

Going solo or waiting for love? Relationship and housing choices in a life cycle model^{*,†}

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This version: January 13, 2026

^{*}We are grateful for helpful comments and suggestions from Rob Bauer, Marcel Fischer, Lukas Freudenthal (discussant), Monika Gehde-Trapp, Frank Graef (discussant), Christoph Hambel, Jens Jackwerth, Madi Mangan (discussant), Kusum Mundra, Kim Peijnenburg, Antoon Pelsser, Paulo Rodrigues, Alexander Schandlbauer, Julie Schnaitmann, Peter Schotman, Jonas Wogh, and seminar participants at the 2025 Konstanz—St. Gallen PhD Seminar in Finance, the 2025 Netspar International Pension Workshop, and the Universities of Konstanz, Maastricht, Tilburg, and Tübingen. We would like to thank Chiara Lausser for her excellent research assistance. An early version of this manuscript was circulated under the name “Impact of Marriage and Homeownership Timing on Financial Wealth.”

[†]*Declaration of interests.* Natascha Jankowski gratefully acknowledges financial support from the LBS Foundation at the University of Konstanz. This funding did not have any influence on our research.

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Abstract

Going solo or waiting for love? Relationship and housing choices in a life cycle model

Using a quantitative life cycle model of optimal consumption, savings, housing, and relationship decisions, we investigate how capital, housing, and labor market conditions influence the timing of individuals' relationship and housing choices. We find that capital and labor market returns significantly impact whether individuals should go solo in the housing market or wait for love and buy when in a relationship. Moreover, we show that entering the housing market as a single or in a relationship leads to substantially different life cycle profiles of wealth, consumption, asset allocation, and housing. These differences arise because single individuals and those in a relationship experience capital and housing market returns differently.

Key Words: endogenous housing and relationship decisions, life cycle model, long-term financial decision making, portfolio choice, financial market returns

JEL Classification Codes: D15, E21, G11

1 Introduction

Acquiring real estate is one of the most significant financial decisions individuals face throughout their lives. Many individuals plan carefully when to buy an owner-occupied home and how to finance it. Several factors play an important role in the decision-making process, such as liquid savings, income expectations, financial market conditions, and family composition.

In this manuscript, we focus on the latter two aspects and study how capital, labor, and housing market conditions impact housing and relationship choices. Using a quantitative life cycle model of optimal consumption, savings, housing, and relationship choices, we shed light on the implications of financial market conditions for either going solo or waiting for love in the housing market, i.e., for entering the housing market while still single or when in a relationship.

In a first analysis, we estimate a linear probability model using simulated life cycle data to examine how financial market conditions influence the decision to enter the housing market alone. We find that, in general, individuals are more likely to purchase a home with a partner. However, favorable stock market returns at younger ages — specifically, higher cumulative stock returns by age 25 — significantly increase the likelihood to buy a home on their own, as they have greater financial means to do so. In contrast, individuals with stronger labor income growth are more likely to wait and purchase a home with a partner. This is because higher earners are more likely to match with similarly high-earning partners, making it more attractive to delay individual homeownership. Moreover, at a young age, their labor-to-wealth ratios are still high — that is, labor income makes up a large share of their total wealth. If labor income rises sharply, total wealth responds strongly, allowing individuals to substantially increase their wealth in a short period. As a result, it may be optimal to delay purchasing a home in order to avoid more of the mortgage interest rate margin without reducing consumption.

When taking a look at the life cycle outcomes, we find that individuals who enter the housing market in a relationship accumulate higher levels of total wealth, have better consumption opportunities, and live in more valuable homes while not having substantially higher loan-to-value ratios, compared to those who enter the housing market as singles.

Our final regression analysis, again using simulated life cycle data, helps explain these differences in life cycle outcomes. While the timing of entering a relationship relative to home-

ownership does not directly affect wealth at retirement, the key driver lies in how individuals are exposed to capital market returns. Those who buy a house as a couple maintain significantly higher equity exposure throughout their life cycle, making them more responsive to stock market returns. This elevated exposure allows them to benefit more from the higher expected returns on stocks.

With our manuscript, we, among others, contribute to the literature on life cycle portfolio choice. There are several papers that study optimal consumption, savings, and housing decisions but do not account for (changes in) family composition at all (see, e.g., Cocco, 2005; Kraft and Munk, 2011; Fischer and Stamos, 2013; Schlafmann, 2021). Other papers consider changes in family composition by accounting, e.g., for marriage, divorce, and children, but treat these changes as exogenous shocks. Examples include Fischer and Khorunzhina (2019), who study housing choices under divorce risk, and Bacher (2022), who studies housing and savings behavior across different family types. We contribute to this strand of literature by expanding the classical consumption, savings, and housing choice models with endogenous relationship choices.

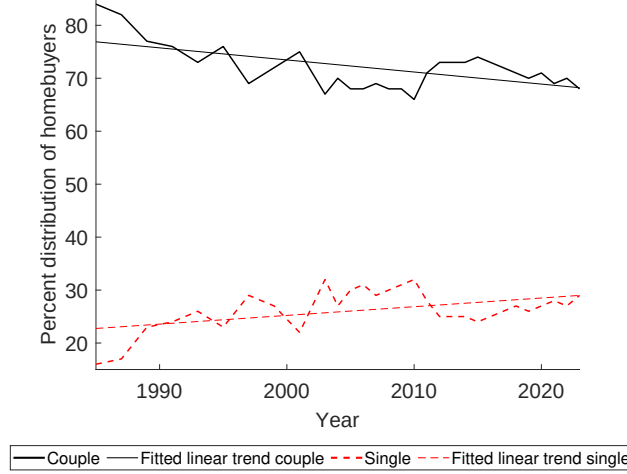
Moreover, we contribute to the recently evolving strand of literature that models marriage market choices as endogenous. For example, Low et al. (2022) endogenize marriage market choices to study the impact of time limits on welfare receipt in the U.S. and Reynoso (2023) studies the impact of unilateral divorce on marriage and divorce decisions. However, in contrast to our paper, these papers do not include housing choices, which are typically among the biggest financial challenges singles and couples face throughout their lives.

Chang (2024) is most likely closest to our paper. She empirically observes that the proportion of young singles in the housing market increased from 1970 to 1995 while the proportion of young couples decreased. Using a life cycle model, she finds that a lower likelihood of marriage helps explain the increasing homeownership rates for young singles. However, she also treats marriage as an exogenous shock. Moreover, we focus more strongly on financial aspects and study how capital, labor, and housing market conditions impact housing and relationship choices.

Our manuscript proceeds as follows: Section 2 empirically motivates our study. Section 3 outlines our quantitative model of optimal consumption, savings, housing, and marriage market decisions, while section 4 presents and discusses our quantitative model’s results. Finally, section 5 concludes.

2 Empirical motivation

Figure 1: Distribution of single homebuyers and those in a relationship in the U.S. between 1985 and 2023



This figure depicts the percent distribution of homebuyers in the U.S. between 1985 and 2023. The black solid line depicts the results for homebuyers in a relationship and the black dotted line shows a fitted linear trend. The red dashed line depicts the results for single individuals (i.e., single male and single female individuals) and the red dash-dotted line again shows a fitted linear trend. We obtain the data from Kasper et al. (2023).

In this section, we outline the empirically-observed demographic changes of homebuyers over time. Figure 1 depicts the distribution of homebuyers' relationship statuses in the U.S. between 1985 and 2023. The black solid line depicts the results for homebuyers in a relationship. The red dashed line depicts the results for single individuals (i.e., single males and single females). The black and red straight lines show the results of a fitted linear trend to the percent distribution of homebuyers in a relationship and single homebuyers, respectively. We include these trends to allow for an easier eyeballing of the data. The figure is based on data from Kasper et al. (2023). We refrain from reporting the trends for other demographic groups to improve the readability of our graphs. This, however, leads to the shares not summing up to 100%.

