Housing Decisions under Divorce Risk*

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Abstract

We investigate the role of divorce as a risk factor that affects household consumption and housing decisions in a realistically calibrated life-cycle model. Divorces result in a reduction of household net worth, and therefore reduce the likelihood of being a homeowner. The reduction in homeownership lasts for decades, even though households can remarry later. Welfare costs from getting divorced can exceed 20% of lifetime consumption at the age of 30, and more than double by the age of 60. The risk of divorce leads to precautionary savings, facilitates earlier homeownership, and has welfare implications even for individuals not getting divorced.

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1 Introduction

Throughout the recent decades, household formation has undergone dramatic changes. Individuals are increasingly delaying marriage, which has resulted in the lowest ever marriage rates and increased to a historically high level the share of individuals who have never been married. Rising divorce rates have further contributed to this trend.[1] The increase in divorce rates has given rise to a growing literature that explores the impact of divorce risk on savings and wealth accumulation over the life cycle. The studies of Cubeddu and Rìos-Rull (2003), Fernández and Wong (2014), González and Özcan (2013), and Mazzocco, Ruiz, and Yamaguchi (2014) find that in the face of higher divorce risk, the savings motives of households change, especially for females, who prefer to increase savings in order to transfer more assets to the divorce state.

Little research has investigated how divorce risk affects housing decisions and the demand for homeownership. Given that owner-occupied homes constitute the largest single financial asset for the majority of households, understanding the implications of divorce risk in the presence of housing is important. To investigate housing decisions under divorce risk, we extend life-cycle models with housing, such as Cocco (2005) and Yao and Zhang (2005), by explicitly taking family structure into account.[2] Simultaneously, we extend the work of Love (2010) that investigates how family structure affects portfolio decisions, by modeling housing decisions. Optimal housing decisions under divorce risk have not received much attention in the literature so far. The investigation of this relationship and our model are the main contributions of our paper.

We construct a life-cycle model of consumption, investment, and housing decisions, in which changes in family composition are drivers of homeownership and housing demand. Gender, the number and ages of children in a household, and marital status characterize the family structure of households. We distinguish between single, married, divorced, and widowed households, and allow households' marital status to change over time. A combination of both exoge-

[1] See Bramlett and Mosher (2002), Copen, Daniels, Vespa, and Mosher (2012), and Jacobsen, Mather, and Dupuis (2012) for a statistical overview of the recent marriage and divorce trends.

[2] The work of Cocco (2005) and Yao and Zhang (2005) has been extended along several other dimensions not related to family structure, such as allowing for costly mortgage refinancing (Hu, 2005), adjustable-rate mortgages (Van Hemert, 2010), tax-arbitrage (Marekwica, Schaefer, and Sebastian, 2013), autocorrelation in residential house prices (Fischer and Stamos, 2013), or mortgage default (Campbell and Cocco, 2015).

nous and endogenous factors determines the process for marriage and childbirth. To address the impact of divorce risk on housing decisions, we model divorce as a shock, as in Cubeddu and Rìos-Rull (2003). However, we allow divorce to dependent on individuals' characteristics, such as age, sex, and whether children are present in the household. Mortality rates determine the transition to widowhood and out of population through death.

Apart from the risk of divorce, households live in an environment of uncertain formation of economic resources, including risky returns on financial assets and real estate, as well as unspanned labor income. Differences in the volatility of labor income for married and single individuals, and economies of scale from living in a partnership are important features of our model. Combined net worth and income of married households is larger than that of singles, which alone can explain a large part of the increased demand for homeownership for married households. Further, being subject to lower volatility in their labor income streams, and therefore, being less sensitive to unfavorable income shocks, allows for even greater savings for married households and a therefore greater likelihood of living in owner-occupied homes. Economies of scale enable married couples to save more in the short run and acquire a home earlier. For divorced individuals, the loss of economies of scale and the higher volatility of labor income are important factors that lead to a reduction of their demand for homeownership.

Our model predicts that divorces have a long-lasting effect on the demand for homeownership. The event of a divorce causes a rapid decrease in household net worth and income, and an immediate drop in the likelihood of being a homeowner. Divorce also results in a persistent reduction of homeownership rates that lasts for decades, even though households can remarry later. Finally, divorces are associated with large welfare losses. Our results indicate that a 30-year-old individual getting divorced needs an increase in net worth and future labor income of 24% to attain the same welfare as an individual not getting divorced. By the age of 60, this welfare effect more than doubles.

We find divorce risk triggers the precautionary savings motive (see also Cubeddu and Rìos-Rull, 2003; Fernández and Wong, 2014; González and Özcan, 2013; Mazzocco, Ruiz, and Yamaguchi, 2014, on that effect). It drives higher savings at a younger age and thus facilitates earlier homeownership. This behavior is equally pertinent for both married and single individuals. It also suggests that with reduced divorce risk and despite the reduced risk of homes sales and the implied transaction cost burden in the event of a divorce, homeownership would be delayed. The effect of the precautionary savings motive outweighs the transaction cost burden in the event of a divorce. This implication is in line with the empirical observation of moderating divorce rates since the early 1980s occurring simultaneously with the increasing average age of first-time home buyers. Other explanations for the delayed homeownership among the young include changing demographics (Segal and Sullivan, 1998), the decline in marriage rates (Fisher and Gervais, 2011), and the reduction of housing affordability (Mayer and Engelhardt, 1996).

We also test how ignoring the possibility of divorce, a phenomenon, known as one of the marriage paradoxes, affects household decisions.[3] Our analysis illustrates the sluggishness of the precautionary savings channel if individuals underestimate their probability of divorce, which also leads to significant welfare losses and delayed homeownership. Overall, our findings indicate the possibility of divorce is an important risk factor, in addition to uncertainty in income, house prices, and financial assets – the risk factors typically studied in the life-cycle literature with owner-occupied housing (Cocco, 2005; Yao and Zhang, 2005).

This paper proceeds as follows. We formulate and calibrate our life-cycle model in section 2. In section 3, we outline our model's predictions and investigate the effect of divorce risk on household life-cycle decisions. Section 4 concludes. The appendix provides technical details on the solution of our model, the estimation of households' labor income process, and data construction.

2 The Model

In this section, we present a life-cycle model of consumption, housing, portfolio choice, and family decisions, in which changes in family composition are important drivers of household decisions. We employ a discrete-time framework, where T denotes the maximum length of the household's life cycle and t determines the household's adult age (computed as actual age minus 20). Gender

[3]The work of Frey and Eichenberger (1996) contains a general discussion of marriage paradoxes, including underestimation of the likelihood of divorce, whereas the survey in Fowers, Montel, Lyons, and Shaked (2001) provides evidence supporting this phenomenon.

composition, the number and ages of children, and marital status characterize the family structure of the households. We distinguish between single, married, divorced, and widowed households.[4]

Throughout their lives, households can experience changes in marital status. The process governing marital transitions is modeled to be determined by a combination of both exogenous and endogenous factors. We model marriage formation to depend on age and gender. These factors exogenously determine the order of magnitude of the marriage rate. Depending on other household characteristics (e.g., net worth, homeownership status, and the number and ages of children), individuals can deviate from this exogenously given level within an order of magnitude according to their preferences for getting married.

We model the birth of children in a similar way to depend on the the mother's age and marital status. These rates determine the exogenously given order of magnitude of the likelihood of giving birth to a child. Depending on other household characteristics, individuals can reduce or increase birth probabilities relative to the exogenously given ones. Divorce rates are exogenously given and depend on age, gender, and whether children are living in the household. Mortality rates determine the transition to widowhood and out of population through death.

Adult females can give birth to children during their fecund period up to age 40. We allow up to four children being born to a female during each of her "early" (before age of 30) and "late" (after 30) stages of her fecund period. Children remain in a households until age 18, after which they leave the household from ages 18 to 22 to attend post-secondary school, financed by their parents.

Apart from uncertainty in demographic transitions, households live in an environment of uncertain formation of economic resources, including unspanned risky labor income, risky returns on financial assets, and real estate. Households select consumption, housing, homeownership, and asset allocation and decide on their prospects of getting married and having children to achieve the objective of maximizing expected lifetime utility.

[4]With a slight abuse of wording, we refer to all partners cohabiting for more than one year, as being married. Similarly, we refer to separate partners as being divorced. We also explored how treating only legally married individuals as married and only legally divorced as divorced affects our empirical results. Because this differentiation does not significantly alter our main results, we do not report these findings here in detail. They are, however, available from the authors upon request.

2.1 Preferences

Households derive utility from consumption and the home in which they live. We use a Cobb-Douglas per-period utility function over consumption of a non-durable good, C_t, and home size, Q_t. Because many households choose to have children, especially the married ones, we allow the per-period utility to be affected by the "taste" shifter, which captures the joy and pride of having children. We model the utility shifter from children as a multiplying factor g, which increases in the number of children at a decreasing rate and is higher for married individuals, thus allowing for a higher preference in married individuals for giving birth to children.

