divorce risk are applied.[17]

[17]The assumption of exogenous marriage and divorce shocks allows me to conduct a straightforward decomposition analysis by feeding in marriage and divorce probabilities constructed from the data. If I endogenize marriage and divorce, then I will need underlying structural shocks affecting marital decisions. What underlying shocks to be modeled and how to design a decomposition analysis with time-varying marriage and divorce become less clear.

5.1 Major changes between 1970 and 1995

(1) Marital transition probabilities

This change is the main channel of interest in this paper. 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 1995. In this decomposition exercise, I feed in the probabilities in 1970 instead, holding the other things fixed, to see how the housing variables would have looked under this scenario.

(2) Downpayment constraint

The downpayment constraint was tighter in 1970 compared to 1995. Fisher and Gervais (2011) point out that the average downpayment in the 1990s was about two-thirds of the value of the average in the 1970s. The parameter governing the tightness of the borrowing constraint is η. The baseline η is set to be 0.75, which equals a 25% downpayment constraint. Instead, I use $\eta = 0.65$ for 1970, which is a value similar to that documented in Bullard (2012).

(3) 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 $\sigma_{\widetilde{x}}$. The parameters for 1970 are set to reflect the 40% increase in volatility from 1970 to 1995 as reported in Fisher and Gervais (2011).

(4) 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 15% from 1970 to 1995. I set the value of $\widetilde{\chi}(j)$ in 1970 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 higher in 1970 so that the average spousal labor force participation rate matches 0.52 in 1970.

5.2 The effect of each channel

I show how each change affects the housing decisions of single and married households. I look at the single households' homeownership rates and the married households' housing asset share, since these variables changed significantly between 1970 and 1995.

(1) Marital transition probabilities

Compared to the baseline, I generate counterfactual housing variables in Figure 5 by changing the marriage and divorce probabilities to be 1970 values. I focus on the age groups from 25 to 44 years old since marital transitions happen relatively early in life. In the left panel of Figure 5, the homeownership rate for young singles becomes lower under the high marriage probabilities of 1970. It is worth noting that the gap between the baseline homeownership and the counterfactual homeownership closes as I look at older ages. This captures the fact that the difference in marriage probabilities between 1970 and 1995 is more conspicuous for those in their 20s or early 30s. The mechanism that generates this drop in homeownership is as follows: a single who expects to get married in the near future will refrain from owning a house due to the transaction costs of selling or resizing. In addition, the prospect of marriage, which causes a free-rider problem with asset pooling, prevents singles from saving.

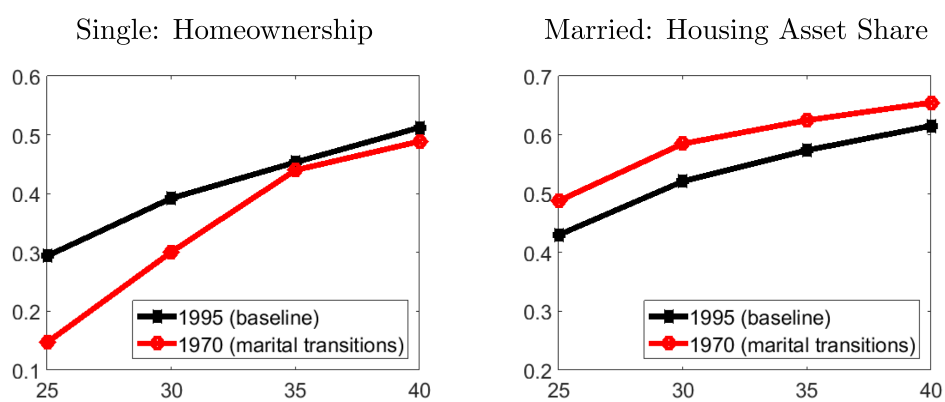

Figure 5: The Effect of the Change in Marital Transition Probabilities on Housing Decisions

Notes: The black lines are generated from the model using the marriage and divorce probabilities in 1995 (baseline). The red lines are obtained by applying the marriage and divorce probabilities in 1970, holding the other things identical to the baseline specification.

The married households face lower divorce probabilities in 1970. Due to a reduced idiosyncratic risk of separation, their precautionary savings motive diminishes, which could reduce the homeownership rate of the married. On the other hand, the housing asset share increases with lower divorce probabilities. Under the 1970 probabilities, the expected return on housing goes up as it is less likely to incur the transaction costs associated with divorce. As shown in the right panel of Figure 5, the married households' housing asset share is bigger under 1970's likelihood of divorce. The gap between the baseline and the counterfactual share does not close for the housing asset share, which reflects the fact that the gap in divorce probabilities does not get narrower even up to age 44.

Figure 6: The Effect of Each Channel on Housing Decisions

Notes: The black lines are generated from the 1995 baseline specification. The red lines are obtained by only changing the marital transition probabilities to be 1970's values, holding the other things identical to the baseline specification. The other lines are obtained by only applying one change to mimic the 1970's economy while preserving the others as in 1995; compared to the baseline, the blue lines are with tighter downpayment constraint, the pink lines are with lower labor volatility, and the cyan lines are with lower spousal labor productivity.

(2) Downpayment constraint

Figure 6 includes the life-cycle profiles generated by each channel considered between 1970 and 1995. The red lines are the same as in Figure 5, showing the effect of marriage and divorce risk. The blue lines are generated by changing the borrowing constraint to mimic 1970's environment while holding the other things fixed to 1995's values.

The borrowing constraint of interest is $b' \geq -\eta P^H h'$. With a tighter borrowing constraint as in 1970, single households' homeownership rates decrease a little, whereas married households' homeownership rates do not change much. However, the average house size for married couples becomes smaller, which results in a decrease in housing asset share. In other words, the intensive margin adjusts with the change in financial constraint, although the extensive margin does not change much for married households. Still, the overall change in housing variables does not seem to be substantial, with the only change being the loan-to-value parameter η moves from 0.75 to 0.65.