We observe that the distribution of homebuyers' relationship statuses changes over time. While the share of individuals in a relationship acquiring real estate has decreased from 84% in 1985 to 68% in 2023, the share of single individuals acquiring real estate has increased from 16% in 1985 to 29% in 2023. These changes over time raise the questions of why individuals

adjust their behavior and what the implications for financial well-being are.

In related work, Chang (2024) studies the trend of increasing homeownership rates for singles and decreasing rates for married couples. Specifically, she finds that from 1970 to 1995, homeownership rates among young singles have increased by 4.6 percentage points, while homeownership rates among young couples have decreased by 1.7 percentage points. While Chang (2024) focuses on explaining the changes in homebuyers’ relationship statuses (e.g., via generally decreasing marriage rates), our work takes a different focus and studies the impact of capital, housing, and labor market conditions on individuals’ relationship and housing choices.

3 Model

In this section, we outline our quantitative life cycle model of optimal consumption, savings, housing, and relationship decisions, which covers individuals from age 20 to age 100. Individuals make their financial and relationship decisions to maximize their expected discounted lifetime utility characterized by Epstein–Zin preferences (Epstein and Zin, 1989) under the presence of stochastic labor income (Cocco et al., 2005), risky housing and stock market returns, and mortality risk.

3.1 Housing and capital market

We model house prices and thus housing investments to be risky. We denote the price per home unit by H_t and the gross return on the price per home unit from time t to $t + 1$ by R_t^H . We assume that R_t^H is log-normally distributed with an expected return of μ_H and a standard deviation of σ_H , i.e.,

$$\log R_t^H \sim \mathcal{N}(\mu_H, \sigma_H^2). \quad (1)$$

Individuals face a rent-versus-own decision, i.e., they can either live in a rented place or an owner-occupied home. Owner-occupied homes serve a dual role as an asset and a durable consumption good. That means that individuals expose themselves to changes in the home’s value via the asset channel and derive utility from living in the home via the consumption good channel. We employ a Cobb-Douglas utility function, u , over consumption and housing (see, e.g., Cocco, 2005; Yao and Zhang, 2005; Kraft et al., 2018) and, following Kiyotaki

et al. (2011), we account for individuals' preferences of living in an owner-occupied home instead of a rented place by assigning a higher utility, $\zeta \in [0\%, 100\%]$, per home unit, when individuals own the home. Let $h_t \in \{0, 1\}$ be a binary variable that denotes the individual's homeownership status and takes the value zero if the individual is a renter from time t to $t+1$ and the value one if the individual lives in an owner-occupied home from time t to $t+1$. If Q_t denotes the size of the home the individual lives in from time t to $t+1$ and C_t their consumption, then

$$u(C_t, Q_t, h_t) = C_t^{1-\theta} (Q_t (1 + \zeta h_t))^\theta, \quad (2)$$

where θ is the individual's preference for housing consumption.

Following the large literature on optimal housing choices (see, e.g., Yao and Zhang, 2005; Fischer and Stamos, 2013), individuals also face recurring costs, m , and non-recurring costs, n , that are proportional to the value of their home. Recurring costs reflect the rent rate for renters and the maintenance costs for owners; non-recurring costs are transaction costs that occur when individuals acquire a new owner-occupied home or move from one owner-occupied home to another. These transaction costs cover, for example, taxes and fees for real estate agents.

The recurring costs, m , can be summarized as follows:

$$m(h_t, Q_t) = \mathbb{1}_{\{h_t=0\}} m_r Q_t H_t + \mathbb{1}_{\{h_t=1\}} m_o Q_t H_t, \quad (3)$$

where $m_r \in [0\%, 100\%]$ denotes the rent rate and $m_o \in [0\%, 100\%]$ the rate for maintenance costs. Both are proportional to the value of the home.

The non-recurring costs, n , take the following form:

$$n(h_{t-1}, h_t, Q_{t-1}, Q_t) = n_p Q_t H_t (\mathbb{1}_{\{h_{t-1}=0 \wedge h_t=1\}} + \mathbb{1}_{\{h_{t-1}=1 \wedge h_t=1 \wedge Q_{t-1} \neq Q_t\}}), \quad (4)$$

where $n_p \in [0\%, 100\%]$ denotes the share of the value of the home that has to be paid as transaction costs. We assume transaction costs are always covered by the buyer of the home at the time of purchase.

Owner-occupiers can use their home as collateral and borrow up to $\delta \in [0\%, 100\%]$ of the home's value. Let B_t denote the amount of money invested from time t to $t+1$ at a constant interest rate of R_B if $B_t \geq 0$ and the size of the mortgage on which interest at a rate of R_D

has to be paid if $B_t < 0$. We assume that $R_D > R_B$, i.e., that individuals face an interest rate margin on mortgage debt. The individual’s borrowing constraint is then

$$-B_t \leq \delta_t Q_t H_t. \quad (5)$$

Renters do not have any borrowing opportunities, i.e., we assume that borrowing against human capital is not possible.

Furthermore, individuals face an asset allocation decision. They cannot only invest their savings in a risk-free asset, but also in a risky asset that represents a stock market index. Let S_t denote the amount of money invested in stocks from time t to $t + 1$. Stocks earn a risky gross return R_t^S , which is log-normally distributed with mean μ_S and standard deviation σ_S :

$$\log R_t^S \sim \mathcal{N}(\mu_S, \sigma_S^2). \quad (6)$$

3.2 Relationships

We model relationship choices as endogenous. This substantially extends other papers studying family composition and housing choices in a theoretical framework, such as Fischer and Khorunzhina (2019) and Bacher (2022), as they model marriage as an exogenous “shock.”

We assume that the individual for whom we solve the quantitative life cycle model and to whom we will from now on refer as the “head” of the potential family unit, enters the life cycle as a single and a renter. Every period $t = 1, \dots, T$, the head meets one potential partner who is also a renter.

There is an increasing tendency for individuals to find partners with similar socio-demographic characteristics, i.e., to find partners with similar age, income, education, and net worth (see, e.g., Schwartz and Mare, 2005; Bredemeier and Juessen, 2013; Fernández and Wong, 2014; Greenwood et al., 2014). Thus, we assume the potential spouses have the same age, educational attainment, and wealth as the head. Further, their gender is opposite to the head’s gender. These assumptions are similar to those made in, e.g., Cubeddu and Ríos-Rull (2003) along the age dimension, Love (2010) along the income dimension, Voena (2015) along the wealth dimension, and Fischer and Khorunzhina (2019), and also help to ensure the numer-

ical solvability of our model.

In every period, the head can decide whether it wishes to enter a relationship with the potential partner, $\mathcal{P}$, in the following period, i.e., the head decides in period t whether it wants to enter a relationship in period $t + 1$ with the partner met in period t or to remain single. The head decides to enter a relationship with the respective partner if the expected future utility from entering a relationship is higher than the expected future utility from staying single. However, even though it might make sense to enter a relationship for financial reasons, it might not be the optimal choice from a personal perspective. Thus, even though the head wants to enter the relationship for financial reasons, the relationship only becomes effective with probability p^P . With probability $(1 - p^P)$, the head stays single even though it is financially suboptimal not to enter the relationship. Once the head is in a relationship, it remains in it until our model's terminal period.¹ We denote the head's relationship status by $P_t \in \{0, 1\}$. It takes the value 0 if the head starts period t as a single and the value 1 if the head starts period t in a relationship.