Empirical evidence in Green and White (1997) and Haurin, Parcel, and Haurin (2002) suggests growing up in an owner-occupied home positively affects childrens' outcomes, which may also explain why households that plan on giving birth to children often opt for homeownership (Öst, 2012). We address this empirical regularity by allowing households with children to have a greater preference for living in an owner-occupied home. Similar to Kiyotaki, Michaelides, and Nikolov (2011), who allow for higher utility from living in owner-occupied homes, we allow households with children to enjoy the full utility of their home only when they own it. For that purpose, we multiply the home size, Q_t, by a factor $1-\zeta\chi$, where ζ determines the welfare loss from living in a rented home with children and χ is an indicator variable that takes the value of 1 if children are living in the household and the household lives in a rented place.[5] The per-period utility is given by

$$U\left(C_t, Q_t, M_t, N_t\right) = \left(\frac{C_t^{1-\psi}\left(\left(1-\zeta\chi\right)Q_t\right)^{\psi} \cdot g\left(M_t, N_t\right)}{\eta\left(M_t, N_t\right)}\right), \tag{1}$$

where ψ is the housing-preference parameter, M_t is the marital status at time t (we set $M_t = 1$ for a married individual and $M_t = 0$ for a non-married individual), N_t is the number of children at time t, $\eta\left(M_t, N_t\right)$ is a function determining the household size adjusted for economies of scale, and $g\left(M_t, N_t\right)$ is a function determining the utility from having children.[6]

[5]Other work that allows for higher utility from owning includes Ortalo-Magné and Rady (1999, 2006) and Sinai and Souleles (2005).

[6]Given that M_t and N_t are discrete variables, changes in family composition are events that induce discontinuous jumps in the utility function.

2.2 Income

Several studies, including Bodie, Merton, and Samuelson (1992), Viceira (2001), and Cocco, Gomes, and Maenhout (2005), highlight the importance of labor income as a non-tradable asset in portfolio-choice frameworks. We assume households earn unspanned labor income that, during their working life, is subject to permanent shocks and a drift depending on age, sex, marital status, and the number of children living in the household. Upon reaching retirement age, households start receiving pension income according to their replacement ratio. The replacement ratio is defined as the initial pension income divided by final labor income, and depends on the individual's sex and marital status. We follow Cocco, Gomes, and Maenhout (2005) in assuming real labor income is a constant fraction of final labor income during the retirement phase.

2.3 Capital and Housing Markets

Households can trade a representative risky stock market index, a risk-free bond, and owner-occupied homes. The growth in labor income, and the returns on stocks and owner-occupied homes can be correlated, reflecting that they may depend on common risk factors, such as the state of the economy. We assume the representative stock market index and house prices are jointly lognormally distributed with expected returns of μ_S and μ_H and volatilities of σ_S and σ_H, respectively. We denote the return on the risk-free asset by r.

2.4 Rents, Maintenance, and Moving Costs

The consumption of housing services is associated with recurring expenses for both owners and renters. Renters periodically pay rental costs, $\delta^r QH$, with δ^r denoting the rate of renting costs, Q the size of the home measured in number of housing units, and H the price per housing unit. Owners pay maintenance costs, $\delta^m QH$, where δ^m is the rate of maintenance costs. The rate of running housing costs, δ, can thus be expressed as

$$\delta\left(I_t\right) = \delta^r\left(1 - I_t\right) + \delta^m I_t, \quad (2)$$

where I_t is an indicator variable that takes the value of 1 if the household owns the home during period t, and 0 if the household rents it.

Non-recurring costs are realized if households move to owner-occupied homes. As in Van Hemert (2010) and Fischer and Stamos (2013), a household acquiring a new home faces transaction costs of $\tau Q_t H_t$, where Q_t is the size of the new home. Transaction costs are also incurred if the household continues to be a homeowner but changes home size. Total non-recurring transaction costs, τ^t, can thus be summarized as follows:

$$\tau^t \left(Q_t, Q_{t-1}, I_t, I_{t-1}, H_t\right) = Q_t H_t \begin{cases} \tau & \text{if home purchase } (I_t - I_{t-1} = 1) \\ \tau & \text{if owner changes home size } (I_t = I_{t-1} = 1, Q_t \neq Q_{t-1}) \\ 0 & \text{otherwise.} \end{cases} \tag{3}$$

2.5 Family Structure

Throughout their lives, households can experience changes in marital status and can give birth to children. We consider marriage and childbirth to be events that are driven both by factors that individuals can actively influence and by factors that are beyond their control. Whether an individual gets married depends on exogenous factors and factors that an individual can actively influence. We assume males and females marry a person of the opposite gender, but the same age and with the same education, income, and net-worth level. The assumption that marriage is assortative along age, education, net-worth, and income is found to be increasingly accurate, especially for the most recent decade (Bredermeier and Juessen, 2013; Fernández and Wong, 2014; Greenwood, Guner, Kocharkov, and Santos, 2014; Schwartz and Mare, 2005). An advantage of this assumption is that it keeps the optimization problem numerically tractable and allows us to isolate the impact of marriage, because it keeps household income and net worth per adult constant. Although marriage prospects depend strongly on wealth, the composition of the household portfolio is not likely to be a decisive factor in marriage formation, even if one considers an extended portfolio with housing (Fisher and Gervais, 2011). However, marriage formation depends to a large degree on the presence of children, and the prospects of giving birth to children in the future. We let such factors affect marriage probabilities endogenously through the individual's utility maximization problem.

The probability of giving birth to a child varies with the parents' fertilities. We construct exogenously given orders of magnitudes of fertility rates to depend on age, education, and marital status. However, individuals can also actively affect the probability of pregnancy. For example, individuals who receive a high welfare gain from giving birth to a child should engage in behavior that increases the likelihood of giving birth. The factors that affect fertility prospects, aside from age, marital status, and the number of children already born, include income (Black, Kolesnikova, Sanders, and Taylor, 2013; Lindo, 2010), housing wealth (Dettling and Kearney, 2014; Lovenheim and Mumford, 2013), or homeownership (Öst, 2012).

We therefore model the probabilities of marriage, $p_{m,t}$, and childbirth, $p_{c,t}$, as depending on exogenous age- and sex-dependent factors calibrated to match their empirical counterparts and on factors the individuals can actively influence: $p_{m,t} = \overline{p}_{m,t} + \epsilon_{m,t}$ and $p_{c,t} = \overline{p}_{c,t} + \epsilon_{c,t}$, where $\overline{p}_{m,t}$ and $\overline{p}_{c,t}$ are the age- and education-specific population averages and $\overline{p}_{m,t}$ also varies over gender; $\epsilon_{m,t}$ and $\epsilon_{c,t}$ are idiosyncratic components that vary over individuals and depend on their welfare gains or losses from getting married or having children. We also impose upper and lower bounds, $p^u_{m,t}$, $p^u_{c,t}$, $p^l_{m,t}$, and $p^l_{c,t}$, on these behavior-implied probabilities:

$$0 \leq p^l_{m,t} \leq p_{m,t} \leq p^u_{m,t} \leq 1, \qquad 0 \leq p^l_{c,t} \leq p_{c,t} \leq p^u_{c,t} \leq 1. \tag{4}$$

Apart from allowing individuals to actively affect birth rates, our way of modeling births of children closely follows Love (2010) and has the desirable feature of keeping the optimization problem numerically tractable. We make four assumptions. First, we assume mothers beyond the age of 40 do not give birth to children; that is, beyond age 40, it holds that $p^l_{c,t} = p_{c,t} = p^u_{c,t} = 0$.[7] Second, children born before the mother turns 30 are referred to as being born "early," whereas others are referred to as being born "late." We assume females do not give birth to more than four children in either of these two periods. Therefore, the maximum number of children born to a female is eight. Third, we assume children born within each of these two periods are evenly spaced two

[7]Empirically, less than 1% of females beyond age 40 give birth to a child (Mathews and Ventura, 1997).

years apart. Finally, the number of children and whether the first child was born early or late determine the age of the mother when the first child was born.[8] The mother has the first child in the early period at 27 if only one child is born in that period, at 26 if two are born, at 25 if three are born, and at 24 if four are born. For children born late, the mother is 34 if one child is born, 33 if two are born, 32 if three are born, and 31 if four are born. Similar to Love (2010), we assume children attend college from ages 18 to 22.

To address the impact of divorce risk on housing decisions, we model divorce as an exogenous process, which is dependent on household characteristics. Divorce rates depend on age, sex, and whether children are living in the household. In doing so, we account for the observation that, according to the 2001 Survey of Income and Program Participation (SIPP), households with children are less likely to get divorced.

Although divorce is, strictly speaking, not an exogenous event, the literature with detailed family structure often treats changes in marital status, and divorces in particular, as exogenous. For example, Cubeddu and Rìos-Rull (2003), Fernández and Wong (2014), and Love (2010) assume exogenous marital changes. Given the intertwined nature of the family-composition decisions with the resource-accumulation choices, a proper way to treat a family process in a life-cycle model is to let it arise endogenously from a model (e.g., Guner and Knowles, 2007; Greenwood, Guner, Kocharkov, and Santos, 2015; Mazzocco, Ruiz, and Yamaguchi, 2014). Both approaches, however, seem to lead to similar conclusions about the response to divorce risk, especially for females, who prefer to increase savings. In those papers, a similar mechanism drives the effect of divorce risk: following divorce, a household faces a reduction in savings, whereas a greater divorce risk strengthens the precautionary savings motive. In view of the similar conclusions, our choice of modeling divorces as a shock rather than a choice gives us the advantage of keeping our model numerically tractable. An issue with an exogenous divorce rate may arise at the time of the divorce shock itself. Unpredictable timing of the divorce may lead to over-reaction to divorce in the short run. As shown in Mazzocco, Ruiz, and Yamaguchi (2014), individuals tend to smooth their resource allocation in antic-

[8] These last two assumptions significantly reduce the number of state variables required to solve the life-cycle consumption, housing, investment, and family problem, and thereby make solving the model possible. Essentially, they imply the mother's age and whether a child was born "early" or "late" determine the age of the children.

ipation of divorce, whereas in our model, individuals may respond to a divorce shock more abruptly. However, the long-term wealth effects due to divorces, which our work is concerned with, are not likely to be altered.