However, this does not rule out the possibility that relaxed credit constraints have a decisive effect on housing decisions in times of housing price booms or busts. This will be studied more closely in Section 6, where we study the housing boom in the mid-2000s.

(3) Labor market volatility

With 40% lower labor market volatility, labor supply increases for all household members.[18] Furthermore, the level of income in each state changes with diminishing income risk. I check whether the average household labor income is almost identical before and after the change in volatility. There is only about a 2% increase in the average labor income from this change, so the essential differences in housing decisions will be mostly from the income risk.

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. Under the baseline parameterization, the latter force dominates the former so the homeownership rate decreases under lower income risk. This is the case for both single and married households.

In terms of housing asset share, the magnitude of the change in percentage is smaller than that of the homeownership rate. This is because the reduced precautionary savings motive is split between housing assets and non-housing assets. If there were only one asset available in which to invest, say, a housing asset, then the decrease in homeownership rate would have been larger as it would have absorbed all of the reduction in the precautionary savings motive. With multiple assets, households can adjust, and therefore the portfolio share of housing assets does not fall as much.

(4) Spousal labor productivity and fixed cost of working

The homeownership rate for both single and married households is not affected much by the change in spousal labor force participation. Especially for married couples, this is because a head can increase labor supply as his/her spouse's labor supply diminishes. Figure 7 shows how the life-cycle profiles of labor force participation change as I apply the lower spousal labor productivity $\widetilde{\chi}(j)$ and the higher fixed cost of working $\widetilde{\phi}$. This result is consistent with the observed pattern in the data that married heads worked more in 1970 than those in 1995. With the endogenous labor

[18] This pattern is the opposite of the data's pattern since the spousal labor supply was much smaller in 1970. The change to capture spousal labor supply correctly is studied below.

supply, the homeownership rate does not necessarily fall with a decreased spousal labor supply since the other household member can adjust his/her labor supply upward.

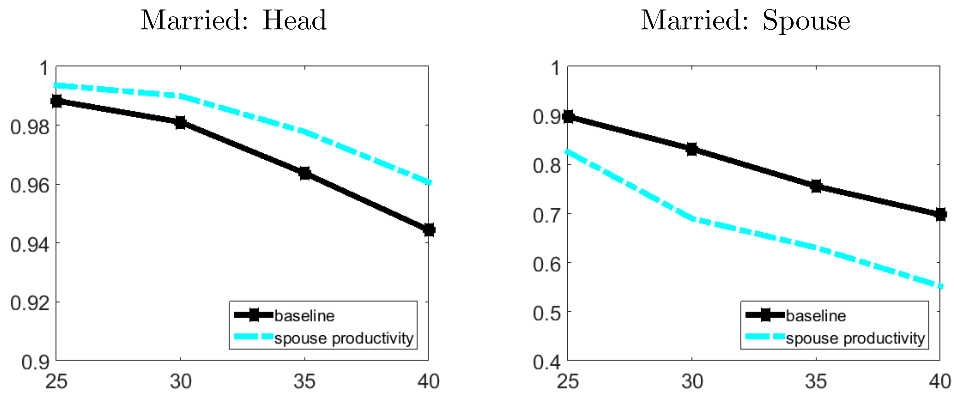

Figure 7: Life-Cycle Profiles of Labor Force Participation (Married Households)

Notes: The black lines are generated from the 1995 baseline specification. The cyan lines are obtained by only changing spousal labor productivity and the fixed cost of working to mimic the 1970 economy while preserving the others identical to the 1995 baseline.

5.3 Decomposition with the data

In this section, I look at the changes in housing variables from the real-world data between 1970 and 1995 and quantify how much of the change can be accounted for by the change in marital transition probabilities.

(1) Homeownership of single households

The homeownership rate of single households was lower in 1970 compared to that in 1995 as shown in the left panel of Figure 8. The right panel of Figure 8 includes two counterfactual life-cycle profiles of homeownership. First, the line associated with Case (I) is generated by applying all the changes except for the marriage and divorce probabilities. In other words, the marital transition probabilities are kept at 1995 values, whereas the downpayment constraint, labor volatility, and spousal labor productivity are set to reflect 1970's environment. All the changes except for the marital transition probabilities induce homeownership to fall compared to the baseline in 1995. However, this does not generate a sufficient drop to match that which is observed in the data, especially for young households in their 20s. The line associated with Case (II) is obtained once I additionally incorporate 1970's marriage and divorce probabilities. As younger singles refrain from

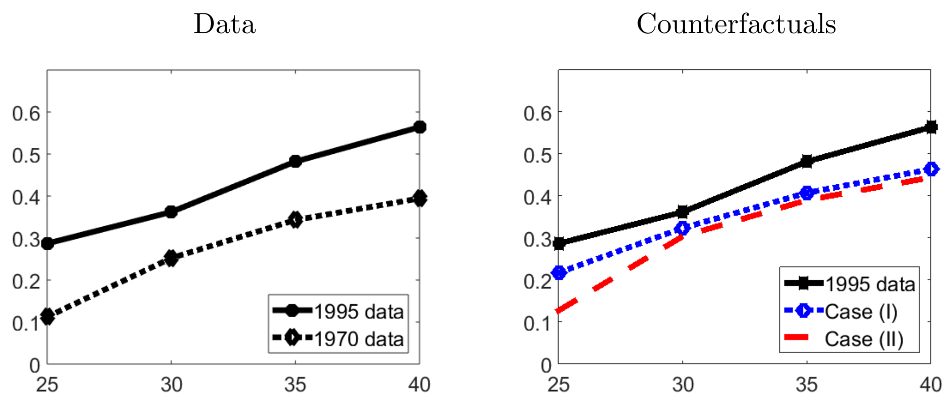

Figure 8: Homeownership of Single Households (Data *vs.* Counterfactuals)

Notes: Case (I) denotes the counterfactual homeownership rate generated by applying the changes in downpayment constraint, labor volatility, and spousal labor productivity to mimic the 1970 economy holding the others at 1995 values. Note that the marriage and divorce probabilities are kept at 1995 values for Case (I). Case (II) is obtained by additionally applying 1970's probabilities of marital transitions to Case (I).

buying a house under the likelihood of marriage in 1970, the homeownership rate drops further from the line under Case (I).