Relationships only become effective one logical second before decisions at time $t + 1$ are made, i.e., the head starts its life in a relationship in period $t + 1$ by moving to a joint residence with the spouse. This implies that the head still makes its own housing decision in period t .

If the head is an owner, they move to the house of the head before decisions in period $t + 1$ are made. However, directly in period $t + 1$, they can then decide how to adjust their housing choice for period $t + 1$ to $t + 2$.²

For single individuals, the Cobb-Douglas utility function over consumption and housing, u , has its standard form as introduced in equation (2). Individuals in a relationship have a different utility function, u^P , building on our assumptions on the couple's financial decision-making processes. We assume that couples share all their wealth, but the head is responsible for making all investment decisions.

The couple's joint consumption from time t to $t + 1$ is denoted by C_t^P . However, the head

¹As our manuscript focuses on how capital, labor, and housing markets impact housing market and relationship entry, we deliberately do not allow couples to separate. Our emphasis is on the individuals' accumulation phase of savings and the interplay of their transition from being single to a couple and their transition from renter to owner. Further, divorce risk is already well-studied in pre-existing literature, such as in Fischer and Khorunzhina (2019).

²As renting is not associated with transaction costs in our model, we do not need a specific decision rule in case the head is a renter when getting married.

who, in our model, is optimizing its expected present discounted lifetime utility, does not derive utility from the couple's total consumption but only from a fraction $\phi \in (0\%, 100\%]$, indicating that some of the amount consumed is solely consumed by the partner and the head does not derive any utility from this share of total consumption.³ Usually, it holds that $\phi > 50\%$, indicating that there are goods both partners simultaneously derive utility from. Guner and Knowles (2007) and Chang (2024) provide a thorough discussion of this economy-of-scale argument.

In line with the argumentation for splitting the couple's consumption, we assume that individuals in a relationship also do not derive utility from the total home size but only from a fraction $\xi \in (0\%, 100\%]$.

Further, we assume, in line with, e.g., Fischer and Khorunzhina (2019) and Chang (2024), that individuals have a preference for being in a relationship over being single. In the same fashion as we account for individuals' preferences of being owners instead of renters, heads derive a higher utility of $\pi \in [0\%, 100\%]$ when they are in a relationship.

Taking everything together and denoting the joint homeownership status from time t to $t+1$ by h_t^P and the size of the couple's residence from time t to $t+1$ by Q_t^P , the utility function of a head who is in a relationship, u^P , takes the following form:

$$u^P(\phi C_t^P, \xi Q_t^P, h_t^P) = \left((\phi C_t^P)^{1-\theta} (\xi Q_t^P (1 + \zeta h_t^P))^\theta \right) (1 + \pi_t). \quad (7)$$

3.3 Optimization problem

Singles make five interrelated decisions simultaneously at every point in time to maximize their expected present discounted utility. They decide upon their homeownership status, h_t , the size of their home, Q_t , their bond investment/size of the mortgage, B_t , the amount of money invested into stocks, S_t , and whether they would want to enter a relationship with the potential partner, $R_t \in \{0, 1\}$. Heads in a relationship only make four interrelated decisions, as they no longer decide upon their relationship status. We now turn to setting up the optimization problem for singles and individuals in a relationship separately.

³Setting $\phi = 0\%$ is not possible as it implies that the head has a consumption level of zero, which cannot be an optimal solution.

Single

If L_t denotes the head's labor income received at time t that is stochastic prior to attaining retirement age and a constant share of the last working period's labor income after attaining retirement age as in Cocco et al. (2005), then the total wealth of a single head at time t is

$$\begin{aligned} W_t &= B_{t-1} (\mathbb{1}_{\{B_{t-1} \geq 0\}} R_B + \mathbb{1}_{\{B_{t-1} < 0\}} R_D) + S_{t-1} R_{t-1}^S + h_{t-1} Q_{t-1} H_t + L_t \\ &= C_t + h_t Q_t H_t + m(h_t, Q_t) + n(h_{t-1}, h_t, Q_{t-1}, Q_t) + B_t + S_t. \end{aligned} \quad (8)$$

The wealth in period $t + 1$ depends on whether singles stay single or enter a relationship with potential partner $\mathcal{P}$ and is given by

$$W_{t+1} = (B_t (\mathbb{1}_{\{B_t \geq 0\}} R_B + \mathbb{1}_{\{B_t < 0\}} R_D) + S_t R_t^S + h_t Q_t H_{t+1} + L_{t+1}) (1 + W_P \mathbb{1}_{\{P_{t+1}=1\}}), \quad (9)$$

where W_P reflects how much wealth the potential partner has, relative to the wealth of the head. The head's wealth increases by this amount upon entering the relationship.

Let $f(t)$ denote the individual's probability of survival from time t to $t + 1$, β its time preference factor, γ the risk aversion parameter, and ψ the elasticity of intertemporal substitution. Then, the optimization problem for a head who is single at time t before decisions are made using Epstein–Zin preferences (Epstein and Zin, 1989) has the following form:

$$\begin{aligned} V_t(\mathcal{X}_t) &= \\ \max_{d_t} &\left((1 - \beta) u(C_t, Q_t, h_t)^{1 - \frac{1}{\psi}} + \right. \\ &\beta \left(f(t) \mathbb{E}_t \left[(1 - p^P) V_{t+1}(\mathcal{X}_{t+1})^{1 - \gamma} + \right. \right. \\ &\left. \left. p^P \left((\mathbb{1}_{\{R_t=1\}} V_{t+1}^P(\mathcal{X}_{t+1}^P) + \mathbb{1}_{\{R_t=0\}} V_{t+1}(\mathcal{X}_{t+1}))^{1 - \gamma} \right) \right] \right)^{\frac{1 - \frac{1}{\psi}}{1 - \gamma}} \left. \right)^{\frac{1}{1 - \frac{1}{\psi}}} \end{aligned} \quad (10)$$

subject to

$$C_t, Q_t > 0, S_t \geq 0, \quad (11)$$

and equations (5), (8), and (9). $\mathcal{X}_t = [t, W_t, Q_{t-1}, h_{t-1}, L_t, P_t]$ denotes the vector of state variables needed to solve this problem and $d_t = [h_t, R_t, C_t, B_t, Q_t, S_t]$ the vector of choice variables. Here, V_{t+1}^P denotes the expected utility from entering a relationship with partner $\mathcal{P}$ and $\mathcal{X}_t^P = [t, W_t^P, Q_{t-1}^P, h_{t-1}^P, L_t^P, P_t]$ the vector of state variables needed to solve the optimization problem for a head that enters a relationship.⁴

Couple

If the head starts period t in a relationship and it is not the first period it is in a relationship its wealth is given by

$$\begin{aligned} W_t^P &= B_{t-1}^P \left(\mathbb{1}_{\{B_{t-1}^P \geq 0\}} R_B + \mathbb{1}_{\{B_{t-1}^P < 0\}} R_D \right) + S_{t-1}^P R_{t-1}^S + h_{t-1}^P Q_{t-1}^P H_t + L_t^P \\ &= C_t^P + h_t^P Q_t^P H_t + m(h_t^P, Q_t^P) + n(h_{t-1}^P, h_t^P, Q_{t-1}^P, Q_t^P) + B_t^P. \end{aligned} \quad (12)$$

where the superscript P denotes the couple's joint decisions.⁵ If it is the first period, the head is in a relationship, we have to account for the changing composition of wealth when transitioning from being single to being in a relationship. Thus, the wealth at the beginning of this period is given by equation (9).