When getting divorced, households typically experience significant changes in both household net worth and income. Ideally, one would estimate these effects for each age and sex separately. However, as Love (2010) already noted, available data typically contain insufficient information to precisely estimate all these parameters. We assume that immediately after the divorce, household income decreases by 50%, an owner-occupied home is sold, and household net worth is split equally. We also computed results under the assumption that the home goes to the custodial parent. Given that a family-size home is typically too large and expensive for a divorced individual, the individual usually has to sell it, and results do not differ much from those reported throughout. We allow for a 10% deduction to account for legal costs and inefficiencies resulting from the splitting of assets. We assume children stay with their mothers, whereas fathers pay child support. Finally, we assume that conditional on the age of the individual and the number and ages of children in a household, the income process for divorced individuals corresponds to that of single ones.

2.6 The Optimization Problem

The household maximizes expected lifetime utility by deciding each period, $t = 0, 1, \ldots, T$, upon consumption of the non-durable good, C_t; home size, Q_t; ownership status, I_t; exposure to stocks, π_t^s; bonds, π_t^b; probability of transitioning into marriage when single, $p_{m,t}$; and probability of childbirth when not exceeding the age of 40, $p_{c,t}$. Married individuals agree to maximize the sum of their equally-weighted respective utilities. As long as they are married, they care as much about their partner's well-being as they care about their own. Non-married individuals maximize only their own utilities.

Hurd (1989) shows households' incentives for desired bequests are small. We therefore abstract away from explicitly modeling utility from bequests to children when the last household member dies. A household's evolution of net worth, W_t, is given by

$$W_t = \pi_{t-1}^s W_{t-1} R_{s,t} + \pi_{t-1}^b W_{t-1} R + L_t + H_t \cdot Q_{t-1} \cdot I_{t-1} + \Delta W_t^{MD}, \quad (5)$$

where L_t is the household's labor income earned from time $t-1$ to t, ΔW_t^{MD} denotes a change in household net worth due to marriage or divorce at time t, and $R_{s,t}$ and $R = 1 + r$ are the gross returns on the stock and the bond position, respectively. The household's budget constraint is

$$W_t = C_t + \delta(I_t) \cdot H_t \cdot Q_t + H_t \cdot Q_t \cdot I_t + \tau^t(Q_t, Q_{t-1}, I_t, I_{t-1}, H_t) + W_t^S + \Xi_t, \quad (6)$$

where W_t^S denotes child support paid or received at time t, and Ξ_t is total college costs paid at time t. We impose the restriction that households cannot short-sell stocks: $\pi_t^s \geq 0$. Bonds can only be shorted to finance homeownership. The minimum housing downpayment for home owners is $\kappa > 0$, implying the amount of debt, $-\pi_t^b W_t$, has to obey

$$-\pi_t^b W_t \leq (1-\kappa) I_t \cdot H_t \cdot Q_t \quad (7)$$

in every period. Ideally, we would only require this constraint to hold when a home is purchased. However, this increases the number of state variables required to solve our optimization problem and would thus significantly increase its complexity. We therefore follow the literature (e.g., Yao and Zhang, 2005) and require the constraint to hold in every period. To avoid being forced to sell their homes when house prices fall, households therefore typically do not lever up to the maximum possible level.

To break the relationship between the degree of risk aversion, γ, and the elasticity of intertemporal substitution, ϕ, implied by the CRRA preference function, we allow for recursive preferences (Epstein and Zin, 1989). Hence, an individual's optimization problem is given by

$$\begin{aligned} V(X_t, Y, t) = \sup_{\{C_t, Q_t, I_t, \pi_t^s, \pi_t^b, p_{m,t}, p_{c,t}\}} \Bigg[(1-\beta) \cdot U\left(C_t, Q_t, I_t, M_t, N_t^e, N_t^l\right)^{1-\frac{1}{\phi}} \\ + \beta \cdot \mathbb{E}\Bigg[M_t \Big\{ f_t \tilde{f}_t \left(\frac{1}{2} V(X_{t+1}, Y, t+1)^{1-\gamma} + \frac{1}{2} V\left(X_{t+1}, \tilde{Y}, t+1\right)^{1-\gamma} \right) \\ + f_t \left(1 - \tilde{f}_t\right) V(X_{t+1}, Y, t+1)^{1-\gamma} + (1 - f_t) \tilde{f}_t V\left(X_{t+1}, \tilde{Y}, t+1\right)^{1-\gamma} \Big\} \\ + (1 - M_t) f_t V(X_{t+1}, Y, t+1)^{1-\gamma} \Bigg]^{\frac{1-\frac{1}{\phi}}{1-\gamma}} \Bigg]^{\frac{1}{1-\frac{1}{\phi}}}, \end{aligned} \quad (8)$$

subject to equations (2) to (7), where f_t is the probability of the individual surviving from time t to $t+1$, $\tilde{f}_t$ is the corresponding probability for a partner, Y is the individual's gender, $\tilde{Y}$ is a partner's gender, N_t^e and N_t^l are the number of children born "early" and "late," respectively, and

$$X_t = \left[Q_{t-1}, I_{t-1}, L_t, W_t, H_t, M_t, N_t^e, N_t^l, t\right] \tag{9}$$

is the vector of state variables. The constrained optimization problem is not solvable in closed form. We therefore solve the life-cycle consumption, housing, investment, and family problem numerically. The technical details are outlined in Appendix A.

2.7 Parameterization

In this section, we describe the parameterization of our model. We estimate the evolution of real home prices, using the log-returns on the Case Shiller Home Price Index from 1953 to 2013.[9] The expected historical annual real house price return does not differ statistically from zero, reflecting that saved rent payments, rather than a high expected return, are the reward home owners receive for house-price risk. We therefore set the expected annual real house price return to $\mu_H = 0.0\%$. The historical annual real volatility of the home price index is 5.5%. However, price changes for individual homes are far from perfectly correlated. The aggregation in the house price index therefore reduces house-price volatility, which we have to account for in our calibration. Case and Shiller (1989) argue the annual volatility of individual house prices is close to 15%. Bourassa, Haurin, Haurin, Hoesli, and Sun (2009) find empirical estimates of a similar magnitude. We therefore set house-price volatility to $\sigma_H = 15\%$. The risk-free rate is set to $r = 1.9\%$, the average real one-year Treasury Bill rate from 1953 to 2013.

The expected real stock return and its volatility are set to their empirical estimates using the S&P 500 index from 1953 to 2013: $\mu_S = 6.3\%$ and $\sigma_S = 16.2\%$, respectively. We set the correlation between stock returns, housing returns, and labor income to match the empirical evidence. The correlation between log-stock returns and log-house returns is $\rho_{SH} = 0.03$, the historical

[9]This home price index is publicly available on Robert Shiller's homepage: http://www.econ.yale.edu/~shiller/data.htm.

correlation of the return on the S&P 500 and the Case Shiller Home Price Index from 1953 to 2013. Flavin and Yamashita (2002) report a correlation in the same order of magnitude. We set the correlation between stock and labor income shocks to $\rho_{SL} = 0.2$, the empirical estimate of Cocco (2005), thus reflecting on the generally low correlation between the stock and the labor market for individual households. Correlation between house-price and labor-income shocks is set to $\rho_{HL} = 0.55$, the empirical estimate of Cocco (2005). The home-equity requirement is $\kappa = 20\%$; the rent rate, moving costs, and the costs of trading an owner-occupied home are set to $\delta^r = 6.0\%$, $\delta^m = 1.5\%$, and $\tau = 6.0\%$, the estimates of Yao and Zhang (2005).

We estimate the income processes separately for single males, single females, and married individuals, using the 1980–2011 waves of the Panel Study of Income Dynamics (PSID) for high school graduates. Our estimation closely follows Cocco, Gomes, and Maenhout (2005) and Love (2010) and is outlined in more detail in Appendix B. The resulting coefficients reported in Table 1 are of a similar order of magnitude as those estimated by Love (2010), yet reflect that our coefficients are estimated using the PSID data until 2011, and thus also cover the recent financial crisis. Consistent with the findings in Love (2010) and Santos and Weiss (2015), a married household's labor income is estimated to be less volatile than that of singles.

At age 20, individuals are single and have no children. We set their initial level of net worth to US$ 25,000, the median level of net worth right after receipt of one-year labor income for a 20-year-old individual in the PSID data.[10] We set the maximum household age to 95 because estimates for the average probability of getting married, $\overline{p}_{m,t}$, become rather noisy thereafter. We set retirement age to 65. We take mortality rates from the 2007 Period Life Table published by the US Social Security Administration.

We construct average birth rates, $\overline{p}_{c,t}$, as in Love (2010), using fertility data published in a US National Center for Health Statistics report (Mathews and Ventura, 1997, Table 5, page 13). The report publishes birth rates by race, education, and marital status for different age brackets. Fertility rates for ages 20 through 40 are estimated by fitting a third-degree polynomial (evaluated

[10]We include one-year labor income in net worth, because we measure net worth in our model right after the receipt of one-year labor income. Given that our individuals have CRRA preferences, the initial level of net worth is an immaterial assumption that does not affect their relative consumption-investment, housing, and family decisions.

