Housing and Tax-deferred Retirement Accounts*

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Abstract

Assets in tax-deferred retirement accounts (TDA) and housing are two major components of household portfolios. These assets share similarities in terms of favorable tax treatments and liquidity constraints. In this paper, we develop a life-cycle model to examine the interaction between households' use of TDA and their housing decisions. The model is quantitatively consistent with life-cycle patterns of home ownership and households' net worth composition. We find that TDA promotes home ownership as households take advantage of tax benefits for both TDA and home ownership by accumulating wealth in TDA, paying lower down payments and becoming homeowners earlier in their lives. We also find that housing-related policies, such as a minimum down payment requirement and mortgage interest deductibility, affect households' housing decisions and savings in regular taxable accounts more than their use of TDA.

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1 Introduction

Assets in tax-deferred retirement accounts (hereafter TDA) and housing are two major components of household portfolios.[1] In the U.S., these two assets share similarities in terms of favorable tax treatments and liquidity constraints. TDA provides tax benefits through untaxed investment returns and income tax deferral.[2] However, early withdrawals of TDA assets before retirement age are typically subject to a 10% penalty in addition to the income taxes incurred from asset withdrawals. For housing, mortgage interest is income tax deductible and the service flow from owner-occupied housing is untaxed, but buying and selling a house involves high transaction costs and there are down payment constraints in the mortgage market.

For households with employer-sponsored defined contribution (DC) plans, several salient life-cycle patterns of household portfolio can be observed in the Survey of Consumer Finances (SCF). First, the vast majority of these households are homeowners and home ownership increases with age. Second, for homeowners, the home equity share of net worth decreases with age while the TDA share of net worth increases with age. Third, the share of net worth in taxable accounts (hereafter TA) is relatively small throughout the life-cycle. These patterns suggest that households are making joint decisions on housing and retirement savings in TDA. Does households' use of TDA affect their housing decisions, or vice versa? How do TDA policies and housing-related factors, such as a minimum down payment requirement and mortgage interest deductibility, affect the life-cycle patterns of net worth composition?

To answer these questions, we develop a life-cycle model in which households make endogenous decisions on housing and their use of TDA under uninsurable earnings and housing price risks. Households have access to TDA with policies similar to the U.S. 401(k) plans, and they can also save in their TA. Housing decisions entail choices on tenure (renting or owning) and house size. Buying a house requires a long-term fixed-rate mortgage with committed mortgage payments and households can choose their preferred down payments above a minimum required ratio. The model also features a progressive income tax system that mimics the U.S. tax codes with favorable tax treatments on TDA and home ownership. A public pension system (Social Security) is also included in the model to capture households'

[1] Common types of TDA in the United States include Individual Retirement Accounts (IRA) and employer-sponsored defined contribution pension plans such as 401(k) plans.

[2] Contributions to TDA (up to a limit) are income tax deductible and investment income earned in TDA is tax exempt. Subsequent asset withdrawals from TDA upon retirement are taxed as ordinary income. Since marginal tax rates are normally lower in retirement when households withdraw funds from TDA than in working periods, the tax-deferred feature of TDA is beneficial for most households.

retirement income. Our benchmark model generates simulation results that are broadly consistent with data from the SCF, in terms of life-cycle patterns of home ownership and homeowners' net worth composition.[3]

We conduct a series of counterfactual experiments on TDA policies and housing-related factors to evaluate their impacts on households' net worth composition and housing decisions. We find that TDA policies not only affect retirement savings but also promote home ownership. In the presence of TDA, households are attracted to save in TDA *and* take out bigger mortgage loans to buy houses. In doing so, they can enjoy tax benefits for both TDA (untaxed investment returns and income tax deferral through TDA contributions) and home ownership (mortgage interest deductibility). As a result, they reduce their mortgage down payments and become homeowners earlier, leading to a substantial increase in home ownership compared to the case when there is no TDA. We also find that further raising TDA contribution limit slightly increases the TDA share of household net worth, but it has little impacts on home ownership and overall wealth accumulation.

Experiments on housing-related factors show that they only have moderate effects on households' use of TDA. An increase in the minimum down payment requirement delays home ownership as young households become more mortgage credit constrained. They need to accumulate more wealth in TA for a future down payment and consequently their TA share of net worth goes up significantly. When mortgage interest payments and property taxes are not income tax deductible, home ownership declines sharply. Households do not increase their use of TDA. Instead, they accumulate more wealth in TA for bigger down payments, as evidenced by the higher home equity to home value ratio. Overall, housing-related factors affect households' housing decisions and savings in TA more than their use of TDA.

This paper is related to two separate strands of the literature on TDA and housing, and each contains many studies about the impacts of one of these two assets on household decisions. The TDA literature explores the influence of TDA on households' savings decisions and the amount of new savings created (Engen, Gale, and Scholz, 1996; Poterba, Venti, and Wise, 1996; Benjamin, 2003; Engelhardt and Kumar, 2007, among others). Studies on TDA also investigate the macroeconomic impacts of TDA (Imrohoroglu, Imrohoroglu, and Joines, 1998; Kitao, 2010; Nishiyama, 2011) and the implications of TDA for wealth distribution (Chernozhukov and Hansen, 2004). Amromin and Smith (2003) look at the liquidity risk associated with TDA and conclude that a large portion of early withdrawals comes from

[3]The model is also consistent with the data that renters' income is much lower than that of homeowners.

liquidity-constrained households.

In the housing literature, numerous studies have focused on the preferential tax treatment of housing, home ownership over the life-cycle, and the interaction between housing and non-housing consumption. For example, Gervais (2002), Díaz and Luengo-Prado (2008), and Chambers, Garriga, and Schlagenhauf (2009b) study the preferential tax treatment of housing. Chambers, Garriga, and Schlagenhauf (2009a), Chen (2010), Bajari, Chan, Krueger, and Miller (2013), Sommer, Sullivan, and Verbrugge (2013), and Halket and Vasudev (2014) focus on home ownership over the life-cycle and over time. For the interaction between housing and non-housing consumption, see Campbell and Cocco (2007), Li and Yao (2007), and Yang (2009).[4]

Although TDA and home ownership both provide households with favorable income tax treatment and are illiquid in nature, little attention has been paid to the interaction between households' use of TDA and their housing decisions. To our best effort, we can only identify two papers that study household decisions in the presence of both TDA and housing, but they have a different research focus. Amromin, Huang, and Sialm (2007) show that empirically at least 38% of households who prepay their mortgages could be better off by contributing their prepayments to a TDA. This is because households earn pre-tax returns in TDA, which could be higher than after-tax mortgage rates they pay for mortgages. Marekwica, Schaefer, and Sebastian (2013) study households' asset allocation between stocks and bonds in the presence of TDA and housing.[5] They assume a fixed TDA contribution rate and that home owners always choose the maximum possible mortgage over the life cycle.