	Data	**Counterfactuals**	
Age	% Change	Case (I)	Case (II)
25 - 29	-61%	-24%	-56%
30 - 34	-30%	-11%	-16%
35 - 39	-29%	-16%	-19%
40 - 44	-30%	-18%	-21%
Average	-38%	-17%	-28%

Table 6: Homeownership of Single Households (Data *vs.* Counterfactuals)

Notes: Single households' homeownership change in percentage from the benchmark year 1995. The column labeled Data shows how different the homeownership rate in 1970 was compared to the homeownership rate in 1995. Case (I) is based on the counterfactual homeownership rate generated by applying the changes in downpayment constraint, labor volatility, and spousal labor productivity to mimic the 1970 economy holding the others at 1995 values. Case (II) additionally applies 1970's probabilities of marital transitions to Case (I). The columns labeled Counterfactuals include the homeownership change obtained by applying Case(I) and Case(II), respectively.

Table 6 quantifies the change in percentage, taking 1995 as the benchmark. For instance, the homeownership of single households of age 25-29 was 61% lower in 1970 compared to 1995. The third column, Case (I), shows the counterfactual homeownership rates generated by applying all the changes except for the marriage and divorce probabilities. By taking the average over the age groups from 25 to 44 years, this specification generates the 17% drop in homeownership compared to the baseline. In summary, 45% of the change observed in the data can be explained by the combined change captured by Case (I).

The last column, Case (II), shows the values obtained by additionally applying 1970's marriage and divorce probabilities to Case (I). This specification generates the average of a 28% drop in the homeownership rate from age 25 to 44. In other words, 29% of the observed change can be additionally accounted for by the change in marriage and divorce probabilities. The change in marital transitions seems to be quantitatively of comparable importance to the combined effect of borrowing constraints, earnings risk, and spousal productivity.

(2) Housing asset share of married households

Figure 9 shows that the housing asset share of married households was higher in 1970 than in 1995. The line under Case (I), from the changes except for the marital transition probabilities, shows a small decrease in the housing asset share. Since the reduced precautionary savings motive is split between housing assets and non-housing assets, the housing asset share does not fall as much as the homeownership rate would fall. On the other hand, the reduction in divorce risk induces married households to tilt their portfolio toward housing assets. This change is reflected in the line associated with Case (II) in Figure 9.

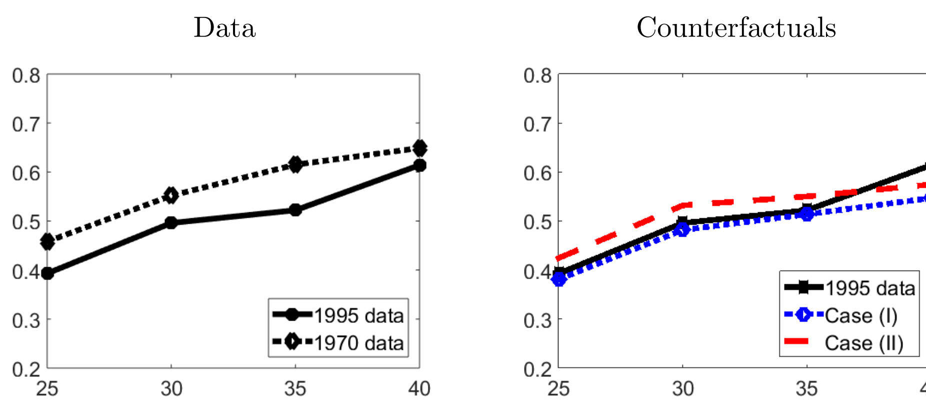

Figure 9: Housing Asset Share of Married Households (Data *vs.* Counterfactuals)

Notes: Case (I) denotes the counterfactual housing asset share generated by applying the changes in downpayment constraint, labor volatility, and spousal labor productivity to mimic the 1970 economy holding the others at 1995 values. Note that the marriage and divorce probabilities are kept at 1995 values for Case (I). Case (II) is obtained by additionally applying 1970's probabilities of marital transitions to Case (I).

Table 7 summarizes the change in percentage of the housing asset share. Without the change in marital transition probabilities, the average change has a negative sign, which is the opposite of what we observe in the data. However, once 1970's marriage and divorce probabilities are incorporated, the direction of change becomes consistent with the data. With all the changes applied, 31% of the observed change in portfolio share can be generated. This decomposition analysis emphasizes that the change in marital transition probabilities is an important risk factor when it comes to understanding the change in housing decisions.

	Data	**Counterfactuals**	
Age	% Change	Case (I)	Case (II)
25 - 29	+17%	-3%	+8%
30 - 34	+11%	-3%	+7%
35 - 39	+18%	-2%	+5%
40 - 44	+6%	-11%	-6%
Average	+13%	-3%	+4%

Table 7: Housing Asset Share of Married Households (Data *vs.* Counterfactuals)

Notes: Married households' housing asset share change in percentage from the benchmark year 1995. The column labeled Data shows how different the housing asset share in 1970 was compared to the housing asset share in 1995. Case (I) is based on the counterfactual housing asset share generated by applying the changes in downpayment constraint, labor volatility, and spousal labor productivity to mimic the 1970 economy holding the others at 1995 values. Note that the marriage and divorce probabilities are kept at 1995 values for Case (I). Case (II) additionally applies 1970's probabilities of marital transitions to Case (I). The columns labeled Counterfactuals include the housing asset share change obtained by applying Case(I) and Case(II) respectively.