The optimization problem for a head who is in a relationship at time t then has the following form:

$$\begin{aligned} &V_t^P(\mathcal{X}_t^P) = \\ &\max_{d_t^P} \left((1 - \beta) u^P(\phi C_t^P, \xi Q_t^P, h_t^P)^{1 - \frac{1}{\psi}} + \beta \left(f(t) \mathbb{E}_t \left[V_{t+1}^P(\mathcal{X}_{t+1}^P)^{1 - \gamma} \right] \right)^{\frac{1 - \frac{1}{\psi}}{1 - \gamma}} \right)^{\frac{1}{1 - \frac{1}{\psi}}}, \end{aligned} \quad (13)$$

subject to

$$C_t, Q_t > 0, S_t \geq 0, \quad (14)$$

and equations (5) and (12). $\mathcal{X}_t^P = [t, W_t^P, Q_{t-1}^P, h_{t-1}^P, L_t^P, P_t]$ is the vector of state variables needed to solve this problem and $d_t^P = [h_t^P, C_t^P, B_t^P, Q_t^P, S_t]$ the vector of choice variables.

⁴Since the head only enters the relationship in period $t + 1$, the Cobb-Douglas utility function at time t is given in equation (2) (the utility function for singles). The utility from being in a relationship only enters the optimization in terms of its expected future value, as entering the relationship only takes place with probability p^P .

⁵As soon as individuals are in a relationship, their wealth dynamics for all future time periods are described by this equation. In contrast to individuals who are single, the wealth dynamics of individuals in a relationship remain unchanged.

If individuals are in a relationship, $f(t)$ denotes the probability that both partners survive until the next period.⁶

We outline how we solve the optimization problems in greater detail in Appendix A.

3.4 Calibration

This section presents the calibration of our model, which is also summarized in Table 1. In our model, individuals enter the life cycle at age 20 and die at the latest at age 100. However, they may die earlier as they face mortality risk. To calculate their survival probabilities, we use the life table from the Center of Disease Control and Prevention (Arias and Xu, 2018). In our base case setting, we assume that the head of the couple is female and a high school graduate. We explicitly model her labor income and assume that it is stochastic prior to attaining retirement age and a constant fraction of the last working period’s labor income after attaining retirement age. For calibrating the labor income process, we use the coefficients from Fischer and Koch (2025), who re-estimate those of Cocco et al. (2005) with more recent data.

We estimate the financial market parameters using historical data. In a first step, we adjust all time series for inflation using the U.S. consumer price index. That implies that all our estimates presented below are in real terms. We set the annual risk-free rate at which individuals can invest their savings to $r_B = 0\%$. This matches the average real 3-month Treasury Bill rate between 1934 and 2024. The real interest rate at which individuals can borrow is set to $r_D = 3.6\%$, reflecting the average annual 30-year fixed rate mortgage from 1971 to 2024 – the maximum time span for which data is available. We estimate stock returns using annual real returns on the S&P500 from 1934 to 2024. We find an average stock return of 8.8% and a standard deviation of $\sigma_S = 18.2\%$. However, Claus and Thomas (2001) argues that even though the risk premium was historically high, it is unlikely to persist at this high level. Thus, we follow their argumentation and set the equity risk premium to 4% , implying an expected return on equity of $\mu_S = 4\%$.

We calculate the real return on housing based on the 1934–2024 U.S. S&P’s CoreLogic Case-Shiller Home Price Index and estimate the mean to be $\mu_H = 1.4\%$ and the standard

⁶We acknowledge that this is a significant simplification. However, we are mainly interested in the impact of capital market conditions on entering relationships and acquiring real estate. Thus, we focus on the accumulation phase of savings and given that the probabilities of survival are close to 1 in the accumulation phase (i.e., before age 65), we argue that our assumption does not lead to invalid key findings.

deviation to be $\sigma_H = 5.1\%$. Case and Shiller (1989) and Chinloy et al. (2022), among others, argue that the volatility of the prices of individuals' homes is substantially higher than the volatility of the home price index. We follow their consensus and set the standard deviation of the annual expected return on housing to $\sigma_H = 8.7\%$, the empirical estimate of Chinloy et al. (2022) for the U.S. housing market for 1990 to 2020.

Following Cocco (2005), we set the correlation between stock returns and labor income to $\rho_{S,L} = 0.047$, the correlation between housing return and labor income to $\rho_{H,L} = 0.553$, and the correlation between stock returns and housing return to $\rho_{S,H} = 0$.

In every period, the head meets a potential partner who is a renter. We set the probability of successfully entering a relationship with this partner to $p^P = 0.4$, since according to Rosenfeld (2014) around 60% of relationships fail within the first year. Following Yang (2009), we set the economies of scale when being in a relationship to $\phi = 1/1.34 \approx 0.74$ for non-durable consumption and to $\xi = 1/1.1 \approx 0.91$ for housing services.

We set the preference parameters to roughly match several key features found in the data, such as the age of entering a committed relationship and the growth of wealth. Our choices are $\gamma = 10$ for risk aversion (see, e.g., Cocco et al., 2005), $\psi = 0.1$ for elasticity of intertemporal substitution (see, e.g., Fischer and Khorunzhina, 2019), $\beta = 0.98$ for time preference (see, e.g., Cocco, 2005), $\zeta = 10\%$ for the utility shifter that captures individuals' preferences for owning over renting (see, e.g., Kiyotaki et al., 2011), and $\pi = 0\%$ for the utility shifter that captures individuals' preferences for being in a relationship over being single. We choose π such that we match the age of entering a relationship with the empirically-observed age of first marriage.

4 Quantitative results

We now turn to discussing the results of our model. First, we demonstrate that our model's predictions match key features in the data. Second, we analyze the impact of capital market conditions on individuals' optimal decision making, and third, we investigate differences in life cycle outcomes under the presence of endogenous relationship decisions based on exposure to different market conditions.

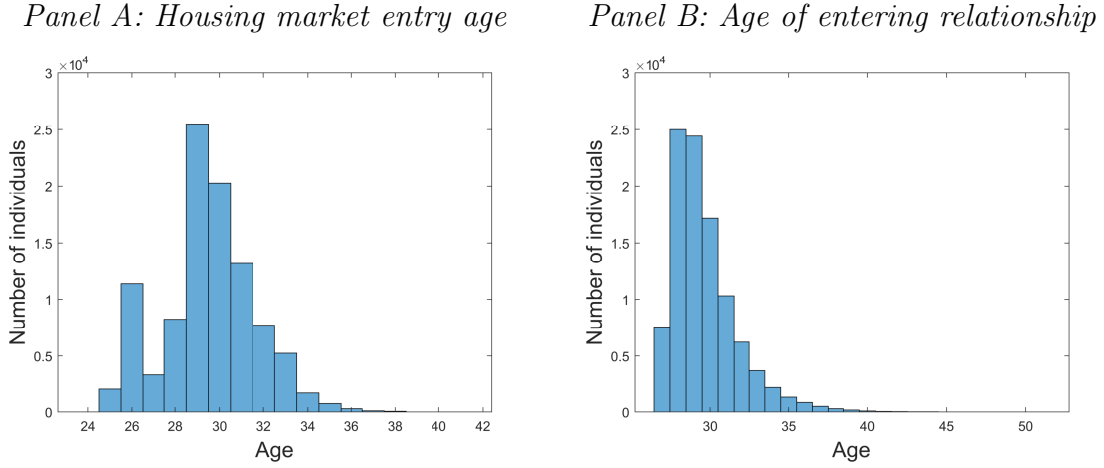
We choose our model's calibration so that we match two key features in the data: (1) average age of entering a relationship and (2) average growth of wealth in the accumulation phase of savings. Figure 2 shows the distribution of the housing market entry age in Panel A and of