By endogenizing households' use of TDA and their housing decisions, this paper offers additional insights on households' joint decisions of retirement savings and housing over the life-cycle. We show that a TDA is not only a retirement savings vehicle but also has a significant impact on households' housing decisions. In particular, the existence of TDA increases home ownership as TDA induces households to make lower down payments and become homeowners earlier. Our results also have important implications for retirement preparedness and suggest an explanation to findings in recent studies that holdings in 401(k) plans for a substantial share of U.S. households remained low (Munnell, Golub-Sass, and Muldoon,

[4] Other studies examine housing and macroeconomy and housing investment over the business cycle. See Davis and Heathcote (2005), Silos (2007), and Iacoviello and Pavan (2013).

[5] There are other studies examining households' portfolio choices between stocks and bonds under the influence of housing (Cocco, 2005; Yao and Zhang, 2005; Becker and Shabani, 2010) or TDA (Amromin, 2003; Dammon, Spatt, and Zhang, 2004; Huang, 2008; Gomes, Michaelides, and Polkovnichenko, 2009; Zhou, 2009).

2009; Munnell, 2012; Poterba, 2014). The TDA share of net worth is small over most of a household's life-cycle because housing investment is also an attractive savings vehicle with consumption value. This finding complements Scholz, Seshadri, and Khitatrakun (2006) in understanding households' savings for retirement and sheds light on households' life-cycle portfolios in wealth accumulation.

The rest of the paper is organized as follows. Section 2 presents some stylized facts on households' use of TDA and housing decisions. Section 3 describes the model in detail. Section 4 outlines the parametrization of the model. Section 5 reports the results of our benchmark model. Section 6 evaluates the effects of changes in TDA-related policies and housing-related factors. Section 7 concludes.

2 Stylized Facts

In this section, we provide some stylized facts about households' use of TDA and their housing decisions from the Survey of Consumer Finances (SCF). The SCF is a triennial cross-sectional survey conducted by the Board of Governors of the Federal Reserve System. It provides the most complete data on household balance sheets in the United States and it also contains data on earnings and other demographic information.

We use data from the 2001, 2004 and 2007 SCFs as they span over many years and the average values from these 3 waves minimize the influence of business cycles. Since we focus on households' joint decisions of TDA and housing, only households with heads between ages 25–64 having employer-sponsored DC plans are included.[6]

Empirically, we define TDA as retirement accounts whose owners make pre-tax contributions and their own investment decisions. These accounts include IRAs and most of the employer-sponsored DC pension plans (such as 401K/403B/457/SRA and Thrift Savings plans). For home ownership, we exclude households with a principle residence being a mobile home or on a farm/ranch, because the sample size is very small and these households are unlikely to be covered by employer-sponsored DC pension plans.

2.1 Home Ownership and Life-cycle Net Worth Composition

We first document the home ownership rate of households with an employer-sponsored DC plan. Home ownership can be viewed as the extensive margin of savings through home

[6] Data for households with heads aged 65 and above having DC plans are not reported because the sample size for these older households is very small.

equity. Figure 1 plots the life-cycle profile of home ownership from the 3 waves of SCFs. The overall home ownership rate is 78%.[7] The ownership rate increases with age, rising from 62% at age group 25–34 to 89% at age group 55–64. Comparing homeowners and renters, we find that income of renters is much lower than that of homeowners.[8]

For DC plan participants who are also homeowners, housing and assets in TDAs are two most important components of their wealth.[9] Figure 2 reports the net worth composition regarding home equity, TDA wealth, and TA wealth for these households over the life cycle. Home equity is the difference between the value of principal residence and mortgage on principal residence. TDA wealth is the balance in TDA, net of loans against main job pensions. TA wealth is defined as financial assets in TA, net of debts associated with TA. More details on the data are provided in Appendix A. Given the skewness of the wealth distribution in the data, we therefore choose to report the median values.[10]

Home equity dominates households' net worth for young homeowners (a median ratio of 61% at age group 25–34). As households move to later stages of their life-cycle, the median home equity to net worth ratio drops to about 43% at age group 55–64. On the other hand, the TDA wealth to net worth ratio increases with age. The median ratio is about 23% at age group 25–34, and it increases to 34% at age group 55–64. The median TA wealth to net worth ratio remains low throughout households' life-cycle, implying that households primarily hold their financial wealth in TDA to take advantage of its preferential tax treatment. In terms of dollar value, total net worth increases with age as households build up their assets in all TA, TDA, and home equity. The TDA wealth to net worth ratio increases (and the home equity to net worth ratio decreases) because households accumulate assets in TDA at a faster rate. These ratios suggest that TDA assets become a more important component of net worth as households age.

To summarize, the SCF data suggests that the majority of DC plan participating households are also homeowners. It provides evidence that households are using these two savings vehicles jointly. Furthermore, our stylized facts suggest that the composition of net worth

[7] The home ownership rate for DC participants is higher than the overall ownership rate for all households aged 25–64 (65%).

[8] For the age group 25–64 in the 2007 SCF, the median non-financial income of homeowners was 1.8 times of that of renters.

[9] This is also true for all DC plan participating households with heads aged 25–64. For these household, the median home equity to net worth ratio is about 43% and the median TDA wealth to net worth ratio is 32%, while the median TA wealth to net worth ratio is 9%.

[10] We obtain similar patterns regarding the composition of net worth if we compute the average of the middle 10% households by net worth.

regarding home equity, TDA wealth and TA wealth has clear life-cycle patterns. In the next section, we develop a model to understand how housing decisions may interact with households' use of TDA.