Table 1
Labor-income process

Description	Male	Female	Married
Fitted age polynomials			
Constant	-1.5605	-0.7838	-0.8939
Age	0.1201	0.0601	0.0627
Age^2 / 100	-0.2030	-0.0544	-0.0323
Age^3 / 10,000	0.0947	-0.0091	-0.0430
Replacement rate	0.9537	0.9459	0.9478
Coefficient estimates			
Children age 0-1	-0.0623	-0.0141	-0.0233
	(0.1196)	(0.0277)	(0.0073)
Children age 2-4	0.0607	-0.0072	-0.0267
	(0.0801)	(0.0199)	(0.0061)
Children age 5-7	0.0343	0.0170	-0.0197
	(0.0582)	(0.0187)	(0.0062)
Children age 8-10	0.0299	0.0431	-0.0075
	(0.0501)	(0.0188)	(0.0065)
Children age 11-12	-0.0452	0.0751	0.0140
	(0.0524)	(0.0208)	(0.0082)
Children age 13-15	0.0189	0.0864	-0.0087
	(0.0463)	(0.0185)	(0.0075)
Children age 16-18	-0.0004	0.0964	0.0085
	(0.0587)	(0.0236)	(0.0099)
Constant	9.6390	9.3114	10.0418
	(0.0518)	(0.0461)	(0.0356)
N	5,321	7,526	27,273
R-squared	0.0721	0.0921	0.1101
Variance permanent shock	0.0166	0.0126	0.0111
	(0.0035)	(0.0015)	(0.0010)

This table summarizes the estimated coefficients for the labor-income process of single males, single females, and married couples using the 1980–2011 waves of the PSID for households whose head has a high school degree. Results are based on fixed-effects regressions described in detail in Appendix B. Standard errors are reported in parentheses.

at the median age in each bracket) through the reported probabilities. Upper and lower bounds on birth rates are constructed as $p^u_{c,t} = \overline{p}_{c,t}\left(1 + x_c\right)$ and $p^l_{c,t} = \overline{p}_{c,t}\left(1 - x_c\right)$. The coefficient x_c as well as the utility shifter from children, $g\left(M_t, N_t\right)$, is calibrated to match the empirically observed average number of children per household. We compute average age- and sex-dependent marriage rates of singles, $\overline{p}_{m,t}$, using the SIPP data. Similar to our construction of birth rates, we compute upper and lower age- and sex-dependent bounds for marriage rates for singles as $p^u_{m,t} = \overline{p}_{m,t}(1 + x_m)$ and $p^l_{m,t} = \overline{p}_{m,t}(1 - x_m)$. We calibrate x_m to match the empirical evolution of the share of individuals being married over the life cycle. For married individuals, we set the probability of getting married to zero.

We construct the probabilities of divorce using the SIPP data. For different age brackets, the survey publishes data on divorce transitions for married individuals by gender and whether children are living in a household. According to these data, households with children are less likely to get divorced, which may reflect the desire to let children grow up in intact families. For ages 20–95 for male and female individuals, we estimate the probability of divorce conditional on whether individuals have children, by fitting a third-degree polynomial through the reported probabilities (evaluated at the median age in each bracket).

For the payment of child support and college costs, we follow the modeling of Love (2010). That is, we model child support by adopting the income-sharing formulas prevalent in most US states. For children under 18, the noncustodial parent pays a constant share of income: 17% for one child, 25% for two children, 29% for three children, 31% for four children, and 33% for five or more children. In case of a divorce, children typically stay with their mothers. We therefore assume the noncustodial parent is male, and focus our analysis on females.[11] We assume children attend college from ages 18–22. Following the empirical estimates of Turly and Desmond (2011), we assume married couples spend 9% of income per year on each child's college eduction, whereas single parents spend 7%.

Following Love (2010), we assume the function η, describing household size adjusted for economies of scale, to be given by $\eta(M_t, N_t) = (1 + M_t + 0.7N_t)^{0.7}$, where M_t is the marital status and N_t is the number of children living in the household during period t. Individuals' preference parameters, such as the utility discount factor, β, the degree of risk aversion, γ, the housing preference, ψ, the elasticity of intertemporal substitution (EIS), ϕ, and the penalty term for

[11]We also explore settings in which we focus our analysis on males. Given that this focus does not affect our key results, we do not report these results throughout. They are, however, available from the authors upon request.

Table 2
Base-case parameter values

Description	Parameter	Value	Source
Degree of risk aversion	γ	10	Own calibration
EIS	ϕ	0.05	Own calibration
Housing preference	ψ	0.3	Own calibration
Utility discount factor	β	0.94	Own calibration
Max. length of investment horizon	T	75	Own choice
Risk-free rate	r	1.9%	Own estimation
Expected return stock	μ_S	6.3%	Own estimation
Volatility stock return	σ_S	16.2%	Own estimation
Expected housing return	μ_H	0.0%	Own estimation
Volatility housing return	σ_H	15%	Case and Shiller (1989)
Correlation stocks housing	ρ_{SH}	3%	Own estimation
Correlation stocks labor	ρ_{SL}	20%	Cocco (2005)
Correlation housing labor	ρ_{HL}	55%	Cocco (2005)
Minimum housing downpayment	κ	20%	Yao and Zhang (2005)
Renting costs rate	δ^r	6.0%	Yao and Zhang (2005)
Rate of maintenance costs	δ^m	1.5%	Yao and Zhang (2005)
Home purchasing costs	τ	6.0%	Yao and Zhang (2005)
Penalty children renters	ζ	20%	Own calibration

households with children living in rented homes, ζ, are calibrated to match the empirically observed evolution of homeownership rates and are set to $\beta = 0.94$, $\gamma = 10$, $\psi = 0.3$, $\phi = 0.05$, and $\zeta = 20\%$. With these base case parameters, the economies of scale from living together imply that two married individuals can enjoy the same utility from Equation (1) with 19% lower per capita consumption expenses and home size than a single individual.

3 Household Decisions

In this section, we illustrate the impact of marriage and divorce on household decisions. In section 3.1, we demonstrate our model's ability to replicate important features in the data – both qualitatively and quantitatively. In section 3.2, we assess the long-term consequences of changes in family composition and demonstrate how marriage and divorce affect the long-term demand for homeownership, consumption, and household net worth. In section 3.3, we investi-

Table 3
Births of children

Age	20-25	26-30	31-35	36-40
Model	19.86%	12.86%	6.54%	2.13%
Data	16.90%	11.41%	6.08%	2.04%

This table depicts for different age categories the evolution of birth rates as shares of women giving birth to a child. The first row shows averages from 10,000 paths simulated with our model; the second row shows the fertility rates from the Current Population Survey (Mathews and Ventura, 1997).

gate divorce risk as a risk factor that affects household decisions and welfare.

All model predictions reported throughout are based on 10,000 simulations on the respective optimal paths. To account for potential pre-existing homeownership and net worth, the initial distribution of the income-to-net-worth ratio, the homeownership status, and the housing-to-net worth ratio at age 20 are drawn from the joint empirical distribution in the PSID data.

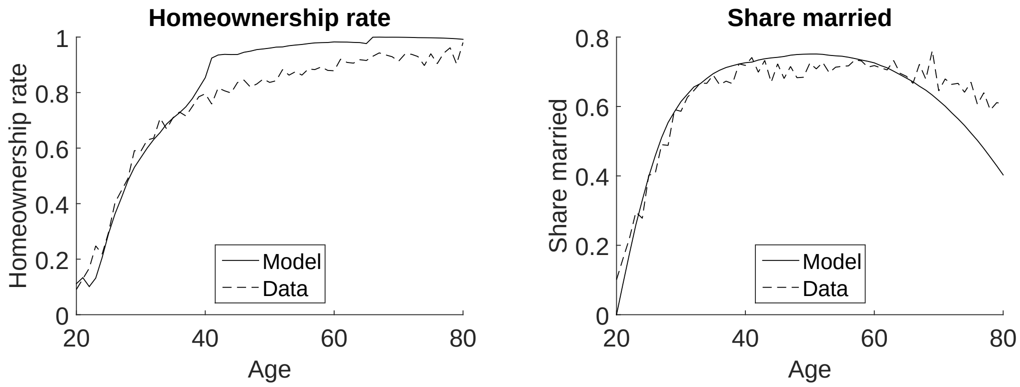
3.1 Simulation Results

Before we proceed with our further analysis, we must ensure that simulated model predictions match key features of the data. In Table 3, we compare the evolution of fertility rates predicted by our model with those based on the Current Population Survey (as reported in Mathews and Ventura, 1997). Our results show our model matches the observed birth rates quite closely. The magnitude of births matches the observed fertility rates for each age cohort very well. The fertility rate is only slightly higher in the model.

Next, we compare simulated model predictions with micro-level data on marital status changes, homeownership, and total networth, including housing wealth, available from the PSID and its Wealth Supplements. The data sample used throughout covers the time period in which information from the Wealth Supplements is available on a bi-annual basis: the years 1999–2011. Given the relatively short time period, we do not control for separate cohort effects. We outline the details of the data-selection process in Appendix C. Figures 1 and 2 compare the model-implied evolution of homeownership rates, shares of households being married, and net worth per adult with the data.