Table 1: Base case calibration

Description	Parameter	Value	Source
<i>Preference parameters</i>			
Degree of risk aversion	γ	10	own calibration
Time preference factor	β	0.98	own calibration
Elasticity of intertemporal substitution	ψ	0.1	own calibration
<i>Financial markets</i>			
Real annual risk-free rate	r_B	0.0%	historical estimate
Real annual risk-free borrowing rate	r_D	3.6%	historical estimate
Real annual expected return on stocks	μ_s	4.0%	Claus and Thomas (2001)
Standard deviation of real annual return on stocks	σ_S	18.2%	historical estimate
<i>Housing market</i>			
Housing preference parameter	θ	0.2	Yao and Zhang (2005)
Maximum borrowing rate	δ	80%	Yao and Zhang (2005)
Annual rent rate	m_r	6%	Yao and Zhang (2005)
Annual maintenance rate	m_o	1.5%	Yao and Zhang (2005)
Transaction costs for purchasing home	n_p	6%	Yao and Zhang (2005)
Real annual expected return on housing	μ_H	1.4%	historical estimate
Standard deviation of real annual return on housing	σ_H	8.7%	Chinloy et al. (2022)
Preference for owning over renting	ζ	10%	Kiyotaki et al. (2011)
<i>Dependence structure</i>			
Stock returns and labor income	$\rho_{S,L}$	0.047	Cocco (2005)
Stock returns and housing return	$\rho_{S,H}$	0	Cocco (2005)
Housing returns and labor income	$\rho_{H,L}$	0.553	Cocco (2005)
<i>Relationships</i>			
Probability of successfully entering relationship	p^P	0.4	Rosenfeld (2014)
Economies of scale for consumption	ϕ	$1/1.34$	Yang (2009)
Economies of scale for housing	ξ	$1/1.1$	Yang (2009)
Preference for relationship over single	π	0%	own calibration

This table summarizes the parameters for the base case of our model.

Figure 2: Average age of entering the housing market and relationships



This figure depicts the distributions of the age individuals enter (1) the housing market in Panel A and (2) a committed relationship in Panel B. All results are based on 100,000 simulated paths on the policy functions obtained when solving the model outlined in section 3.

the age at which individuals enter a relationship in Panel B. We obtain these distributions by solving the model outlined in section 3 and then running 100,000 simulations on the policy function.

From Panel A, we see that the average age at which individuals first enter the housing market is 29.5 years and that there is sufficient dispersion in the timing of housing market entry to make our following results meaningful. From Panel B, we see that the age at which they decide to enter a committed relationship is 29.7 years. When comparing our results with US data, we see that we match the empirically-observed age of first-time marriage (29.4 years in 2024, see United States Census Bureau, 2024) very well.

4.1 Capital market environments and optimal timing decisions

When taking a closer look at our optimization results, we see that the individuals whose life cycle profiles we obtain by running 100,000 simulations on the optimal policy functions can be split into two groups: (1) individuals who wait for love and only enter the housing market after entering a relationship (74,321 individuals) and (2) individuals who go solo in the housing market and enter the housing market before a relationship (25,679 individuals). We can see that for the majority of individuals in our simulation it is optimal to enter the housing market jointly with a partner. The fact that individuals in our model have

homogeneous preferences but still show significantly different behavior with respect to the timing of their housing and relationship choices raises the question of what possibly drives these differences.

Thus, we turn to investigating the impact of capital market conditions, as they are the exogenous variation in our model, on the timing of housing and relationship decisions. More specifically, we run the following linear probability model:

$$\text{Rel_First}_i = \alpha + \beta_1 \mathcal{R}_{25,i}^S + \beta_2 \mathcal{R}_{25,i}^H + \beta_3 \mathcal{R}_{25,i}^L + \varepsilon_i, \quad (15)$$

where the dependent variable Rel_First_i is a dummy variable taking value one if individual i enters a relationship before the housing market and value zero if it enters the housing market before a relationship. The explanatory variables are the cumulative return on stocks, $\mathcal{R}_{25,i}^S$, housing, $\mathcal{R}_{25,i}^H$, and labor income, $\mathcal{R}_{25,i}^L$ that individual i accumulated up to age 25. This is the first age at which one of the 100,000 individuals decides to either enter the housing market or a relationship. α is an intercept, $\beta_1, \beta_2, \beta_3$ the regression coefficients, and ε_i an error term.

We summarize the results for the regression outlined in equation (15) in Table 2. For ease of interpretation, coefficients on continuous variables have been standardized and should be interpreted as the effect of a one-standard-deviation increase in the respective variable. We see that cumulative stock and labor market returns have a significant impact on the timing of relationship and housing market decisions, whereas cumulative housing market returns have no significant impact.⁷

Our results show that, generally, it is more likely to enter a relationship before entering the housing market. However, this decision is also strongly influenced by returns on stocks and labor income. We find that one-standard-deviation higher cumulative stock returns until the age of 25 decrease the likelihood of entering a relationship before entering the housing market by 19.06%, i.e., it becomes more likely to enter the housing market as a single. This reflects the fact that if stock market returns are high, individuals are wealthier and have more financial resources to buy a home on their own. Thus, it is less important to pool

⁷Why cumulative housing market returns have no significant impact is partly driven by our model construction. As outlined in Appendix A, we normalize the optimization problem with total wealth, leading to $q_t = Q_t H_t / W_t$ being one decision variable that directly impacts the individual's utility. Thus, individuals make decisions about their next period's home's value while not observing the trade-off between Q_t and H_t . Consequently, cumulative housing returns do not contribute to, e.g., meeting borrowing constraints.

Table 2: Regression results: Capital market returns and timing of housing market entry and relationships

Coefficient	Estimate
α	0.7830*** (0.0073)
$\mathcal{R}_{25}^S$	-0.1906*** (0.0012)
$\mathcal{R}_{25}^H$	0.0006 (0.0015)
$\mathcal{R}_{25}^L$	0.0784*** (0.0015)
N	100,000
R^2	0.387