3 Model

The life-cycle model used for our analysis is described in this section. In summary, households have access to both TDA and TA. Their income is subject to aggregate and idiosyncratic income shocks. Every period households make housing decisions and savings decisions in TDA and TA. Housing can be acquired through either renting or owning. Buying a home requires a traditional long-term fixed rate mortgage with a down payment requirement and committed future mortgage payments. The model economy also features a progressive income tax system that mimics the U.S. tax codes with favorable tax treatments on TDA contributions and owner-occupied housing.

3.1 Demographics and Preferences

Households enter the model at age 25, work until age 64, and live at most up to age 95. In modeling terms, they work the first $R = 40$ periods and at most live for $J = 71$ periods. They have stochastic lifetime and s_j denotes the survival probability in period j conditional on being alive in period $j-1$. In any period j, households derive utility from consumption of non-durable goods, c_j, and housing service, h_j. Housing service should be interpreted broadly as reflecting both the physical size of a house and its quality. The utility function is time-separable with discount factor β. The instantaneous utility function is

$$u(c_j, h_j) = \frac{\left(c_j^{1-\omega} h_j^{\omega}\right)^{1-\gamma}}{1-\gamma} \tag{1}$$

where γ is the coefficient of relative risk aversion and ω measures the preference for housing relative to consumption of non-durable goods.

Let W_j be the estate left behind when a household dies in period j. The household gains utility from leaving the estate. For simplicity, we assume that the utility function applied to the estate is the same as the utility function applied to housing service and consumption when alive:

$$u(W_j) = \frac{(W_j)^{1-\gamma}}{1-\gamma} \tag{2}$$

3.2 Income Process

Households supply labor inelastically to work in the first R periods of life. Specifically, household i of age j receives stochastic labor income Y_{ij}, against which the household cannot borrow. Let $y_{ij} = \ln(Y_{ij})$ denote the log of income, which is defined as

$$y_{ij} = f_{ij} + \eta_j + \varepsilon_{ij} \tag{3}$$

where f_{ij} is a deterministic age-earnings profile, η_j is an aggregate income shock, and ε_{ij} is an idiosyncratic persistent shock. Deterministic age-earnings profile f_{ij} is a function of household age and other characteristics (e.g. education level), and it is estimated to capture the hump-shape life-cycle earnings pattern. The aggregate income shock, η_j, is common among all households and follows an AR(1) process

$$\eta_{j+1} = \rho_\eta \eta_j + \xi^\eta_{j+1} \tag{4}$$

Similarly, the idiosyncratic persistent shock, ε_{ij}, also follows an AR(1) process

$$\varepsilon_{ij+1} = \rho_\varepsilon \varepsilon_{ij} + \xi^\varepsilon_{j+1} \tag{5}$$

We assume aggregate shocks and idiosyncratic shocks are uncorrelated, where ξ^η_j and ξ^ε_j are i.i.d. random variables normally distributed with mean zero and variance ${\sigma_\eta}^2$ and ${\sigma_\varepsilon}^2$, respectively.

Households retire after R periods and receive social security benefits, determined as a constant fraction, λ, of last working period's deterministic earnings and idiosyncratic shock.[11] That is,

$$y_{ij} = \ln(\lambda) + f_{iR} + \varepsilon_{iR} \tag{6}$$

This specification simplifies the solution for the model, as it retains heterogeneity in retirement income without keeping track of households' entire income histories. To simplify our notations, subscript i expressing household-specific variables is dropped in the rest of the paper.

3.3 Housing

The size of housing services available (H) in the model is discretized into 5 levels with $H = \{H_1, H_2, H_3, H_4, H_5\}$, where H_1 and H_5 correspond to the minimum and maximum house sizes, respectively. Housing prices follow the process in Cocco (2005). Let P_j be the

[11] We allow λ to differ by education group.

price per unit of housing in period j, measured in terms of non-durable consumption goods (the numeraire). Hence, a house of size $h \in H$ is valued at $P_j h$. Let $p_j = \log(P_j)$ be the period j log price of one unit of housing and $\tilde{p}_j = p_j - g(j-1)$ be the detrended log price of housing, where g is a constant growth rate of house price over time. As in Cocco (2005), we assume that fluctuations in house prices are perfectly positively correlated with aggregate labor income shocks, and uncorrelated with households' idiosyncratic income shocks.[12]

Housing services can be obtained either by renting or owning. Let $DR_j \in \{0, 1\}$ denote a household's housing tenure choice in period j, with $DR_j = 1$ indicates renting a house and $DR_j = 0$ indicates owning a house. During their working lives ($j \leq R$), households can choose to be a renter or an owner. They also make decisions on house size. We assume that rental housing is generally in smaller units than owner-occupied housing, similar to the setup in Gervais (2002). Let h_j denote the house size choice in period j, such that

$$h_j = \begin{cases} \in \{H_1, H_2, H_3\} & \text{if } DR = 1 \text{ (renter)} \\ \in \{H_2, H_3, H_4, H_5\} & \text{if } DR = 0 \text{ (owner)} \end{cases} \tag{7}$$

After retirement ($j > R$), we assume that renters are not allowed to purchase houses and they only make decisions on the rental house size.[13] Retired homeowners can choose to be owners or become renters. If they continue to be owners, they can choose to stay in their own houses or downsize to a smaller unit.

Renters pay a fraction ϕ of the house value as the periodic rental cost. Households can choose to purchase a house through a traditional N-period mortgage with a fixed mortgage interest rate at r_m.[14] Let n denote the period in which the current house is purchased. Households pay a fraction θ_n^D of the house value as down payment at period n. Working-age households can choose their down payment ratio from 5 choices ranged from 10% to 100%. Hence, there is a minimum down payment requirement. Retired homeowners who choose to downsize are required to pay their new homes in full. Down payment decision for home

[12] The assumption of correlation equal to 1 greatly simplifies the solution of the problem. Using PSID data, Cocco (2005) estimates the correlation to be 0.553 and significant at the 2% level.

[13] As suggested in Nakajima and Telyukova (2012), only a very small proportion of renters buy houses late in life.