In Figure 1, we compare the evolution of homeownership rates and the share

Figure 1
Evolution of homeownership rate and share married over the life cycle

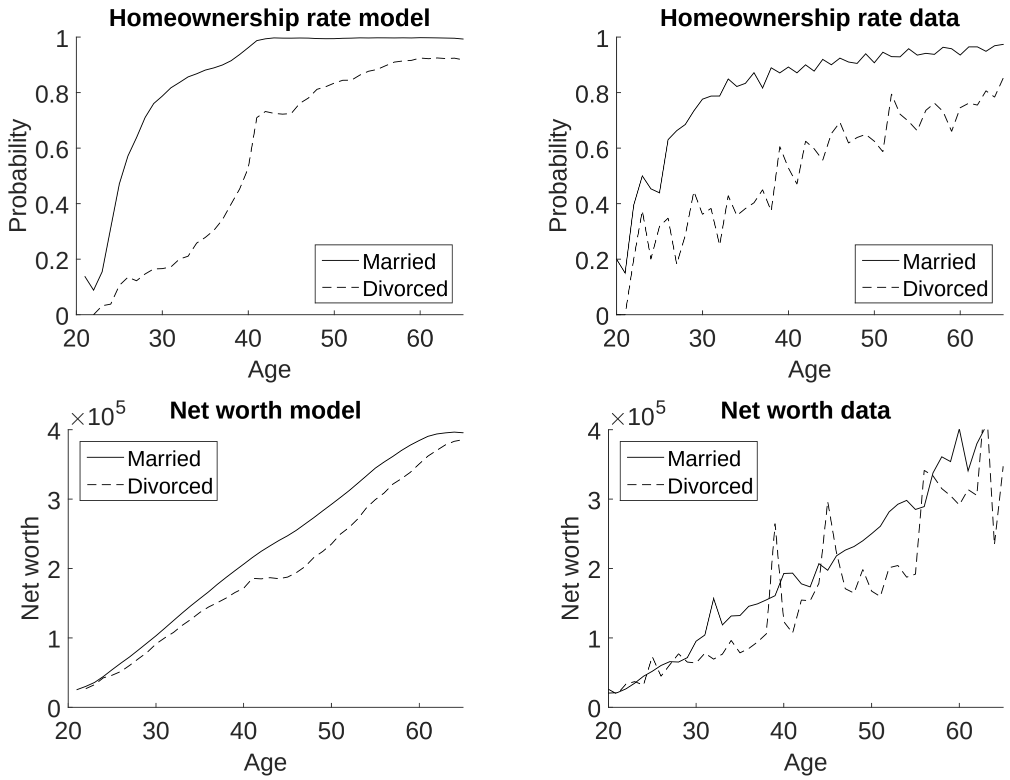


This figure depicts the evolution of homeownership rates (left graph) and the share of individuals being married (right graph) over the life cycle. The solid lines show results generated with our model; the dashed lines show the empirical counterpart in the PSID data.

of individuals being married with their empirical counterparts from the PSID. The two panels in Figure 1 show our model accurately predicts the share of individuals being married and the homeownership rate over the life cycle. For the evolution of homeownership rates, our model's predictions are particularly sharp before children start leaving home. The following three factors—among others—may drive the discrepancy between our model's predictions and the data for older ages. In our model, mothers beyond the age of 40 do not give birth to children, thus reducing the probability of changes in family size beyond that age and thereby making homeownership more attractive. Next, in our model, children leave home at the age of 18, whereas the data show a certain degree of heterogeneity in this regard. Finally, we consider individuals with a given set of preference parameters, whereas individuals' preferences in the data may differ. For married individuals with the set of preferences studied in our work, living in an owner-occupied home for a large part of the life cycle is optimal. Only significant shocks can prevent these individuals from being homeowners. Vestman (2012) shows that allowing for heterogeneity in preferences can generate a higher degree of dispersion in household savings and homeownership rates.

Our model is not only accurate in replicating unconditional homeownership rates; it also replicates homeownership rates conditional on marital status rather well. We also replicate the conditional patterns in household net worth. Figure 2 compares the evolution of homeownership rates and household net worth for

Figure 2
Evolution of homeownership and net worth for married and divorced



This figure depicts the evolution of the homeownership rate (upper panels) and the average net worth (including housing wealth) per adult living in the household (lower panel) over the life cycle for married and divorced individuals that are not remarried. The left panels depict results from 10,000 simulated paths of our model; the right panels depict results in the PSID data. Levels of net worth in the PSID data are reported in 2008 USD.

married and divorced individuals with their empirical counterparts computed from the PSID. It shows that, similar to the patterns observed in the data, our model predicts married individuals are more likely to be homeowners and tend to be endowed with higher levels of net worth per adult than divorced individuals.

We further explore how the model matches the transitional dynamics in homeownership and renting observed in the data. To illustrate the impact of marriage and divorce on the likelihood of becoming a homeowner or abandoning homeownership, we compare a linear probability model of the decision to become a homeowner and abandon homeownership, estimated from simulated data generated with our model with the PSID data. The results in Table 4 doc-

Table 4
Housing decisions of movers

	Panel A: Become owner		Panel B: Become renter	
	Data	Model	Data	Model
Just married	0.127	0.342	-0.029	-0.157
	(0.011)	(0.001)	(0.013)	(0.002)
Just divorced	-0.006	-0.060	0.070	0.707
	(0.007)	(0.002)	(0.008)	(0.004)
Children age 0-4	0.046	0.044	-0.060	-0.059
	(0.008)	(0.001)	(0.009)	(0.001)
Children age 5-10	-0.007	-0.006	-0.034	-0.081
	(0.008)	(0.001)	(0.008)	(0.001)
Children age 11-17	-0.039	-0.007	-0.023	-0.064
	(0.007)	(0.001)	(0.008)	(0.001)
Age 20-29	0.187	0.040	0.209	0.049
	(0.012)	(0.001)	(0.014)	(0.002)
Age 30-39	0.167	0.034	0.022	0.101
	(0.011)	(0.001)	(0.012)	(0.002)
Age 40-49	0.088	0.021	-0.049	-0.094
	(0.011)	(0.001)	(0.011)	(0.001)
Age 50-59	0.064	0.002	-0.053	-0.112
	(0.010)	(0.001)	(0.010)	(0.001)
Age 60-69	0.030	0.001	-0.043	-0.096
	(0.011)	(0.001)	(0.011)	(0.001)
Income-to-net-worth ratio	-0.138	-0.050	0.426	1.548
	(0.010)	(0.001)	(0.011)	(0.002)
Constant	0.065	0.006	-0.021	-0.015
	(0.008)	(0.001)	(0.008)	(0.001)
Number of observations	18,067	740,000	18,067	740,000

This table reports results of the estimation of a linear probability model documenting the impact of marriage and divorce on the decision to acquire homeownership (Panel A: Become owner) and abandon it (Panel B: Become renter). The "Children age" variables are dummy variables indicating whether children in the corresponding age group live in the household. We refer to individuals that got married or divorced between periods $t-1$ and t as "just married" and "just divorced," respectively. The income-to-net-worth ratio in the PSID data is the latest available observations prior to the household move. Standard errors are reported in parentheses.

ument our model's predictions are commensurate with the empirical evidence that newly married individuals are more likely to acquire homeownership and newly divorced individuals are more likely to abandon it. Similarly, our model's predictions match the empirical finding that households with young children are more likely to acquire homeownership. Younger households are more likely to become homeowners. This result may reflect that older households are more likely to already live in an owner-occupied home. Households with higher income-to-net-worth ratios are less likely to transition into homeownership and more likely to become renters. A high income-to-net-worth ratio indicates a household's savings are small relative to its income. Such a household is able to increase its future net worth at a faster rate. It should therefore have a preference for moving to a larger home in a couple of years. To avoid the high transaction costs involved with trading owner-occupied homes, the household may have a preference for remaining a renter until it has increased savings. Consequently, it is less likely to move to an owner-occupied home and more likely to move to a rented place.

The magnitude of the coefficients for being newly married or divorced tend to be higher in our model, which is likely to be attributed to the not entirely endogenous change in marital status, discussed earlier. In line with the smooth resource reallocation during transition to marriage or divorce, studied in Mazzocco, Ruiz, and Yamaguchi (2014), households in the PSID data may sell their homes earlier than they formally get divorced. Also, they may sell their homes later, for example, because of long-lasting disputes over household finances, or a slow housing market. Our stylized life-cycle model abstracts away from such reasons. Nevertheless, from Figure 2, our model is able to match the long-term consequences of marriage and divorce, which our work is mainly concerned with, quite well.

3.2 Long-term Effects of Marriage and Divorce

In this section, we investigate the long-term effects of marriage and divorce in more detail.[12] We assess how these events affect the long-term demand for homeownership, consumption levels, housing wealth, and household net worth.

[12] We also explore the long-term effects of having a child. Given that this event does not cause an immediate wealth effect, and does not contribute to our understanding of divorce risk, we do not present these results in more detail here. They are, however, available from the authors upon request.