6 Recent experiences in the housing market

The change in marital transition probabilities is shown to help account for the change in housing variables between 1970 and 1995. The question in this section is whether marital transitions have continued to change and, if so, whether they are still useful to understand the change in housing variables in recent years. In the previous decomposition analysis, the two years — 1970 and 1995 — were deliberately chosen because while real house prices were similar in levels, the marital transition probabilities were different. This allows me to study the effect of marital transition probabilities while controlling for house price, which is a confounding factor. Furthermore, cohabitation was prevalent neither in 1970 nor 1995, which justified treating only the legally married households as being married.

However, if one wants to study the change in housing variables in more recent periods, it is inevitable to consider the changes in house prices. This section focuses on the house price boom in the mid-2000s, which is a representative example of a big swing in house price.[19] Over these periods, there have also been major changes in credit constraints, wages, and households' beliefs on future housing prices. The main analysis of this section focuses on whether the likelihood of marital transitions plays a role in explaining housing decisions, considering several factors that characterize recent experiences in the housing market. Also, as cohabitation has become more common these days, it is worth looking at whether there is any difference between legally married households and cohabiting couples in terms of housing decisions. The last subsection serves as a robustness check by categorizing cohabiting couples as married households.

6.1 Major changes over time

(1) Marital transition probabilities

Figure 10 overlays the marriage and divorce probabilities in 2007 on those in both 1970 and 1995. The marriage probabilities for young singles in their 20s or 30s continued to fall. In addition, the divorce probabilities fell for young singles. From 1995 to 2007, marital transition probabilities moved in the same direction for young households. This is the opposite of what happened between 1970 and 1995; marriage probabilities fell, while divorce probabilities increased.

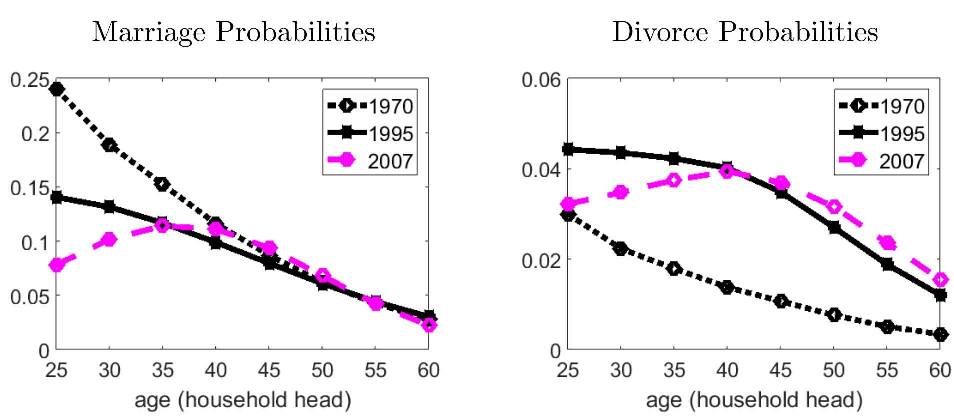

Figure 10: Marriage and Divorce Probabilities

(2) Housing prices and beliefs on price appreciation

This paper considers housing prices to be exogenous, which means I do not analyze what drives the substantial price changes over time. When analyzing the change in house prices in more

[19] I also analyzed the recovery period after the bust using the data for the years 2010 and 2013. This analysis is available upon request, although omitted in the paper.

recent years, I model the common house price to be a shock similar to Corbae and Quintin (2015). Referring to the price index by Shiller (2000),[20] real home values were relatively stable between 1890 and 2013, except for two periods. The first exception is from 1920 to 1939, which featured low home values. The other is the recent housing price boom, which lasted from 1999 until the crisis. Hence, the common house price is modeled as $P_t^H = P^H \times z_t$, where z_t is a three-point process

$$z_t \in [0.7, 1, 1.3]$$

with a Markov transition matrix. The support is set from the observation that average home values during low times are about 30% below the corresponding average during normal times. Symmetrically, the highest price is set to be 30% higher than the middle price.[21] The transition matrix Π_{P^H} is set as

$$\begin{bmatrix} 0.75 & 0.25 & 0 \\ 0.045 & 0.91 & 0.045 \\ 0 & 0.375 & 0.625 \end{bmatrix}.$$

This matrix is set based on the following: the middle price is maintained from 1940 to 1995, which corresponds to 11 model periods. Deviations to the lowest level are expected to last for 20 years. Lastly, deviations to the highest level are expected to last for about 13 years.

Changes	1995	2000	2005
Housing price shock P_t^H	p_2^H	p_2^H	p_3^H
Belief shock of appreciation o_t	0	ϵ	ϵ
Wage w	1.0	1.07	1.07
Downpayment constraint $(1-\eta)$	0.25	0.2	0.15
Borrowing interest rate r^H	0.07	0.06	0.05
Savings interest rate r	0.02	0.018	0.015
Likelihood of marital transitions	baseline	marriage ↓, divorce ↓	

Table 8: The Sequence of Changes Over Time

Notes: p_2^H stands for the middle house price and p_3^H is for the high house price. The wage is normalized so that the value in 1995 is 1.0. The interest rates are reported in annual terms. The likelihood of marital transitions is from marriage and divorce probabilities over the life-cycle as in Figure 10.

Let's first look at the life-cycle profiles of homeownership rates from applying the shock above. Starting from the steady state of 1995, I feed in the house price series so that the highest price hits the economy only in 2005 as described in Table 8. The blue dotted lines in Figure 11 are obtained

[20] http://www.econ.yale.edu/∼shiller/data.htm

[21] This is in line with the observation that the real house price in 2005, which can represent the boom period, was 30% higher than the price in 1995.

in the model period 2005.[22] The model cannot simulate households to own more housing while facing the more expensive price. The homeownership rates of both single and married households are much lower compared to what is observed in the 2007 data. Since housing prices are at their highest levels, they are expected to fall. Hence, households do not invest in housing assets unless they expect the asset price to rise more.