[14] A 30-year fixed rate mortgage is common in the United States. For more complicate mortgage choice problem, see Chambers, Garriga, and Schlagenhauf (2009c). To make the model tractable, we do not allow mortgage default and refinancing, which is the focus in Agarwal, Driscoll, and Laibson (2013), Chen, Michaux, and Roussanov (2013), Khandani, Lo, and Merton (2013) and Campbell and Cocco (2015).

buyers is formulated as

$$\theta_n^D = \begin{cases} \in \{0.1, 0.2, 0.5, 0.75, 1\} & \text{if } \ n \leq R \\ 1 & \text{if } \ n > R \end{cases} . \tag{8}$$

The initial housing value is captured by three parameters: the house size (h), the period of house purchase (n), and the housing price shock in that period ($\tilde{p}_n$). The initial loan principle, denoted by L, for a house of size h before any mortgage payment is given by

$$L = \begin{cases} (1-\theta_n^D)e^{g(n-1)+\tilde{p}_n}h & \text{if } \ n \in [1, R] \\ 0 & \text{otherwise} \end{cases} \tag{9}$$

This mortgage contract is characterized by a constant mortgage payment over the length of the mortgage, which results in an increasing amortization schedule of the principal and a decreasing schedule for interest payments. Mortgage payment in period j is defined as

$$M_j = \begin{cases} \frac{r_m L(1+r_m)^N}{(1+r_m)^N - 1} & \text{if } \ n \in [1, R] \ \text{ and } n \leq j \leq (n+N-1) \\ 0 & \text{otherwise} \end{cases} \tag{10}$$

Mortgage payment M_j can further be decomposed into principal payment E_j and mortgage interest payment I_j, with $M_j = E_j + I_j$. The principle payment and interest payment in period j are given as

$$E_j = \begin{cases} \frac{r_m L(1+r_m)^{j-n}}{(1+r_m)^N - 1} & \text{if } \ n \in [1, R] \ \text{ and } n \leq j \leq (n+N-1) \\ 0 & \text{otherwise} \end{cases} \tag{11}$$

and

$$I_j = \begin{cases} \frac{r_m L\left[(1+r_m)^N - (1+r_m)^{j-n}\right]}{(1+r_m)^N - 1} & \text{if } \ n \in [1, R] \ \text{ and } n \leq j \leq (n+N-1) \\ 0 & \text{otherwise} \end{cases} \tag{12}$$

The remaining loan principle, LL_j after mortgage payment in period j is

$$LL_j = \begin{cases} \frac{L\left[(1+r_m)^N - (1+r_m)^{j-n+1}\right]}{(1+r_m)^N - 1} & \text{if } \ n \in [1, R] \ \text{ and } n \leq j \leq (n+N-1) \\ 0 & \text{otherwise} \end{cases} \tag{13}$$

Housing transaction is endogenous in the model. To capture realtor fees and other costs associated with housing transaction, selling and buying a house are associated with transaction costs that equal to θ^S and θ^B fraction of house value, respectively. If a homeowner desires to own a house of different size, her existing house must be sold and the full mortgage balance becomes due upon the sale of it.[15] Homeowners also pay δ proportion of house value as annual maintenance costs and property tax at rate τ.

[15] We assume there in no tax on housing capital gains.

Housing expenditure depends on a household's tenure choice. Let x_j denote a household's expenditure on housing in period j. There are five different situations regarding the household's housing tenure status: (1) a household is a renter in both last period and current period ($DR_{j-1} = DR_j = 1$); (2) a household was a homeowner in last period and becomes a renter in current period ($DR_{j-1} = 0, DR_j = 1$), (3) a household was a renter in last period and is an owner current period ($DR_{j-1} = 1, DR_j = 0$), (4) a household is owner in both periods and stays in the same house ($DR_{j-1} = DR_j = 0$ and $h_{j-1} = h_j$), and (5) a household is owner in both periods but changed house size in current period ($DR_{j-1} = DR_j = 0$ and $h_{j-1} \neq h_j$). Hence, the household expenditure on housing (net of equity on previously owned house when there is a house sale in current period) is given by

$$x_j = \begin{cases} \phi P_j h & \text{if } DR_{j-1} = DR_j = 1 \\ \phi P_j h_j + LL_{j-1} - (1-\theta^S) P_j h_{j-1} & \text{if } DR_{j-1} = 0 \text{ and } DR_j = 1 \\ M_j + \left(\theta^B + \theta_j^D + \tau + \delta\right) P_j h_j & \text{if } DR_{j-1} = 1 \text{ and } DR_j = 0 \\ M_j + (\tau + \delta) P_j h_j & \text{if } DR_{j-1} = DR_j = 0 \text{ and } h_j = h_{j-1} \\ M_j + \left(\theta^B + \theta_n^D + \tau + \delta\right) P_j h_j & \text{if } DR_{j-1} = DR_j = 0 \text{ and } h_j \neq h_{j-1} \\ +LL_{j-1} - (1-\theta^S) P_j h_{j-1} & \end{cases} \tag{14}$$

where M_j is the mortgage payment in period j as defined in equation (10), and LL_{j-1} is the remaining loan principle in period $j-1$ defined in equation (13).

3.4 Tax-deferred Account and Taxable Account

All households have access to two types of accounts: a tax-deferred account (TDA) and a taxable account (TA). Each period of their working lives, households can contribute their pre-tax labor income to TDA, up to $\bar{q}$ fraction of their current income. Assets withdrawn from TDA prior to age 60 ($j < R - 4$) is subject to early withdrawal penalty at rate $pen \in (0, 1)$, in addition to the ordinary income tax incurred. Households are not allowed to contribute to TDA after retirement, and they decide the amount of withdrawals from TDA and pay tax on the withdrawals at ordinary income tax rate.[16] There is a minimum required distribution after age 70 ($j > R + 6$).

The amount of assets in TDA at the beginning of period j is denoted by a_j^D. Let q_j denote

[16] We do not model penalty-free early withdrawal from TDA and household loans against their TDA assets, because the magnitude of these are very small in reality.

a household's contributions to TDA in period j, with $q_j < 0$ implies asset withdrawals. Thus,

$$q_j \in \begin{cases} \left[-a_j^D, \bar{q} * Y_j\right] & \text{if } j \leq R \\ \left[-a_j^D, 0\right] & \text{if } j \geq R+1 \text{ and } j \leq R+6 \\ \left[-a_j^D, -\frac{1}{J-j+1} a_j^D\right] & \text{if } j > R+6 \end{cases} \tag{15}$$

where $\frac{1}{J-j+1}$ is the minimum withdrawal rate after age 70.