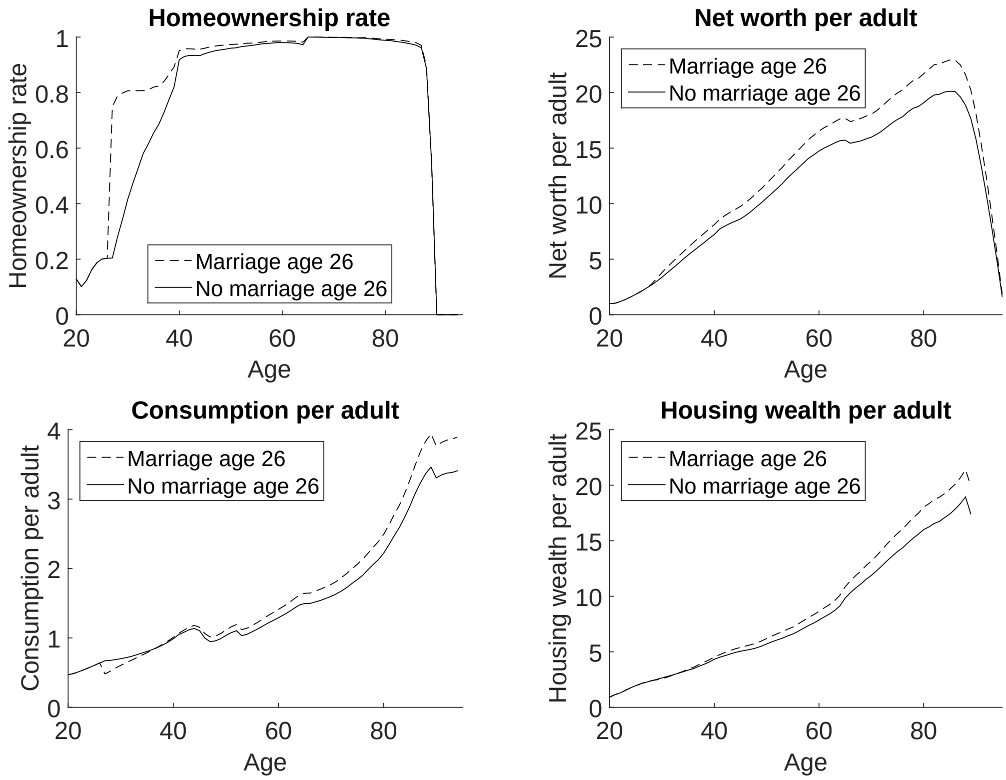
3.2.1 Marriages

Individuals' marital status has important implications for their financial situation. Married individuals' household net worth is usually higher than that of singles, thus better protecting the households against financial shocks. Married households' labor income is subject to lower volatility than that of singles. Individuals' labor income streams are typically far from perfectly correlated. In particular, in case of an individual's job loss, the partner's labor income provides a certain degree of financial protection. Consequently, married individuals should be better able to handle temporary periods of unemployment. In addition, married individuals benefit from economies of scale. For example, married individuals usually share one kitchen, whereas two singles typically have one kitchen each.

To explore the long-term effects of marriage, we consider the evolution of homeownership rates, household net worth, consumption expenses, and homeowners' housing wealth after individuals get married. Our results are displayed in Figure 3. We focus on the subsample of our 10,000 simulated paths, in which the individual is single when turning 26, and compare results for individuals who get married at age 26 (dashed lines) with results when they do not (solid lines). We choose age 26 as the possible marriage age, because it is the median age of first marriages for females (Elliott, Krivickas, Brault, and Kreider, 2012). To facilitate the interpretation of our results, we report net worth, consumption, and housing wealth per adult living in the household.

Our results show a strong, long-lasting relationship between marital status and homeownership. Married individuals are more likely to live in owner-occupied homes, reflecting that married individuals are endowed with higher household net worth and income but lower labor-income risk. Homeownership rates of individuals marrying at age 26 and of those staying single take more than a decade to reach similar levels. Furthermore, the quantitative impact of getting married on homeownership rates is substantial. For instance, 81% of individuals who get married at age 26 are homeowners at the age of 30, whereas only 47% of those who stay single are. These significant differences in homeownership rates combined with individuals getting married later in life can also help explain the declining homeownership rates among younger households (Fisher and Gervais, 2011).

Figure 3
Impulse-response analysis: Marriage at age 26



This figure depicts the impact of getting married at the age of 26 on homeownership rates (upper left panel), household net worth per adult (upper right panel), consumption expenses per adult (lower left panel), and homeowners' housing wealth per adult (lower right panel) for a female individual. All results reported are averages from the simulated paths, where the individual is single when turning 26. The dashed lines show results when the individual gets married at age 26; the solid lines show results when the individual does not.

Marriage has a positive and permanent impact on household net worth per adult, despite the fact that marriages may end in divorce and individuals who are single at the age of 26 can get married at a later point in time. The shares of households being married under the two different scenarios therefore converge as age increases. For example, 92% of individuals who got married at the age of 26 are still married at age 30, whereas among those individuals who at the age of 26 remained single, only 30% are observed being married by the age of 30. At the age of 60, however, these shares have converged to 76% and 69%, respectively. Yet, households getting married at the age of 26 happen to permanently have higher wealth levels per adult, reflecting that married individuals living together benefit from economies of scale that enable them to attain the same level of welfare at a lower level of expenses per individual than singles. By getting married at a later point in time, individuals cannot compensate for the forgone economies of scale.

Marriage also instantly reduces household consumption per adult. This reduction is again driven by economies of scale. Married individuals can enjoy the same utility from consumption at a lower cost. In the long run, however, consumption per adult is higher for married individuals, reflecting the wealth effect from the economies of scale. For the same reason, housing wealth per adult is higher for homeowners getting married at the age of 26 than for those not getting married.

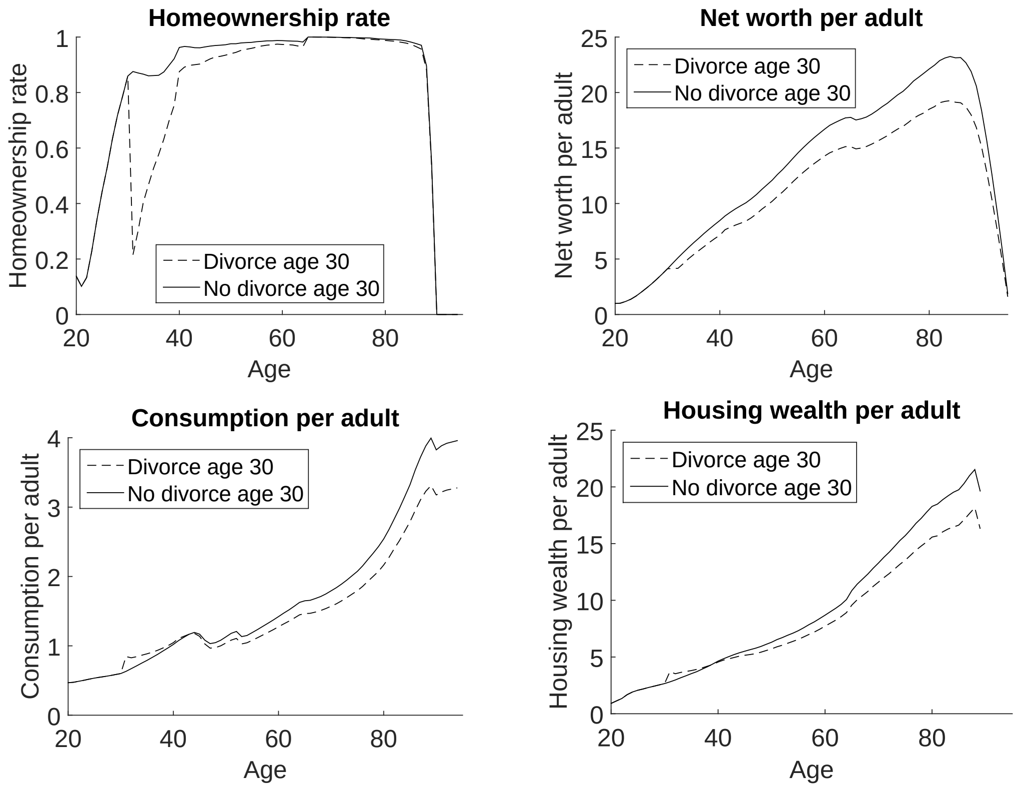
3.2.2 Divorces

We proceed to investigating the financial implications of divorces. In this section, we investigate the long-term consequences of divorces for housing demand, consumption, and household net worth. We do so for an individual at the age of 30, the median age at the first divorce for females in 2009 according to the US Census Bureau.[13] In Figure 4, we therefore focus on the subsample of our 10,000 simulated paths, in which the individual is married when turning 30, and compare the evolution of homeownership rates (upper left panel), household net worth (upper right panel), consumption expenses (lower left panel), and homeowners' housing wealth (lower right panel) when the individual gets divorced at age 30 (dashed lines) with results when she does not (solid lines). Again, we report net worth, consumption, and housing wealth per adult living in the household.

Our results show that many of the effects for marriages are reversed and quantitatively enhanced. Whereas our results in section 3.2.1 show marriage increases homeownership rates, Figure 4 indicates divorce heavily decreases the demand for homeownership. This result is a reflection of the rapid decrease in household net worth and income. For divorced individuals, the higher volatility of the labor income stream for singles amplifies the decrease in homeownership rates. Consequently, homeownership rates drop significantly when individuals

[13]We also explore the impact of divorces at other ages. Given that divorces at other ages do not qualitatively affect our results, we do not report results for these cases here. They are, however, available from the authors upon request.

Figure 4
Impulse-response analysis: Divorce at age 30



This figure depicts the impact of getting divorced at the age of 30 on homeownership rates (upper left panel), household net worth per adult (upper right panel), consumption expenses per adult (lower left panel), and homeowners' housing wealth per adult (lower right panel) for a female individual. All results reported are averages from the simulated paths, where the individual is married when turning 30. The dashed lines report results when the individual gets divorced at the age of 30; the solid lines report results when the individual does not.

get divorced. For instance, only 53% of individuals getting divorced at age 30 are homeowners at age 35, whereas 86% of those not getting divorced are. This finding is in line with the empirical estimation from Table 4 supporting the assertion that divorces increase the likelihood of abandoning homeownership. Furthermore, our results show divorce has a long-lasting effect on homeownership rates. Homeownership rates take decades to return to the level that would have been attained without a divorce.