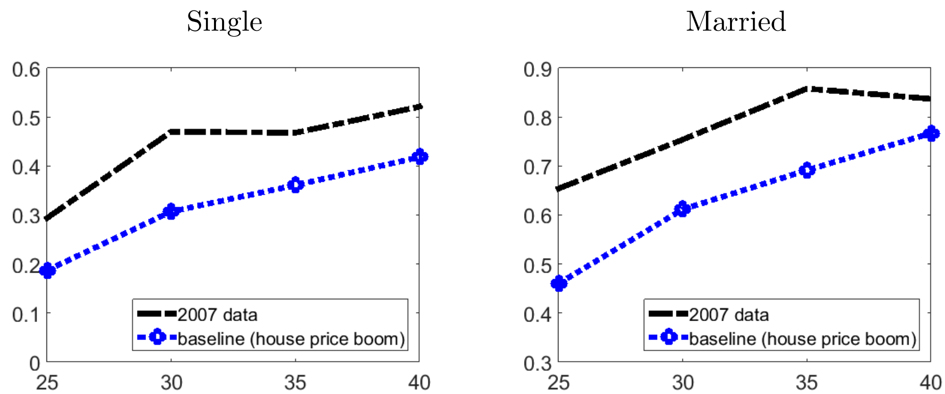

Figure 11: Homeownership at the House Price Boom (Data *vs.* Model)

Notes: The black lines are drawn with the 2007 Survey of Consumer Finances data, which represents the housing price boom. The blue lines are obtained from the model by applying the stochastic house price shock as follows: starting from the steady state of 1995, the house price series is fed so that the highest price hits the economy in 10 years. The blue lines stand for the homeownership rate in this boom period.

Hence, I model that households could expect house price appreciation while facing a higher house price in a similar vein to Kaplan et al. (2017). Specifically, I incorporate an additional shock to households' beliefs on house price appreciation. The belief shock to future appreciation o_t is modeled as the two-state process where $o_t \in \{0, \epsilon = 0.6\}$.[23] With this additional shock, the future house price is expected to be $P^H_{t+1} \times (1 + o_{t+1})$. The transition matrix of o_t is set to be

$$\Pi_o \equiv \begin{bmatrix} \pi_{00} & \pi_{0\epsilon} \\ \pi_{\epsilon 0} & \pi_{\epsilon\epsilon} \end{bmatrix} = \begin{bmatrix} 0.85 & 0.15 \\ 0.5 & 0.5 \end{bmatrix}.$$

In other words, given $o_t = 0$, households expect the future price to be

$$\begin{cases} P^H_{t+1} & \text{with probability } 0.85 \\ P^H_{t+1} \times (1+\epsilon) & \text{with probability } 0.15. \end{cases}$$

[22]When I conduct an analysis with (simulated) housing asset share, the results are qualitatively similar. Hence, the results with homeownership rates are reported.

[23]The value of ϵ is consistent with Case et al. (2012), where survey expectations on annual growth of housing prices are reported to be between 6 and 15%. $\epsilon = 0.6$ is translated as a 12% increase per annum.

Households are not likely to be optimistic about additional future price appreciation. The expected duration of not being optimistic is about 30 years.

On the other hand, given $o_t = \epsilon$, households expect the future price to be

$$\begin{cases} P_{t+1}^H & \text{with probability } 0.5 \\ P_{t+1}^H \times (1+\epsilon) & \text{with probability } 0.5. \end{cases}$$

Once a household becomes optimistic, that is, $o_t = \epsilon$, then the household expects future price appreciation $P_{t+1}^H \times (1+\epsilon)$ with a half probability. The expected duration of being optimistic is 10 years, which is close to the length of the recent housing boom-bust episode in the 2000s. Physical environment at period t such as a budget constraint does not change with o_t. All the change lies in the expectation about future house prices.

Given this additional shock, I define a new state variable $\tau_t \equiv (P_t^H, o_t)$. This shock τ_t can take 6 possible values. $\tau_t \in \{(p_1^H, 0), (p_1^H, \epsilon), (p_2^H, 0), (p_2^H, \epsilon), (p_3^H, 0), (p_3^H, \epsilon)\} \equiv \{\tau_{1,0}, \tau_{1,\epsilon}, \tau_{2,0}, \tau_{2,\epsilon}, \tau_{3,0}, \tau_{3,\epsilon}\}$. The transition matrix is

$$\Pi_\tau = \Pi_{P^H} \otimes \Pi_o = \begin{bmatrix} 0.75 & 0.25 & 0.0 \\ 0.045 & 0.91 & 0.045 \\ 0.0 & 0.375 & 0.625 \end{bmatrix} \otimes \begin{bmatrix} 0.85 & 0.15 \\ 0.5 & 0.5 \end{bmatrix} = \begin{bmatrix} 0.638 & 0.113 & 0.213 & 0.038 & 0 & 0 \\ 0.375 & 0.375 & 0.125 & 0.125 & 0 & 0 \\ 0.038 & 0.007 & 0.774 & 0.137 & 0.038 & 0.007 \\ 0.023 & 0.023 & 0.455 & 0.455 & 0.023 & 0.023 \\ 0 & 0 & 0.319 & 0.056 & 0.531 & 0.094 \\ 0 & 0 & 0.188 & 0.188 & 0.313 & 0.313 \end{bmatrix}.$$

I extend the previous model with an additional state τ_t and its transition matrix Π_τ. The expected value should be carefully computed, taking into account the stochastic nature of τ_{t+1} given τ_t. I apply the sequence of shocks (P_t^H, o_t) in Table 8. There is empirical evidence, such as Piazzesi and Schneider (2009) and Landvoigt (2017), supporting the optimistic beliefs of households for house price appreciation. I set the belief shock to hit both 2000 and 2005, whereas the highest house price shock hit 2005 only. Standing at the baseline year 1995, the ex-ante probability of this particular realization of shocks is close to 0.05%. In this regard, this simulation represents a tail event similar to the boom-bust episode of the 2000s.