Employers also match a fraction, $\tilde{q}$, of employee's contributions. However, employer matching only applies to employee's contribution up to 6% of the employee's labor income. Therefore, the employer's contributions (q_j^E) are

$$q_j^E = \begin{cases} \min(\tilde{q} * q_j, \tilde{q} * 0.06 * Y_j) & \text{if } j \in [1, R] \text{ and } q_j > 0 \\ 0 & \text{otherwise} \end{cases} \tag{16}$$

We do not consider the household's investment decision between stocks and bonds in either account and assume assets earn a constant rate of return, r, in both TDA and TA. The law of motion of assets in TDA is

$$a_{j+1}^D = \begin{cases} (1+r)(a_j^D + q_j + q_j^E) & \text{if } \; j \leq R \\ (1+r)(a_j^D + q_j) & \text{if } \; j > R \end{cases} \tag{17}$$

Let a_j^T be the financial wealth in the TA plus current labor income at the beginning of period j (before current TDA contributions/withdrawals, tax payments, and consumption). The law of motion of assets in the TA is

$$a_{j+1}^T = (1+r)\left[a_j^T - c_j - x_j - q_j - \Gamma_j\right] + Y_{j+1} \tag{18}$$

where x_j is a household's expenditure on housing defined in equation (14) and Γ_j is the total tax liabilities which will be discussed in section 3.5. Both TDA and TA are subject to zero borrowing constraint such that

$$a_j^T \geq Y_j \text{ and } a_j^D \geq 0 \text{ for all } j. \tag{19}$$

When households are born in the model, they are endowed with random idiosyncratic initial wealth a_0^T. When a household dies, it may leave estate. For simplicity, we abstract from the estate tax. The estate left by a household who dies at age j is

$$W_j = \begin{cases} a_j^T + a_j^D + (1-\theta^S) P_j h_{j-1} - LL_{j-1} & \text{if } DR_{j-1} = 0 \\ a_j^T + a_j^D & \text{if } DR_{j-1} = 1 \end{cases} \tag{20}$$

3.5 Taxes

A household's tax liability consists of three parts. First, household income is taxed through a piece-wise linear progressive income tax system, $T(\cdot)$. Total income is defined as the sum of interest income in TA, the household's labor income, and funds withdrawn from TDA. Income contributed to TDA is tax deductible. For homeowners, mortgage interest payments and property taxes are also deductible. Adjusted gross income, AGI, subject to income tax is defined as total income minus total amount of deductions, such that

$$AGI_j = \begin{cases} r\left(\frac{a_j^T - Y_j}{1+r}\right) + Y_j - q_j - I_j - \tau P_j h & \text{if } DR_j = 0 \\ r\left(\frac{a_j^T - Y_j}{1+r}\right) + Y_j - q_j & \text{if } DR_j = 1 \end{cases} \tag{21}$$

where q_j is the contributions to (withdrawals from) TDA, I_j is mortgage interest payments defined in equation (12), and $\tau P_j h$ is the property tax. The marginal income tax rates depend on the AGI. Let $IC = \{IC_1, IC_2, IC_3, IC_4, IC_5\}$ be the cutoff points of the tax brackets. Let $\tau_1, \tau_2, \tau_3, \tau_4$, and τ_5 denote corresponding marginal tax rates. Suppose $AGI_j \in (IC_3, IC_4]$. Then, income tax payment $T(AGI_j) = \tau_1 (IC_2 - IC_1) + \tau_2 (IC_3 - IC_2) + \tau_3 (AGI_j - IC_3)$.

Second, households also pay payroll taxes. Let τ_{ss} be the payroll tax rate and Y_{ss} be the maximum earnings that are subject to payroll tax. Third, the early withdrawal penalty for households who withdraw funds from TDA before age $R-4$ should also be included in the tax payments. Hence, the total tax liability of a household is defined as

$$\Gamma_j = \begin{cases} T(AGI_j) + \min(\tau_{ss} * Y_j, \tau_{ss} * Y_{ss}) - pen * q_j & \text{if } q_j < 0 \text{ and } j < R-4 \\ T(AGI_j) + \min(\tau_{ss} * Y_j, \tau_{ss} * Y_{ss}) & \text{otherwise} \end{cases}. \tag{22}$$

3.6 Household Problem

In each period j, households choose their consumption (c_j), contributions to TDA (q_j), housing tenure choice (DR_j), housing size (h_j), and down payment (θ_n^D). The decisions in period j are based on the following state variables: the aggregate income shock (η_j), the idiosyncratic income shock (ε_{ij}), the wealth levels in the TA (a_j^T) and TDA (a_j^D) at the beginning of the period, housing tenure choice last period (DR_{j-1}), housing size last period (h_{j-1}), the period in which the household buys the current house (n), the house price shock in the period when a household buys a house ($\tilde{p}_n$), and the down payment ratio at the time of purchase (θ^D). The household's decision problem in recursive form is written as

$$\begin{aligned} & V(j, \eta_j, \varepsilon_j, a_j^T, a_j^D, DR_{j-1}, h_{j-1}, n, \tilde{p}_n, \theta_n^D) \\ = & \max_{c_j, q_j, DR_j, h_j, \theta_n^D} \frac{\left(c_j^{1-\omega} h_j^{\omega}\right)^{1-\gamma}}{1-\gamma} \\ & + \beta s_{j+1} E_j \left[V(j+1, \eta_{j+1}, \varepsilon_{j+1}, a_{j+1}^T, a_{j+1}^D, DR_j, h_j, n, \tilde{p}_n, \theta_n^D) \right] \\ & + \beta(1 - s_{j+1}) \frac{(W_{j+1})^{1-\gamma}}{1-\gamma} \end{aligned} \tag{23}$$

subject to income processes (3) to (6) and constraints (7) to (22), in addition to the non-negativity constraint on consumption. A more detailed explanation about the decision problem conditional on a household's tenure choice is relegated to Appendix B.

4 Parametrization

In this section, we outline our choice of benchmark parameter values. All nominal values are adjusted to 2007 dollars by the Consumer Price Index. Table 1 summarizes our benchmark parameter values.