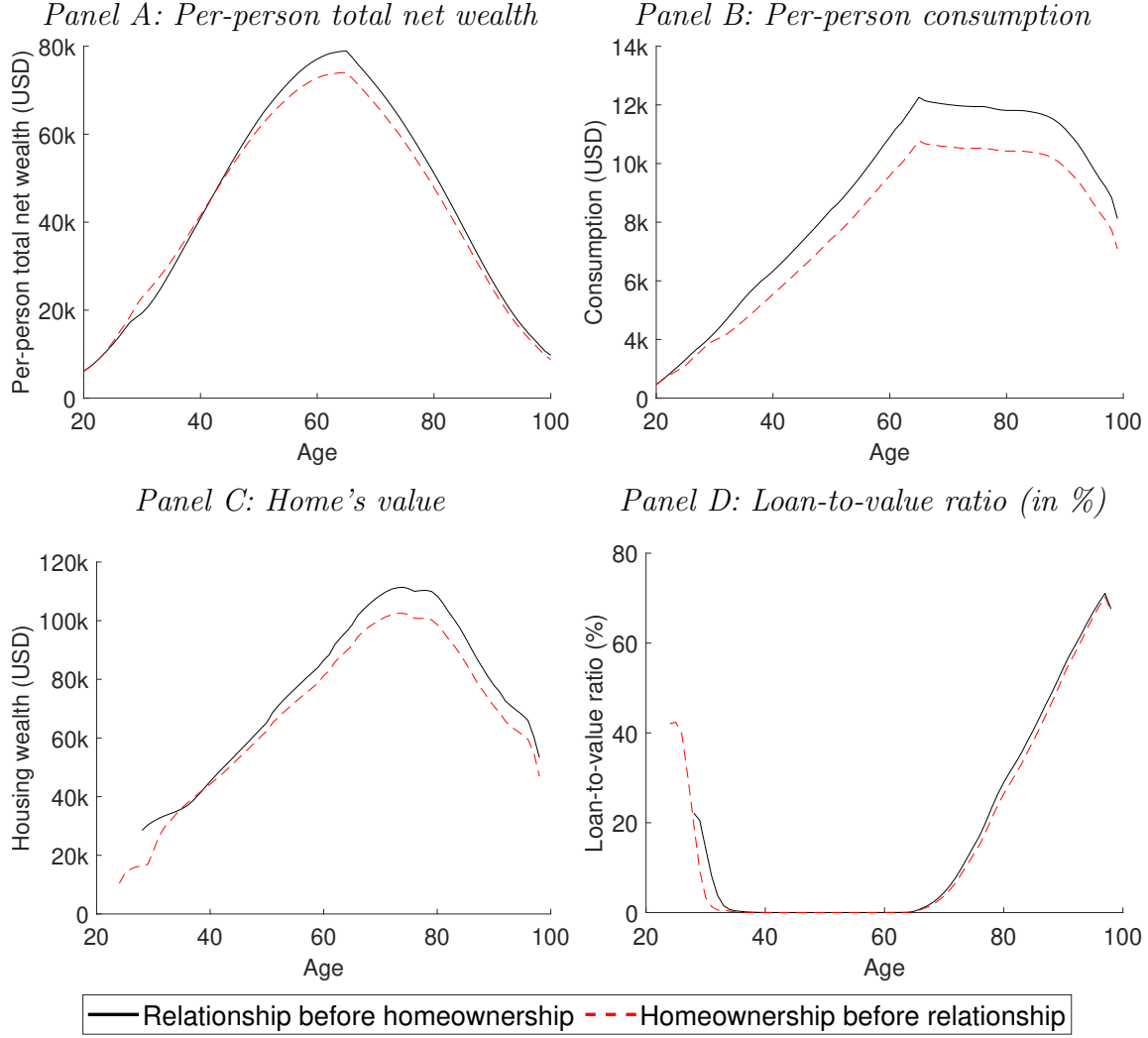
This table summarizes the results for the regression outlined in equation (15). $\mathcal{R}_{25}^S$, $\mathcal{R}_{25}^H$, and $\mathcal{R}_{25}^L$ denote the results for the cumulative stock, housing, and labor market returns accumulated until age 25, respectively. As data, we use the 100,000 paths of life cycle decisions obtained when running simulations on the optimal policy functions that are the solution to the optimization problem outlined in section 3. For ease of interpretation, coefficients on continuous variables have been standardized and should be interpreted as the effect of a one-standard-deviation increase in the respective variable. Standard errors are given in parentheses and ***, **, and * denote significance at the 1%, 5%, and 10% respectively.

resources with a partner. We also find that one-standard-deviation higher returns on the labor market (i.e., a higher increase in income until the age of 25) increase the likelihood of entering a relationship first by 7.84%. Thus, this effect is weaker than the effect of stock returns. According to our model design, individuals with higher incomes also tend to find partners with higher incomes; thus, if the income is higher, it is more desirable to look for a partner early on. A second reason is that individuals with high returns on their labor income are also likely to have high labor-to-wealth ratios, in particular when they are young. That implies that their labor income is high in comparison to their total savings, and if they continue working, they might also be able to save more for the downpayment, consequently helping them to avoid the interest rate margin on mortgage debt, without compromising on their consumption levels.

4.2 Life cycle outcomes

After having shown that the economic environment has a significant impact on the individuals' timing of housing and relationship entries, we now highlight the implications of the different timing decisions for consumption, savings, and housing decisions.

Figure 3: Life cycle profiles of consumption-savings decisions



This figure depicts the life cycle profiles of individuals' consumption-savings decisions. Panel A depicts the evolution of per-person total wealth in USD, i.e., $0.5 \times$ total wealth if the individual is in a relationship and Panel B the per-person consumption level in USD, i.e., $0.74 \times$ total consumption as outlined in section 3.2 if the individual is in a relationship. Panel C depicts the evolution of the value of the homes individuals live in in USD, conditional on them being homeowners, and Panel D the loan-to-value ratios in percent, again conditional on individuals being homeowners. The black solid lines depict the results for individuals who enter the housing market as couples, and the red dashed lines for individuals who enter the housing market as singles. All results are averages of 100,000 simulated paths on the policy functions obtained when solving the model outlined in section 3. In Panels C and D, the results are only reported if at least 100 observations are available, i.e., when at least 100 individuals are homeowners to ensure numerical stability of our results.

Figure 3 shows the evolution of individuals' total wealth (Panel A), consumption (Panel B), home value (Panel C), and loan-to-value ratios (Panel D) over the life cycle. The black solid lines depict the results for individuals who wait for love and enter the housing market as a couple, and the red dashed lines for individuals who go solo and enter the housing market as singles. All results are averages of 100,000 simulated paths on the policy functions obtained when solving the model outlined in section 3.

In Panels A and B, we report per-person results, i.e., we report $0.5 \times$ total wealth and $0.74 \times$ total consumption as outlined in section 3.2 if the individual is in a relationship to avoid distortions in the presentation of our results. The results in Panels C and D are conditional on the individuals being homeowners and we only report the results when at least 100 individuals are homeowners to ensure numerical stability of our results.

A first observation is that even though both groups of individuals behave optimally, there are significant differences in their consumption-savings profiles over the life cycle and the individuals who wait for love, i.e., those who enter a relationship before homeownership, seem to be better off than those who go solo, i.e., those who enter the housing market before a relationship.

From Panels A and B, we see that individuals who enter the housing market as singles accumulate a lower level of per-person total wealth and additionally have lower per-person consumption levels. Panel C shows that individuals who buy a house on their own tend to buy less valuable homes than those who enter the housing market as a couple. This pattern reflects two key factors: (1) their limited total wealth, as they cannot benefit from pooled savings with a partner, and (2) a reduced need for space, given that they live alone. Once they enter a relationship, many of these individuals move to more valuable homes that better suit the needs of a couple. However, even after entering a relationship, they tend to live in less valuable homes than those who entered the housing market directly as a couple. Panel D illustrates that individuals who enter the housing market on their own take out substantially higher loan-to-value ratios when purchasing their first home. The average initial loan-to-value ratio for singles entering the housing market is 29.4%, whereas the one for couples is only 19.1%, i.e., individuals who enter the housing market as singles are hit significantly harder by the interest rate margin on mortgage debt.

4.3 Analysis of different life cycle outcomes

Figure 3 shows substantial differences in the life cycle profiles of those waiting for love and those going solo in the housing market. Thus, a natural next question to ask is what potentially explains these differences.