(3) Wage and credit constraints

In addition to the change in housing prices and households' beliefs, I consider the simultaneous change in wages and credit constraints during the boom as in Kaplan et al. (2017). I set the wage to be 7% higher in both 2000 and 2005 compared to the baseline wage in 1995. This change is similar to the change observed in the median weekly real earnings for wage and salary workers.[24]

For credit constraints, I consider the following changes. First, the downpayment constraint is relaxed by changing $(1 - \eta)$ to be 0.15 in 2005 compared to 0.25 in 1995. Then the value for 2000 is taken to be 0.2, the average of the two. Second, the borrowing interest rate r^H is reduced to be 0.05 per annum and the savings interest rate r is set to be 0.015 in 2005. The values for 2000 are again taken to be the average of the 1995 value and the 2005 value. This change is consistent with the decrease in the fixed rate for a 30-year mortgage and the decrease in the net interest margin.

6.2 The effect of each channel: During boom

The blue lines in Figure 12 (identical to Figure 11) show that the change in housing prices alone is insufficient to generate the homeownership increase observed in the data for both single and married households.

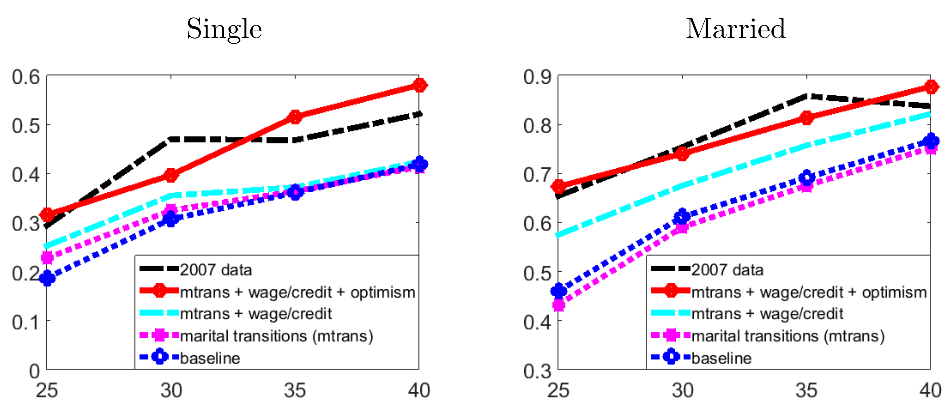

Figure 12: The Effect of Each Channel on Homeownership (During Boom)

Notes: The black lines are drawn with the 2007 Survey of Consumer Finances data, which represents the housing price boom. The blue lines are obtained from the model by applying the stochastic house price shock to reach the highest price. The pink lines are obtained by additionally applying the change in marital transition probabilities. The cyan lines are obtained by incorporating wage increase and credit constraint relaxation. Lastly, the red lines are obtained by reflecting the belief shock on house price appreciation. The sequence of the changes applied is stated in Table 8.

[24] This is based on the LES1252881600Q series from FRED.

(1) Marital transition probabilities

The homeownership rates represented by the pink lines in Figure 12 are obtained by changing the probabilities of marriage and divorce to be the 2007 values, as in Figure 10. The marriage probabilities continued to fall for young households and so did the divorce probabilities. As singles are less likely to get married, their homeownership rate increases. The average homeownership rate from age 25 to 44 increases by 6.8%. As seen in Figure 12, the effect of marital transitions is larger for younger singles. To be specific, there is about a 20% increase for the age group of 25-29 years and a 5% increase for the 30-34 years group. Hence, this channel contributes to narrowing the gap between the baseline and the 2007 data for young singles.

On the other hand, married households' homeownership rate decreases with the decrease in divorce probabilities. The reduced precautionary savings motive exerts downward pressure on married couples to decrease their homeownership. There is about a 3% decrease in the average homeownership from 25 to 44 years. The recent marital transition probabilities slightly widen the gap between the baseline and the 2007 data for married households.

(2) Wage and credit constraints

From Figure 12, the homeownership rate is shown to increase with higher wage and relaxed credit constraints as in Table 8. This is observed for both singles and married households, but the magnitude of increase is bigger for married households across all age groups. As married households are more likely to buy a house with the joint asset and labor income compared to singles, they react more strongly once conditions are improved to make housing affordable. For young singles, wage increase and improved credit accessibility help to increase homeownership. Although the model generates a higher homeownership rate with better wage and credit constraints, it is still insufficient to match the homeownership rate observed in the 2007 data.

(3) Beliefs on house price appreciation

Lastly, I add the shock to beliefs about future price appreciation. When I do so, the homeownership rate becomes similar in level to what is observed in the real-world data. It is worth noting that it is not only the effect of optimism on price appreciation. Without the wage increase and the lax credit constraints, the increase in homeownership from mere optimism is much smaller than what I observe in the data. Thus, to enable households to afford more housing, I need beliefs about housing price appreciation in addition to changes in labor income and borrowing capacity. A similar point is also made in Kaplan et al. (2017).

To sum up, although the magnitude of change is smaller compared to that in the past (1970 *vs.* 1995), the change in the likelihood of marital transitions still increases homeownership among single households and decreases homeownership among married households. However, the unprecedented changes in wages, credit constraints, and beliefs of appreciation, coupled with a boom in housing prices, played a tremendous role in generating a surge in the homeownership rate. For married households, these changes during the boom seemed to mask the trend of decreasing homeownership rates induced by the marital transitions. In contrast, the change in marriage probabilities contributes to replicating the homeownership increase for young singles even when housing prices were expensive.

6.3 Robustness check with cohabiting couples

The rate of cohabitation more than doubled between 1995 and 2010. In all the analysis prior to this subsection, only legally married households are considered to be married. The concern is whether legal marriage in recent years is mere labeling; if legally married households and cohabiting couples are qualitatively similar in terms of housing decisions, it might be misleading to categorize cohabiting couples as single households. In the following subsections, I look at two data sources with information on cohabitation and see whether the previous analysis is still robust regardless of how cohabiting couples are categorized.