4.1 Demographics and Preferences

Households enter the model at age 25, work until age 64, begin to receive retirement benefits at age 65, and live at most up to age 95. A model period is set to one year, thus $J = 71$ and $R = 40$. We use year 2000 life table of the National Center for Health Statistics to parameterize the conditional survival probabilities.

The annual discount factor β is 0.96. The coefficient of relative risk aversion γ is 2, which falls in the range of 1–3 widely used in the macroeconomic literature. Households' preference for housing relative to non-durable consumption goods, ω, is set at 0.2, following Li and Yao (2007) and Yao and Zhang (2005).

4.2 Income Process

Households have different labor income profiles conditional on their education levels. For households with assets in TDA in the 2007 SCF, 64% of household heads have grades of 14 years or more, 30% have grades of 12–13 years, and 6% have grades of less than 12 years. As the proportion of households with less than high school education is small, we assume that households with college and high school education account for 64% and 36% of total households, respectively. The corresponding parameter values for the age-earnings profiles of these two groups are taken from Cocco, Gomes, and Maenhout (2005). The median income of period-1 households is set at $38,000 and normalized to 1 in our model.[17]

The remaining parameters of the labor income process in working periods are ρ_η, σ_η, ρ_ε, and σ_ε. For aggregate income shock, we set $\rho_\eta = 0.748$, and the standard deviation of aggregate income shock $\sigma_\eta = 0.019$. These values are taken from Cocco (2005) who estimates these parameters using the Panel Study of Income Dynamics (PSID). For the idiosyncratic persistent income shock, we set $\rho_\varepsilon = 0.973$ and $\sigma_\varepsilon = 0.133$. These values are from Heathcote, Storesletten, and Violante (2010). We discretize the income shocks using the Tauchen method outlined in Adda and Cooper (2003).[18]

During retirement, the social security replacement rate for high school graduate (λ_{HS}) and college graduate (λ_{COL}) is 0.6 and 0.4, respectively (Díaz and Luengo-Prado, 2008; Munnell and Soto, 2005).

4.3 Housing

In order to parameterize the levels of house size, we look at households in the 2007 SCF and focus on households with a TDA and household heads aged 25–64. For these households, we compute the ratio of reported house value to the median non-financial income of households with TDA and with heads aged 24–25. The ratio at the bottom 10 percentile is about 2. Hence, we set the minimum house size in the model at 2 times of median labor income of period 1 households. We use 5 points to approximate the levels of house size corresponding to 2, 4, 6, 8, and 10 times of median income in model period 1. Following Cocco (2005), the annual growth rate of house prices g is set at 1% and the standard deviation of house prices is 6.2%.

House maintenance cost parameter δ is set at 1.5% as in Yao and Zhang (2005). For housing transaction costs, θ^S is set at 6% for sellers and θ^B at 1.5% for buyers. The property tax τ for homeowners is set at 1%. We set the rental cost, ϕ, at 6.5% of the value of the house, which falls in the range 6.0–7.5% used in Yao and Zhang (2005) and Li and Yao (2007).

[17] We also need to specify households' initial wealth a_0^T in the model. We look at households with heads aged 23–24 in the 2001–2007 SCFs and compute the net worth distribution for these households by education group. We then randomly assign their net worth to period 1 households (age 25) in the model by education group using the same distribution.

[18] The aggregate income shock is approximated by a 3–state Markov process, while the idiosyncratic persistent income shock by a 5–state Markov process.

The length of a traditional fixed rate mortgage contract is N=30 years, following Chambers, Garriga, and Schlagenhauf (2009a). Mortgage interest premium is 2.7%, according to the average mortgage interest premium over the rate on certificate of deposit from 1998 to 2007 (IMF, 2010). The rate of return for savings in both TA and TDA is set at 2%. Thus, the mortgage interest rate r_m is 4.7%. The minimum down payment ratio θ^D is set at 10% as in Yang (2009).

4.4 Tax-deferred Accounts

Households can make contributions to TDA in their working periods. Joulfaian and Richardson (2001) find that 85% of households contributed less than 10% of their income and the average employee contribution rate is 5.9%. Thus we set the contribution limit, $\bar{q}$, to 8% of annual labor earnings in the benchmark model. Sensitivity analysis on increasing the contribution limit is conducted in latter section. The employer matching rate, $\tilde{q}$, is set at 33.3% of an employee's contributions (up to 6% of the employee's labor income). We use this relatively low matching rate to reflect the fact that not all employers provide matching. Adding employee contributions and employer matching together, a maximum of 10% of employee's labor income can be contributed to TDA each period in the benchmark. According to the U.S. regulations early withdrawal penalty, *pen*, is 10%, penalty-free withdrawal starts at age 60 ($R-4$) and mandatory TDA withdrawal starts after age 70 ($R+6$).

4.5 Income and Payroll Taxes

Income tax system in the model mimics the federal income tax code in the United States, prevailing in 1993–2000. We follow the U.S. income tax code in year 2000. To be consistent with other monetary variables, taxable income thresholds are converted to 2007 dollars using the consumer price index. Table 2 describes the cutoff points of the tax brackets and the marginal tax rates. There are five tax brackets, with marginal tax rates of 15%, 28%, 31%, 36%, and 39.6% corresponding to taxable income thresholds at \$52,800, \$127,600, \$194,400, and \$347,200, respectively. Personal exemptions in income tax are also considered in our calculation. We take the case of a household comprised of a couple filing jointly and set total personal exemptions to \$8,850. Payroll tax rates and maximum taxable earnings for payroll tax are taken from the Old-Age, Survivors, and Disability Insurance (OASDI) program in 1968–2007. We use the average tax rate for employees (5.60%) and the average real maximum taxable earnings (\$74,160) to compute the payroll taxes.

5 Benchmark Results

We focus on the stationary distribution and solve the model numerically. Data and results from model simulation are reported in Table 3 and graphically presented in Figure 3 and Figure 4.