Therefore, we run another regression, this time with the aim of explaining wealth at retirement age, and include interaction terms between relationship status and capital market returns. More specifically, we run the following regression:

$$\begin{aligned} \text{Wealth}_i^{65} = & \alpha + \beta_1 \text{Rel_First}_i + \beta_2 \mathcal{R}_{65,i}^S + \beta_3 \mathcal{R}_{65,i}^H + \beta_4 \mathcal{R}_{65,i}^L + \\ & \beta_5 \text{Rel_First}_i \times \mathcal{R}_{65,i}^S + \beta_6 \text{Rel_First}_i \times \mathcal{R}_{65,i}^H + \beta_7 \text{Rel_First}_i \times \mathcal{R}_{65,i}^L + \varepsilon_i, \end{aligned} \quad (16)$$

where Wealth_i^{65} denotes individual i 's total wealth in USD at age 65 (i.e., at retirement age) and, as in equation (15), Rel_First_i is a dummy taking the value one if the individuals enters a relationship first and the value zero if it enters the housing market first. $\mathcal{R}_{65,i}^S$, $\mathcal{R}_{65,i}^H$, and $\mathcal{R}_{65,i}^L$ denote the cumulative returns on stock, housing, and labor income that individual i accumulated up to age 65, respectively. α is an intercept, β_j , $j \in [1, 7]$ are the regression coefficients, and ε_i an error term. Table 3 shows the results of this regression. For ease of interpretation, coefficients on continuous variables have been standardized and should be interpreted as the effect of a one-standard-deviation increase in the respective variable.

The first insight from Table 3 is that better capital market outcomes in the sense of higher cumulative stock market, housing market, and labor market returns lead to higher financial wealth at retirement age. This result makes intuitive sense and supports the validity of our model's predictions. From the coefficient estimates for $\mathcal{R}_{65}^S$, $\mathcal{R}_{65}^H$, $\mathcal{R}_{65}^L$, we see that labor market returns have the biggest impact, i.e., for a one-standard-deviation increase in cumulative returns on labor income, wealth at retirement age increases by USD 54,064.34.

Moreover, our results show that the coefficient on entering the relationship before homeownership, Rel_First , is insignificant. Thus, the fact that an individual enters a relationship before homeownership does not, by itself, drive the different wealth levels of the two groups (individuals who enter the housing market as singles and those who enter it as couples) at the beginning of retirement.

From the coefficient estimates for the interacted terms in Table 3, we see that the main factor that drives the difference in wealth is that capital market outcomes affect the two groups

Table 3: Regression results: Analysis of different life cycle outcomes

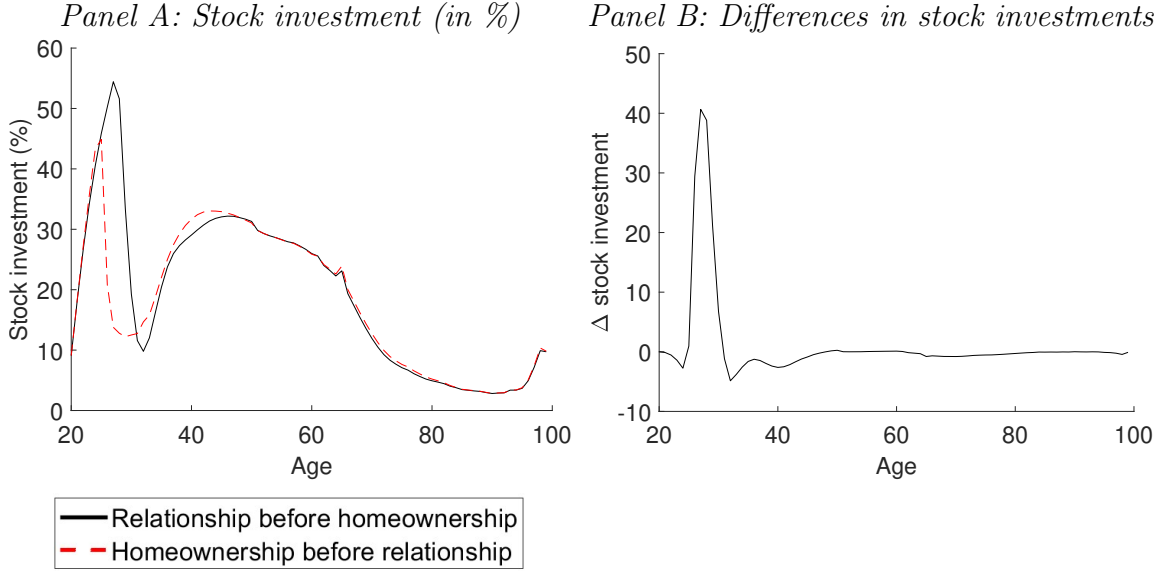
Coefficient	Estimate
α	15,826.00*** (477.95)
Rel_First	-202.81 (553.63)
$\mathcal{R}_{65}^S$	12,489.01*** (154.63)
$\mathcal{R}_{65}^H$	26,641.19*** (268.99)
$\mathcal{R}_{65}^L$	54,064.34*** (279.27)
Rel_First $\times \mathcal{R}_{65}^S$	11,858.59*** (224.56)
Rel_First $\times \mathcal{R}_{65}^H$	-1,268.50*** (306.38)
Rel_First $\times \mathcal{R}_{65}^L$	-1,952.43*** (312.90)
N	100,000
R^2	0.815

This table summarizes the results for the regression outlined in equation (16). $\mathcal{R}_{65}^S$, $\mathcal{R}_{65}^H$, and $\mathcal{R}_{65}^L$ denote the results for the cumulative stock, housing, and labor market returns accumulated until age 65, respectively. Rel_First is a dummy taking value one if a relationship precedes entering the housing market and zero otherwise. As data, we use the 100,000 paths of life cycle decisions obtained when running simulations on the optimal policy functions that are the solution to the optimization problem outlined in section 3. For ease of interpretation, coefficients on continuous variables have been standardized and should be interpreted as the effect of a one-standard-deviation increase in the respective variable. Standard errors are given in parentheses and ***, **, and * denote significance at the 1%, 5%, and 10% respectively.

differently. Individuals entering the housing market only as a couple are less affected by the cumulative returns of the housing and labor market. When they buy a house as a couple, they tend to enter the housing market later in life, thus exposing themselves to housing returns for a shorter period and being less affected by them. Moreover, they tend to start earning joint labor income earlier, as they often enter into relationships at a younger age. The main difference between those who enter a relationship before buying a house and those who buy a house before entering a relationship is how stock market returns affect them. Individuals who enter a relationship before purchasing a home are nearly twice as sensitive to stock market returns as those who buy a house while single.

Figure 4 illustrates why higher cumulative stock market returns have a significantly stronger

Figure 4: (Differences in) stock investments over the life cycle



Panel A depicts the stock investments (in %) of individuals over the life cycle. The black solid line depicts the results for individuals who enter a relationship before they enter the housing market and the red dashed lines the results for individuals who enter the housing market before they enter a relationship. All results are averages of 100,000 simulated paths on the policy functions obtained when solving the model outlined in section 3. Panel B depicts the differences between the stock investments of the two different groups (the group that enters the housing market as couples and the one that enters the housing market as singles), i.e., the difference between the black and the red line.

impact on individuals who enter the housing market as a couple. Panel A of Figure 4 shows the equity exposure over the life cycle for individuals who enter the housing market as couples (black solid line) and those who enter the housing market as singles (red dashed line). All results are averages of 100,000 simulated paths on the policy functions obtained when solving the model outlined in section 3.

Panel B of Figure 4 plots the differences in the life cycle equity exposures, i.e., it plots the difference between the black solid and the red dashed line in Panel A. From this line, we see that individuals who enter the housing market as couples have up to 40 percentage points higher equity exposures than their counterparts who enter the housing market as singles. This is driven by the fact that individuals who enter the housing market as singles also tend to enter the housing market earlier and, in order to afford the downpayment for the home, drop out of the stock market.