(1) From SCF data

Figure 13 shows the homeownership rate for married households, where "being married" is differently defined. As cohabitation has become more prevalent since the 2000s, it is useful to look at whether there is a significant difference between legally married households and cohabitors in terms of homeownership. It is shown that married households' homeownership rate becomes lower once I include cohabitors in the married category. This may result from the fact that a household's ability to buy a house is quite different between married couples and cohabitors. For example, a married couple can own a house together, with both of them being on the deed, and sign a joint mortgage contract with tax benefits. However, these benefits are not legally available to cohabiting couples.

The average homeownership during the boom becomes 5.6% lower if I regard cohabitors as married. Also, I can see the fraction of cohabiting couples across different age groups during the boom as in Figure 13. This fraction is higher for younger couples. This composition change of increasing cohabitors puts a downward force on the average homeownership rate if they are categorized as married. It is worth noting that the trend in the homeownership rate over time is qualitatively similar regardless of how cohabitors are categorized, since the average homeownership rate increased during the boom.

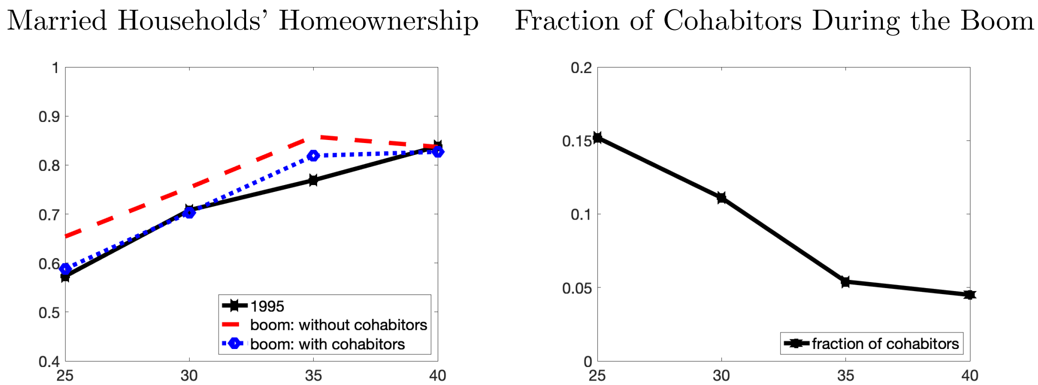

Figure 13: Married Households' Homeownership and Fraction of Cohabitors

Notes: In the left panel, the black solid line for the 1995 data is the baseline drawn with legally married households only. The red dashed line stands for the homeownership rate of legally married households only. The blue dotted line is the homeownership rate of both legally married and cohabiting couples. The right panel shows the fraction of cohabiting couples across different age groups during the boom.

(2) From PSID data

I look at the marriage and divorce probabilities depending on how cohabitors are categorized. In the PSID data, there are two variables related to marital status. Taking the 2007 PSID as an example, variable *ER36023* asks about the legal marital status, whereas *ER41039* asks about marital status where no distinction is made between those legally married and those who merely cohabitate. I construct the age-dependent marriage and divorce probabilities using these two different variables.

Figure 14 shows the marriage and divorce probabilities depending on how cohabitors are categorized. The divorce probabilities become higher once I include cohabitors among the married. So the young cohabitors are more likely to separate than the legally married. The marriage probabilities become lower once I include cohabitors. This indicates that the transition from single to either married or cohabiting is less likely than the one from single or cohabiting to married. However, the discrepancies observed in Figure 14 are small and the recent trend of falling marriage and divorce probabilities is maintained regardless of whether I categorize cohabitors as singles or married.

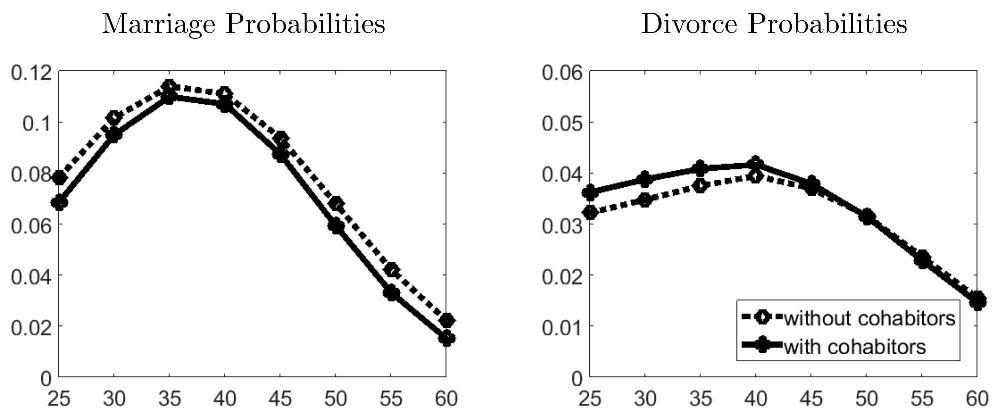

Figure 14: Marriage and Divorce Probabilities with and without Cohabitors

Notes: Marriage and divorce probabilities using the PSID data from 2007 to 2013. The dotted lines are constructed by categorizing cohabitors as singles. In other words, only legally married households are considered as married. The solid lines are obtained by additionally regarding cohabitors as married households.

7 Concluding remarks

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 first look at two 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. Furthermore, the prospect of marriage discourages singles from saving, which makes it unlikely for them to be homeowners. 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 would make the house owned prior to the change no longer suitable. In addition, the model includes features to incorporate the changes in borrowing constraints, earnings risk, and spousal productivity.

I estimate the parameters of the model by a limited information Bayesian method to match the moments from 1995's cross-section data. Then I conduct a decomposition analysis comparing 1970 to 1995 as two steady states with different marriage and divorce probabilities. I find that the change in the likelihood of marital transitions accounts for 29% of the increase in the homeownership rate of singles. This fraction is substantial given that the changes in downpayment requirements, earnings risk, and spousal labor productivity jointly replicate 45% of the change. Furthermore, the model can only reproduce the decline in housing asset share if the changes in marital transitions are included. In their absence, the other drivers predict an increase in this share, again demonstrating the crucial importance of this channel for observed trends in households' housing decisions.