The model generates home ownership rates that are broadly consistent with the data for households between ages 25 and 64. The only notable difference is that the ownership rate for the youngest age group (age 25–34) is lower in the model than in the data (43% vs. 62%). A few factors may contribute to this difference. In reality, some households purchase their houses by paying a much lower down payment than assumed in the model, for example through sub-prime mortgages. Also, the initial wealth used in the model are net of any outstanding debt including student loans, which are amortized with favorable interest rates in reality. Thus, young households in the model have stricter credit constraints and reduce their ability to make down payments.

The model also delivers reasonable results in the life-cycle pattern of *homeowner's* net worth composition. It generates a decreasing fraction of net worth in home equity, an increasing fraction in TDA wealth, and a relatively small fraction in TA wealth over the life-cycle (before retirement). In terms of levels, the model also delivers net worth ratios similar to the data with two exceptions. First, the home equity/net worth ratio for the youngest cohort in the model (73.9%) is higher than that in the data (60.7%), which is likely due to the fact that some households in the reality pay lower down payments. Second, the TDA/net worth ratio in the model is higher than that in the data for the oldest cohort, and we attribute this deviation to the history of TDA. Since TDA such as IRA and 401(k) only started to become popular in early 1980s, not all households between ages 55–64 have TDA throughout their work lives and be able to utilize that to the full extent.[19] In this sense, our model predicts that the importance of TDA wealth for future generations will be higher as a longer period of their work lives will be covered by TDA. Nevertheless, the TDA share of net worth is relatively low over most of a household's life-cycle and the majority of household wealth consists of home equity. Our model also shows that homeowners have higher income than renters. The median income for homeowners is 1.9 times of that for renters in the model, which is close to 1.8 times reported in the 2007 SCF.[20]

Overall, our benchmark results closely resemble the facts presented in section 2. In this

[19] For keeping this already high-dimensional model tractable, we do not incorporate stochastic TDA eligibility. For papers with stochastic eligibility, see Zhou (2012).

[20] In general, renters hold more wealth in TDA than in TA in the model, which is consistent with the data.

sense, the benchmark model performs reasonably well, especially given that our parameter values are strongly restricted to those in the existing literature.

6 Experiments

In this section, we consider two sets of experiments on TDA-related policies and housing-related factors. Comparative statics analysis is conducted to investigate the impacts of different policies on households' net worth composition and their housing decisions. We focus on the net worth composition of *all* households unconditional on their housing tenure choices because home ownership is an endogenous decision in the model. When home equity is of concern, only homeowners are considered.

6.1 Changes in TDA-related Policies

We first consider the effects of TDA-related policies on housing tenure choice and households' use of TDA. Results from different experiments are reported in Table 4. Values for the benchmark model are normalized to 1, such that all the experiment results reported are levels relative to the benchmark model.

6.1.1 Eliminating TDA

How does the existence of TDA affect households' housing decisions over the life-cycle? To answer this question, we conduct an experiment in which we eliminate TDA in the model such that households can no longer contribute to TDA in this experiment, losing access to TDA's tax benefits and employer matching.

We find that eliminating TDA induces enormous changes in households' portfolio. The overall home ownership rate plummets by 31.5%. The median income of homeowners is 11.4% higher than in the benchmark, suggesting that homeowners are further concentrated on higher-income households. Overall, households' net worth drops significantly by 18.2% because households cannot benefit from TDA's tax-deferred features and employer matching. Assets that would have been saved in TDA is shifted to TA, leading to a substantial increase in the TA share of net worth. For homeowners, they allocate a bigger share of their wealth to housing equity so as to reduce mortgage interest payments. Overall, the fraction of home equity in net worth and in home value increase by 36.3% and 76.5%, respectively.

Over the life-cycle, we find that younger age groups are more affected than older age groups when TDA is eliminated from the model. For example, the 25–34 age group registers the largest drop in home ownership. The drop in net worth is also the most pronounced for the youngest age group.

These findings suggest that TDA has important impacts on households' savings *and* housing decisions. In the presence of TDA, households tend to take bigger mortgage loans by making smaller down payments in early stage of their lives and become homeowners earlier. This decision is motivated by the tax benefits for both home ownership (e.g., mortgage interest deductibility) and TDA (e.g., untaxed investment returns and income-tax deferral through TDA contributions). When TDA is not available, a significant portion of households delay their home purchases. These households decide to accumulate more TA wealth to make bigger down payments in the future so that they can reduce their mortgage interest payments.[21] Some households, who would have been homeowners with access to TDA, decide not to buy a house when TDA is not available. Hence, TDA promotes home ownership and increases households' mortgage debt.

6.1.2 Higher TDA Contribution Limit

We further investigate the effects of increasing TDA contribution limit for retirement savings. This experiment focuses on the amount of households' savings in TDA (i.e., the intensive margin). TDA contribution limit ($\bar{q}$) is increased from 8% of household annual income in the benchmark to 12%. The employer matching rate (33.3%) is kept the same as in the benchmark model.

Overall, an increase in TDA contribution limit has limited impact on households' wealth accumulation. The median net worth of working-age households only increases by 0.9%. Older age groups exhibit slightly larger increases in net worth since they have higher level of income and some of them max out their TDA contributions in the benchmark model. An increase in TDA contribution limit has a larger impact on the composition of net worth. The TDA share of net worth increases by 8.7%. Meanwhile, the fraction of TA wealth decreases by 24.8%, which implies that a significant fraction of the new assets in TDA is shifted from TA. The decrease in TA is bigger for older households, because they are less liquidity-constrained and could afford to contribute more to TDA.

Our results show that households' housing decisions are unaffected by the increase in the TDA contribution limit. Home ownership and the median income of owners are the same as in the benchmark model. Only a small decrease in the importance of home equity is observed

[21] This result seems to imply that the incentive for reducing mortgage interest payments is stronger than taking advantage of mortgage interest deductibility.

for older homeowners. The home equity share of net worth for age groups 45–54 and 55–64 drops by 2.2% and 4.1%, respective, due to the increase in TDA savings.

6.1.3 No Employer Matching

Employer matching is one of the most attractive aspects for making contributions to TDA because it can be viewed as immediate returns on employees' contributions. In this section, we eliminate employer matching in TDA to study the extent to which it affects households' use of TDA and their housing decisions. To do so, we lower the employer matching rate from 33.3% of employee contributions in the benchmark model to 0%, i.e. $\tilde{q} = 0$.