The higher equity exposure of individuals who buy a house while in a relationship explains

their heightened sensitivity to cumulative stock market returns, as reported in Table 3. Moreover, the higher equity exposure enables them to benefit from the higher expected return on stocks, subsequently allowing for higher total wealth and lifetime consumption opportunities as outlined in Figure 3.

5 Conclusion

In this paper, we study the interplay of relationships and housing market choices. Using a quantitative life cycle model of optimal consumption, savings, housing, and relationship decisions, we investigate how capital, labor, and housing market conditions impact optimal decision-making over the life cycle.

We find that stock and labor market returns significantly influence whether individuals should go solo in the housing market or enter the housing market only after having entered a relationship. Higher stock market returns make entering the housing market as a single more attractive, whereas higher labor income returns increase the likelihood of entering the housing market as a couple.

Moreover, we show that these timing decisions lead to substantial differences in the life cycle profiles of wealth, consumption, home values, loan-to-value ratios, and equity exposures. Individuals who enter the housing market when they are already in a relationship accumulate a higher level of total wealth, have better consumption opportunities, and live in more valuable housing without having significantly higher borrowing levels.

These wealth differences stem primarily from how capital market returns affect the two groups. In particular, cumulative stock returns up to retirement impact individuals who buy a home after forming a relationship nearly twice as much as those who purchase a home as singles.

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Appendix A Solution of the optimization problem

To simplify the optimization problem, we normalize it with total wealth at time t , W_t . Thus, the new decision variables are $c_t = \frac{C_t}{W_t}$, $b_t = \frac{B_t}{W_t}$, $s_t = \frac{S_t}{W_t}$ and $q_t = \frac{Q_t H_t}{W_t}$. We define them analogously with superscript P for couples. Defining $V_t(\mathcal{X}_t) = v_t(\mathbf{x}_t) \frac{W_t}{H_t^{\bar{\theta}}}$ leads to the following normalized optimization problems for singles and heads of couples, respectively.

Single

The optimization problem for a single after normalizing with total wealth W_t is

$$v_t(\mathbf{x}_t) = \max_{d_t} \left\{ (1 - \beta) u(c_t, q_t, h_t)^{1 - \frac{1}{\psi}} + \beta \left(f(t) \mathbb{E}_t \left[(1 - p^P) \left(v_{t+1}(\mathbf{x}_{t+1}) \frac{W_{t+1}}{W_t} \left(\frac{H_t}{H_{t+1}} \right)^\theta \right)^{1-\gamma} \right. \right. \right. \\ \left. \left. \left. + p^P \left(\left(\mathbb{1}_{\{R_t=1\}} v_{t+1}^P(\mathbf{x}_{t+1}^P) \frac{W_{t+1}^P}{W_t} + \mathbb{1}_{\{R_t=0\}} v_{t+1}(\mathbf{x}_{t+1}) \frac{W_{t+1}}{W_t} \right) \left(\frac{H_t}{H_{t+1}} \right)^\theta \right)^{1-\gamma} \right] \right)^{\frac{1 - \frac{1}{\psi}}{1-\gamma}} \right\}^{\frac{1}{1 - \frac{1}{\psi}}},$$

subject to

(A.1)

$$\begin{aligned} 1 &= b_{t-1} (\mathbb{1}_{\{b_{t-1} \geq 0\}} R_B + \mathbb{1}_{\{b_{t-1} < 0\}} R_D) + s_{t-1} R_{t-1}^S + h_{t-1} \frac{Q_{t-1} H_t}{W_t} + \frac{L_t}{W_t} \\ &= c_t + h_t q_t + m(\cdot) + n(\cdot) + b_t + s_t, \\ &- b_t \leq \delta q_t, \\ &c_t, q_t > 0, \quad s_t \geq 0. \end{aligned}$$

The new vector of state variables is then given by $\mathbf{x}_t = [t, \frac{Q_{t-1} H_t}{W_t}, h_{t-1}, \frac{L_t}{W_t}, P_t]$ and the individual's wealth when staying single evolves as follows:

$$\frac{W_{t+1}}{W_t} = b_t (\mathbb{1}_{\{b_t \geq 0\}} R_B + \mathbb{1}_{\{b_t < 0\}} R_D) + s_t R_t^S + h_t q_t R^H + \frac{L_t}{W_t} R^L \quad (\text{A.2})$$

The budget dynamics when entering a relationship with partner $\mathcal{P}$ become

$$\frac{W_{t+1}^P}{W_t} = \left(b_t (\mathbb{1}_{\{b_t \geq 0\}} R_B + \mathbb{1}_{\{b_t < 0\}} R_D) + s_t R_t^S + h_t q_t R^H + \frac{L_t}{W_t} R^L \right) (1 + W_P \mathbb{1}_{\{P_{t+1}=1\}}). \quad (\text{A.3})$$

Couples

The normalized optimization problem for the head of a couple is

$$V_t^P(\mathcal{X}_t^P) = \max_{d_t^P} \left((1 - \beta) u^P(\phi c_t^P, \xi q_t^P, h_t^P)^{1 - \frac{1}{\psi}} + \beta \left(f(t) \mathbb{E}_t \left[\left(v_{t+1}^P(\mathbf{x}_{t+1}^P) \frac{W_{t+1}^P}{W_t^P} \left(\frac{H_t}{H_{t+1}} \right)^\theta \right)^{1-\gamma} \right] \right)^{\frac{1 - \frac{1}{\psi}}{1 - \gamma}} \right)^{\frac{1}{1 - \frac{1}{\psi}}}$$

subject to

$$(A.4)$$

$$1 = b_{t-1}^P \left(\mathbb{1}_{\{b_{t-1}^P \geq 0\}} R_B + \mathbb{1}_{\{b_{t-1}^P < 0\}} R_D \right) + s_{t-1}^P R_{t-1}^S + h_{t-1}^P \frac{Q_{t-1}^P H_t}{W_t^P} + \frac{L_t^P}{W_t^P} \quad (A.5)$$

$$= c_t^P + h_t^P q_t^P + m(\cdot) + n(\cdot) + b_t^P + s_t^P, \quad (A.6)$$

$$- b_t^P \leq \delta q_t^P, \quad (A.7)$$

The new vector of state variables is then given by $\mathbf{x}_t^P = [t, \frac{Q_{t-1}^P H_t}{W_t^P}, h_{t-1}^P, \frac{L_t^P}{W_t^P}, P_t]$ and the total wealth dynamics follow the dynamics given below:

$$\frac{W_{t+1}^P}{W_t^P} = b_t^P \left(\mathbb{1}_{\{b_t^P \geq 0\}} R_B + \mathbb{1}_{\{b_t^P < 0\}} R_D \right) + s_t^P R_t^S + h_t^P q_t^P R^H + \frac{L_t^P}{W_t^P} R^L \quad (A.8)$$

A.1 Alternative state variables

The original state variables, as given in the section above, cannot simultaneously attain their maximum/minimum values which might cause numerical problems. To avoid this problem, we use alternative state variables that can be transformed back into the original state variables easily. The alternative vector of state variables is given by

$$\mathbf{x}_t^{alt} = \left[t, \frac{Q_{t-1} H_t (1 - \delta)}{W_t - L_t}, h_{t-1}, \frac{L_t}{W_t}, P_t \right]. \quad (A.9)$$

The original state variable $\frac{Q_{t-1} H_t}{W_t}$ can be calculated by

$$\frac{Q_{t-1} H_t}{W_t} = \frac{1}{1 - \delta} \frac{Q_{t-1} H_t (1 - \delta)}{W_t - L_t} \left(1 - \frac{L_t}{W_t} \right). \quad (A.10)$$