I then extend my analysis to study whether the ongoing change in marital transitions still plays a role in explaining housing decisions during the boom in the mid-2000s. To do so, one must inevitably incorporate the dramatically changing house prices. Hence, I simulate homeownership rates with the changes in marital transitions, house prices, beliefs on appreciation, credit constraints, and wages. The decrease in both marriage and divorce probabilities increases the single households' homeownership rate by 6.8%, but it decreases married households' homeownership rate by 3.2%. The changes in credit constraints, wages, and beliefs on appreciation were often suggested as drivers for the homeownership increase during the boom, which is also supported by my paper. It is worth noting that the change in marital transitions contributes to replicating the homeownership increase for young singles even when housing prices were expensive.

Lastly, since marital transitions and housing decisions are complex problems in life, my model abstracts from some interesting dimensions to explore, including strategic interactions within marriage. In other words, my model is a measurement device to see how much the likelihood of marital transitions accounts for the change in housing decisions while ruling out disagreement between spouses. This model is still meaningful to account for the increase in single households' homeownership and the decrease in married households' housing asset share. How these within-group changes in housing decisions are affected by the prospects of marriage and divorce has not been quantified in the literature. However, the current model is not sufficient to study, for example, how divorced males and females differ in their decisions and outlooks and how these discrepancies affect joint decisions during marriage. Incorporating intra-household bargaining or collective decision making would be an interesting avenue for future research.

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

A 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 the 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 = $\begin{cases} \text{net value of housing/total asset} & \text{if total asset} > 0 \\ 0 & \text{if total asset} = 0 \end{cases}$

The variables for the years 2007, 2010, 2013 are all constructed in an analogous manner, hence an explanation is omitted.

(2) Year 1970

(2-1) 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[25], homeownership dummy, housing asset share are analogously defined as with the 1995 SCF.

(2-2) 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 9 shows the summary statistics from the data sets in 1970 and 1995.

[25] 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 (1970 v. 1995)

	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 (imputed v. raw)

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

Table 9: Summary Statistics (1970 vs. 1995)

Notes: M stands for married and S stands for single. Education of 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).

Variables	Coefficients (S.E.)	p-value	Coefficients (S.E.)	p-value	Coefficients (S.E.)	p-value	Coefficients (S.E.)	p-value
log(non-housing asset)	0.131***	0.000	0.132***	0.000	0.132***	0.000	0.133***	0.000
	(0.015)		(0.015)		(0.015)		(0.015)	
age	0.023***	0.000	0.023***	0.000	0.023***	0.000	0.023***	0.000
	(0.003)		(0.003)		(0.003)		(0.003)	
education	0.068***	0.000	0.068***	0.000	0.068***	0.000	0.068***	0.000
	(0.015)		(0.015)		(0.015)		(0.015)	
marriage dummy	0.192***	0.004	0.185***	0.008	0.192***	0.004	0.185***	0.007
	(0.067)		(0.069)		(0.067)		(0.069)	
weekly hours worked	0.003*	0.098	0.003	0.104	0.004*	0.081	0.004*	0.084
	(0.002)		(0.002)		(0.002)		(0.002)	
homeownership dummy	3.835***	0.000	3.832***	0.000	3.837***	0.000	3.834***	0.000
	(0.059)		(0.059)		(0.059)		(0.060)	
children dummy	—	—	0.024	0.690	—	—	0.025	0.684
			(0.061)				(0.061)	
employment dummy	—	—	—	—	-0.075	0.464	-0.075	0.462
					(0.103)		(0.103)	
constant	-3.098***	0.000	-3.124***	0.000	-3.067***	0.000	-3.094***	0.000
	(0.177)		(0.189)		(0.182)		(0.194)	
Number of observations	1570		1570		1570		1570	
Adjusted R-squared	0.794		0.794		0.794		0.794	

Table 10: OLS Regression Results (SCF 1970)

Notes: Statistical significance is expressed with ***: <0.01, **: <0.05, *: <0.1

B Posterior draws

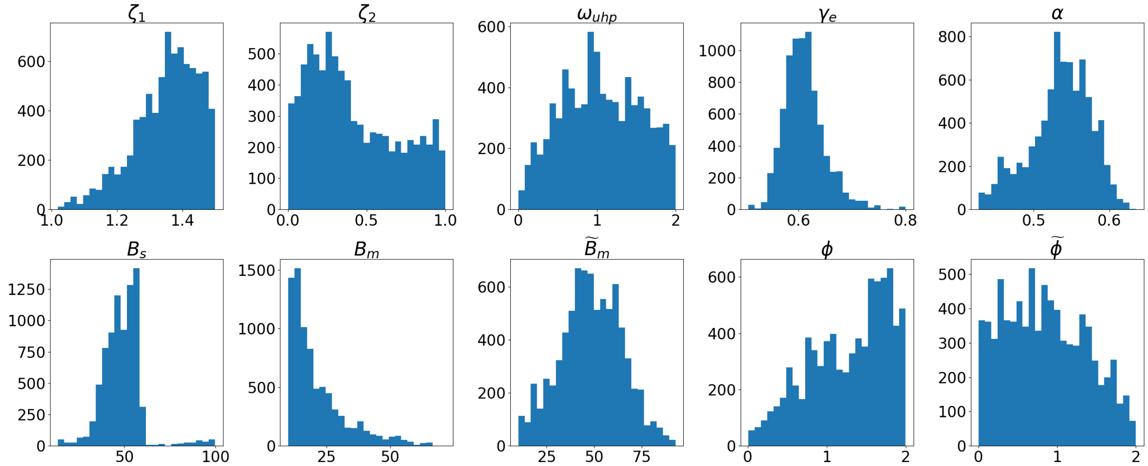

Figure 15: Histogram of Posterior Draws