Divorces have a negative and permanent impact on household net worth per adult. The strong permanent effect continues even though divorced individuals may end up remarrying, and individuals not getting divorced at the age of 30 may get divorced at a later point in time. Divorces affect household net worth per adult not only once in the form of legal costs at the time of the divorce, but repeatedly, because divorces prevent individuals from benefiting from economies of scale. Whereas the benefits from being married are accumulating during marriage, the costs of getting divorced are one-time costs. Hence, even if individuals get divorced after having been married for many years, they may be better off financially than individuals who never married. For instance, for our individuals getting married at the age of 26, they are better off than never-married individuals if they do not get divorced before age 29.

Divorces instantly increase consumption and housing wealth per adult. Immediately after divorce, these individuals have to spend higher amounts on consumption, and require a larger home size per adult to attain the same level of utility as a married individual. However, our results in the lower panel of Figure 4 show this effect is short lived. In the long run, the implied wealth effect results in lower consumption levels and home sizes. Divorces thus affect household net worth and housing wealth through different channels. On the one hand, a divorce permanently reduces household net worth per adult. Housing wealth per adult, on the other hand, increases instantly and decreases in the long run, reflecting the dual role of owner-occupied homes as both consumption and investment goods. Immediately after a divorce, the consumption-smoothing motive dominates and causes individuals to increase their home sizes. In the long run, the investment motive increases in importance, causing households to reduce housing wealth to avoid becoming too heavily exposed to house-price risk.

Our model also allows us to compute welfare effects of divorce. The average certainty equivalent welfare loss from getting divorced at the age of 30 is as high as 24% of future consumption. That is, individuals getting divorced at age 30 require on average an increase of 24% in present net worth and future labor income to attain the same level of expected present discounted utility as individuals that stay married. The welfare costs are thus substantially higher than the immediate costs of 10% of present household net worth.

As individuals age, two opposing effects govern the welfare loss associated with divorce. On the one hand, the increase in wealth and income over the lifetime leads to a dramatic increase in present net worth and permanent income, suggesting an increase in the cost of getting divorced. Likewise, at higher ages, the opportunity costs of a divorce increase. In case of a divorce, 50% of household net worth goes to the former partner; in case of the partner's death, the entire household net worth remains with the surviving individual. On the other hand, with increasing age, life expectancy decreases, in turn suggesting welfare costs from getting divorced might decrease. Our results reveal the former two effects outweigh the latter one. Welfare loss due to divorce increases dramatically with age, reaching more than 50% of present net worth and permanent income by the age of 60. That is, our model predicts the financial consequences of a divorce to be large already at a young age and to sharply increase with age. In other words, the possibility of divorce is an important risk factor.

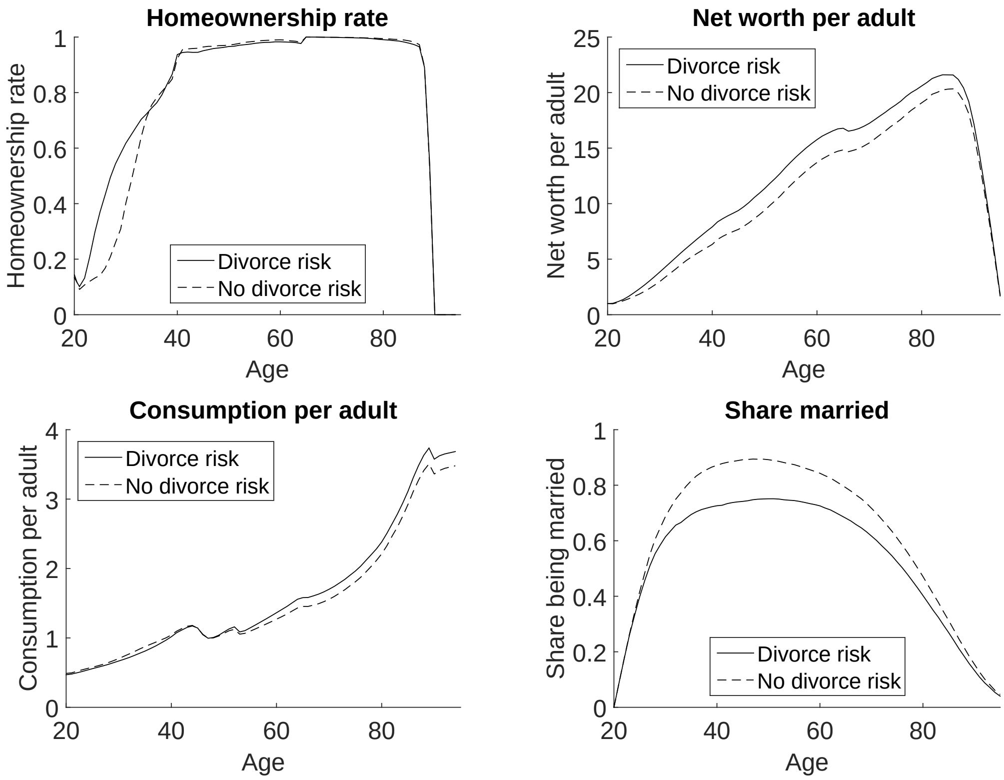
3.3 Divorce as a Risk Factor

In this section, we investigate divorce as a risk factor in more detail. In section 3.3.1, we demonstrate divorce risk affects homeownership rates, households' consumption, and net worth. In section 3.3.2, we show that even for individuals that do not necessarily get divorced, simply the possibility of divorce has significant welfare implications. Furthermore, we explore the welfare consequences of ignoring divorce risk.

3.3.1 How Divorce Risk Affects Household Decisions

Throughout the last century, the share of marriages ending in divorce has increased dramatically. Yet, many individuals tend to ignore or significantly underestimate the probability that their partnership will end in divorce (Baker and Emery, 1993; Fowers, Montel, Lyons, and Shaked, 2001). Surveys find people generally have reasonable perceptions of the likelihood of divorce in the population at large. For example, when asked to estimate the percent of couples marrying today who will get divorced at some time in their lives, individuals typically give a response of around 50%, which is a rather good estimate for the true probability (Norton and Moorman, 1987). At the same time, individuals often overestimate the longevity of their own marriage, often mentioning 0% as the likelihood that they personally will divorce. Fowers, Montel, Lyons, and Shaked (2001) find this phenomenon, known as one of the marriage paradoxes, is pertinent to both married and single individuals and is not dependent on marital duration or marital satisfaction. Furthermore, individuals not only underestimate the probability of their own divorce, but also financial and other

Figure 5
Divorce risk and household decisions



This figure depicts the impact of divorce risk on homeownership rates (upper left panel), household net worth per adult (upper right panel), consumption expenses per adult (lower left panel), and the share of individuals being married (lower right panel). All results reported are averages from 10,000 simulated paths. The solid lines report results when individuals face divorce risk corresponding to the empirically observed probabilities (divorce risk); the dashed lines report when the divorce rate is zero (no divorce risk).

consequences of a divorce. These phenomena motivate our further analysis, where we ask how ignoring the possibility of divorce affects household decisions.

Figure 5 illustrates how divorce risk affects homeownership rates (upper left panel), household net worth (upper right panel), consumption expenses (lower left panel), and the share of individuals being married (lower right panel). The solid lines report results when individuals face divorce risk corresponding to the empirically observed divorce probabilities; the dashed lines report when the divorce rate is zero.

Figure 5 shows the existence of divorce risk causes households to significantly change their behavior and end up on different paths for consumption, savings, and investments over the life cycle. Similar to other risk factors, divorce risk can motivate individuals to save for precautionary motives, which is in line with the empirical evidence in Pericoli and Ventura (2012). In the presence of divorce risk, households increase their savings rates to protect against the negative financial consequences of a possible divorce. In the absence of divorce risk, this savings channel is not active and households need less precautionary savings. Consequently, household net worth is lower when households ignore divorce risk (upper right panel in Figure 5). The lower left panel of Figure 5 shows the precautionary savings motive causes households under divorce risk to consume less when they are young. From about age 45 on, this pattern reverses: households increase their consumption as a response to the wealth effect preceded by higher savings earlier in life.

Simultaneously, households under divorce risk are more likely to be homeowners when they are young (upper left panel in Figure 5). At first glance, this result may seem puzzling given homes are sold in the event of a divorce, implying both former partners lost the costs from trading the home. However, households facing divorce risk build up higher levels of net worth, because of their stronger precautionary savings motive. Hence, these households' higher savings enable them to more easily afford a home, which is why homeownership rates for these households exceed rates for their counterparts not facing divorce risk. This finding suggests the reduction in divorce risk leads to lower homeownership among the young. This implication is in agreement with the observed trends of moderating divorce rates since early 1980s and the increasing average age of first-time home buyers. Other explanations for the delayed homeownership among the young include changing demographics (Segal and Sullivan, 1998), the decline in marriage rates (Fisher and Gervais, 2011), and the reduction of housing affordability (Mayer and Engelhardt, 1996).

Finally, the lower right panel in Figure 5 shows households that ignore the possibility of divorce marry earlier. For instance, at the age of 40, they are found to be married with a probability of 87%, which exceeds the probability after accounting for divorce risk by 15 percentage points. However, even when households do not face divorce risk, the share of households being married does not attain 100%, but peaks at about 90%. These results reflect that not all individuals who attempt to find a partner actually succeed in doing so.

3.3.2 Welfare Implications of Divorce Risk

In addition to the previously documented substantial instant welfare effects of divorce, in this section, we quantify the welfare consequences of divorce risk in two additional ways. First, we determine the welfare effects of the existence of divorce risk for a 20-year-old's lifetime utility. We ask how the existence of divorce risk alone affects lifetime utility even when the individual is not necessarily getting divorced. To do so, we compare expected present discounted lifetime utility of 20-year-olds facing divorce risk with their counterparts not subject to divorce risk. This exercise allows us to evaluate the welfare consequences of divorce risk as a risk factor. Second, we ask what the welfare consequences of behaving as if divorce risk did not exist are, that is, when behaving as if the probability of divorce was zero. To compute these welfare consequences, we compare the levels of attainable expected present discounted lifetime utility of 20-year-olds behaving optimally with those of individuals behaving as if divorce could not happen to them. This analysis quantifies the welfare consequences of ignoring divorce risk in decision making.

We find divorce risk not only alters household decisions, but also affects welfare. To avoid divorce risk, individuals are willing to give up 4% of lifetime consumption. They can attain the same level of expected lifetime utility with a 4% lower initial endowment and lifetime labor income than individuals facing divorce risk.

Likewise, ignoring the fact that one is subject to divorce risk can be costly. Our model predicts individuals who ignore divorce risk when deciding about consumption, housing, investments, children, and marriage need a more than 6% higher initial endowment and lifetime labor income to attain the same level of expected lifetime utility as an individual who explicitly considers divorce risk in decision making. Individuals who neglect the possibility of divorce thus face significant welfare losses.

4 Conclusion

This paper contributes to the literature on the life-cycle wealth accumulation by investigating how divorce risk affects the demand for owner-occupied homes in a life-cycle model. Owner-occupied homes constitute a household's largest single financial asset. Therefore, understanding the implications of divorce risk is particularly important in the presence of housing. To investigate housing decisions under divorce risk, we construct a life-cycle model of consumption, investment, and housing decisions, in which changes in family composition are drivers of homeownership and housing demand.

We find divorce is associated with large welfare losses, which may become prohibitively large for older households. Divorces have a long-lasting effect on the demand for homeownership. The event of a divorce causes a rapid decrease in household net worth and income and an immediate drop in the likelihood of being a homeowner. The reduction of homeownership rates is persistent and lasts for decades. We also illustrate that the risk of divorce is an important risk factor for households, along with other risk factors such as labor income risk and uncertainty in house prices and financial assets.

We find divorce risk triggers a precautionary savings motive. For both married and single individuals, higher divorce risk drives higher savings at a younger age and facilitates earlier homeownership. Finally, we quantify the welfare consequences of ignoring divorce risk in decision making. We find individuals would be willing to give up 4% of lifetime consumption to avoid divorce risk. The welfare cost of ignoring the possibility of divorce is even larger, reaching 6% of lifetime consumption.

Overall, we show that explicitly accounting for changes in family composition in general and divorces in particular is important for understanding households' housing, consumption, and investment decisions, because these events significantly alter optimal housing decisions and have large welfare effects.

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A Solution of Model

We reduce the state space of the optimization problem by exploiting the homogeneity of the Cobb-Douglas function in C and Q. Defining $v = V/\left(W_t/H_t^{\psi}\right)$, it holds that

$$
\begin{aligned}
& v\left(x_t, Y, t\right) \\
= & \sup_{\{c_t, q_t, I_t, \pi_t^s, \pi_t^b, p_{m,1}, p_{c,t}\}} \Bigg[(1-\beta) \cdot U\left(c_t, q_t, I_t, M_t, N_t\right)^{1-\frac{1}{\phi}} \\
& +\beta \cdot \mathbb{E}\Bigg[M_t \Bigg\{ f_t \tilde{f}_t \left(\frac{\frac{W_{t+1}}{W_t}}{\left(\frac{H_{t+1}}{H_t}\right)^{\psi}} \right)^{1-\gamma} \left(\frac{1}{2} v\left(x_{t+1}, Y, t+1\right)^{1-\gamma} + \frac{1}{2} v\left(x_{t+1}, \tilde{Y}, t+1\right)^{1-\gamma} \right) \\
& + f_t \left(1-\tilde{f}_t\right) \left(\frac{\frac{W_{t+1}}{W_t}}{\left(\frac{H_{t+1}}{H_t}\right)^{\psi}} \right)^{1-\gamma} v\left(x_{t+1}, Y, t+1\right)^{1-\gamma} \\
& + \left(1-f_t\right) \tilde{f}_t \left(\frac{\frac{W_{t+1}}{W_t}}{\left(\frac{H_{t+1}}{H_t}\right)^{\psi}} \right)^{1-\gamma} v\left(x_{t+1}, \tilde{Y}, t+1\right)^{1-\gamma} \Bigg\} \\
& + \left(1-M_t\right) f_t \left(\frac{\frac{W_{t+1}}{W_t}}{\left(\frac{H_{t+1}}{H_t}\right)^{\psi}} \right)^{1-\gamma} v\left(x_{t+1}, Y, t+1\right)^{1-\gamma} \Bigg]^{\frac{1-\frac{1}{\phi}}{1-\gamma}} \Bigg]^{\frac{1}{1-\frac{1}{\phi}}},
\end{aligned}
\tag{A.10}
$$

where $c_t = C_t/W_t$ is the consumption-net-worth ratio, $q_t = Q_t/W_t$ is the household's normalized home size for which we have normalized H_t to 1, and

$$
x_t = \left[\frac{Q_{t-1} H_t}{W_t}, I_{t-1}, \frac{L_t}{W_t}, M_t, N_t^e, N_t^l, t \right] \tag{A.11}
$$

is the normalized vector of state variables. Hence, the policy functions c_t, q_t, I_t, π_t^s, π_t^b, $p_{m,t}$, $p_{c,t}$, and the value function, v, depend on seven state variables: (1) the normalized size of the home, (2) the homeownership status, (3) the income-to-net-worth ratio, (4) marital status, (5) the number of children born "early," (6) the number of children born "late," and (7) age.

We numerically compute the optimal policy function using backward induction in the discretized seven-dimensional state space. We discretize the continuous state variables: normalized value of the home, the labor income-to-net-worth ratio, and time. The expectation in equation (A.10) is computed using Gaussian quadrature. We employ parallel computation to expedite the optimization.

B Estimation of Labor-Income Process

Income data are available in the PSID beyond the waves with the Wealth Supplement. For estimating the labor-income process, we use panel data from the 1980-2011 waves of the PSID. We split our sample of high school graduates into three groups: single males, single females, and married couples. The estimation of income-process characteristics closely follows the procedure outlined in Cocco, Gomes, and Maenhout (2005) and subsequently used by Love (2010). We construct income profiles for each group in two steps. First, we run a fixed-effects regression of the natural logarithm of income on a full set of age dummies and the number of children in different age brackets living in a household. Second, a polynomial of order three is fitted to the age-dummy coefficients.

We compute the replacement ratio for each group in two steps as in Cocco, Gomes, and Maenhout (2005). First, we run fixed-effects regressions of log income on age dummies for each demographic group separately. Second, based on these estimated dummies, we compute the average implied income for individuals aged 55-62 as a proxy for labor income prior to retirement. Likewise, we compute the average implied income for individuals aged 67-80 as a proxy for the first retirement income. The ratio between the latter and the former defines our replacement ratio. We estimate the variances of income shocks, using the procedure proposed by Carroll and Samwick (1997) and used in Cocco, Gomes, and Maenhout (2005) and Love (2010), among others.

C Data Details

In our empirical analysis in section 3.1 and our comparison of model predictions with empirical evidence, we use micro-level data from the PSID along with its Wealth Supplements. Our data sample covers the time period in which data from the Wealth Supplements are available on a bi-annual basis: the years 1999–2011. We exclude households in the Latino sample, the poverty sample, and the immigrant sample to keep our sample representative. We define household income as the sum of labor income and public transfers after taxes.[14] We do not

[14] Taxes are not available in the PSID data for the time period considered in our analysis. We therefore use the TAXSIM software developed by Feenberg and Coutts (1993) to compute taxes. The TAXSIM software is publicly accessible on the NBER's homepage: `http://users.nber.org/~taxsim/`.

include financial income or private transfers, because we explicitly model these in our work. Income therefore only includes wages, bonus payments, overtime payments, tips, commissions and earnings, pensions, working compensation, unemployment compensation, value food stamp benefits, TANF and other state program transfers, Supplemental Security Income payments, as well as other public welfare payments. Net worth is the sum of all assets (including the values of homes) minus all household debt. All monetary values reported are in 2008 dollars.

Similar to Love (2010), we restrict household income to be between \$3,000 and \$3,000,000, and household net worth to be positive. We further remove households with loan-to-net-worth ratios above 0.95, reflecting that these households are more likely to default on their mortgages (Mayer, Pence, and Sherlund, 2009). Likewise, we remove households with substantial debt relative to their net worth. Such households' behavior is likely to be significantly affected by their debt, which goes beyond the scope of our work.[15] More precisely, we remove households with a debt-to-net-worth ratio exceeding 20. We also remove observations with top-coded values, wild codes, and refused or ambiguous answers, such as households reporting they neither own nor rent the home in which they are living.

[15]This issue is, for instance, studied in more detail in Koijen, Van Hemert, and Van Nieuwerburgh (2009), Cocco (2013), and Campbell and Cocco (2015).