We find that households' median net worth drops by 5.4% after employer matching is eliminated. The fraction of net worth in TDA decreases by 25.8%, while the fraction in TA increases by 19.4%. Housing decisions are less affected as home ownership rate slightly increases by 1.2%. For homeowners, home equity becomes more important in their household wealth. The home equity-to-net worth ratio rises by 12.7% and the fraction of home equity in home value increases by 2.6%, indicating that households shift part of their wealth from TDA to home equity when there is no employer matching.

Regarding the life-cycle profiles of net worth composition, the TDA share of net worth drops in all age groups while the TA share of net worth increases. The 25–34 age group has both the biggest drop in the TDA share of net worth (57.4%) and the strongest increase in the TA share of net worth (95.0%). These changes are related to the fact that the median household in this age group is a renter. When there is no employer matching and hence the returns in TDA are lower, a renter tends to contribute less to TDA and accumulate more wealth in TA for a potential future down payment. For homeowners, their income is similar to that in the benchmark in all age groups. However, home equity as a share of net worth is much higher than in the benchmark over the life cycle.

Compared to the above experiment without TDA, eliminating employer matching induces smaller movements relative to the benchmark in terms of home ownership and the composition of net worth. This result suggests that TDA's preferential tax treatments are more important than employer matching in influencing households' decisions.

6.2 Changes in Housing-related Factors

This section examines the effects of a few housing-related factors on housing decisions and the composition of households' net worth. Experiment results are reported in Table 5. Again, all the results reported are levels relative to the benchmark model.

6.2.1 Increase in Down Payment Requirement

As shown in the life-cycle patterns of net worth composition, a large fraction of homeowners' wealth consists of home equity. For young homeowners, the majority of their net worth is in home equity due to the lumpy down payments they make for purchasing houses. This down payment requirement represents a significant barrier for home ownership. We investigate the impact of down payment requirement by increasing the minimum down payment ratio from 10% in the benchmark to 20%. The available down payment choices for working-age households thus become $\theta^D \in \{0.2, 0.5, 0.75, 1.0\}$.

Overall, raising the minimum down payment requirement reduces home ownership rate by 6.8%, while the median household net worth is down by 0.2%. The TA share of net worth increases by 15.7% as households need to accumulate more assets in TA to fulfill the heightened down payment requirement. On the other hand, the fraction of net worth in TDA drops by 1.9%. For homeowners, the ratio of home equity to home value increases by 6.2% due to higher down payment requirement.

Generally speaking, the results are driven by the impacts on households in age group 25–34, and the effects quickly fade away with older age groups. Focusing on the 25–34 age group, the home ownership rate decreases by 27.2% as households have to save more for higher down payments and defer their home purchases. The median net worth drops by 11.5% for these young households. The fractions of net worth in TA and TDA have increased, with a bigger increase in TA which can be reallocated for down payments in the future. Those young households who choose to be homeowners have higher income than in the benchmark model. They make higher down payments and the share of equity in their homes increases by 33.9%. These results suggest that the minimum down payment requirement significantly affects households' saving decision, particularly for young households.

6.2.2 Increase in Rental Cost

In this section we investigate how an increase in rental cost changes households' housing tenure choices and the composition of net worth. An increase in rental cost can be interpreted as an increase in rental market friction. In this experiment, the rental cost (ϕ) is increased from 6.5% in the benchmark to 7% of the housing property value.

As the rental cost increases, obtaining housing services through owning becomes more attractive. Overall the home ownership rate increases by 6.1%, and the median household net worth rises by 6.2%. The fractions of net worth in TDA and TA decrease by 4.3% and 7.0%, respectively. These results indicate that home purchases are financed by a combination of new savings (as overall net worth increases) and shifting assets from other accounts.

Notably a large part of the changes come from younger age groups. For households at age 25–34, the median net worth is up 16.1% and the home ownership rate increases by 16.9%. The increase in ownership comes from households with lower income, as the median income of homeowners decreases by 3.4% for these young households. Among homeowners, the fraction of home equity in home value is slightly higher than that in the benchmark across age groups.

6.2.3 No Tax benefits for Home Ownership

The deductibility of mortgage interest payments and property taxes significantly reduces a household's cost of owning a home. It is viewed as a major factor providing cost advantage to home ownership over renting. We investigate the role of income tax deductibility on home ownership and households' savings decisions. In this experiment, both mortgage interest payments and property taxes are not deductible from taxable income. The adjusted gross income (AGI) in equation (21) becomes

$$AGI_j = r\left(\frac{a_j^T - Y_j}{1+r}\right) + Y_j - q_j \quad \text{for } DR_j \in \{0,1\}. \tag{24}$$

As a result, home ownership on average drops by 19% since the cost of ownership increases. As fewer households accumulate wealth in housing (e.g., through down payments and capital gains), the overall household net worth decreases by 7.8%. The effect is the strongest for households in age group 25–34, who are most financially constrained in making down payments. Their home ownership rate and net worth decrease by 40.0% and 27.2%, respectively. The drop in home ownership rate and net worth are broadly consistent with Poterba and Sinai (2008) and Gervais (2002).

The experiment provides further insights into households' wealth composition, by showing that households in general do not increase their use of TDA when mortgage interest payments and property taxes are not income tax deductible. The overall TDA-to-net worth ratio decreases by 4.4% (the level of TDA wealth also drops compared to that in the benchmark). Households accumulate more wealth in TA, and then use their assets in TA to make bigger down payments so as to reduce their expenses on mortgage interests.[22] Overall, the fraction of equity in home value for homeowners increases by 45.0% and the home equity-to-net worth ratio increases by 6.5%.

[22]Since the model abstracts from mortgage prepayments, making bigger down payments at the time of home purchase is the way for reducing mortgage interest payments.

7 Conclusion

Household's use of TDA and their home ownership decision is studied to shed light on the important life-cycle patterns of home ownership and household net worth composition. We develop a life-cycle model in which the tax benefits and illiquid nature of TDA and housing are highlighted. Households make endogenous savings and housing decisions in the presence of uninsurable earnings risk and housing price risk. With commonly used parameter values, the model generates life-cycle patterns that are consistent with the data.

Counterfactual experiments on TDA-related polices show that TDA has significant impacts on both household savings and housing decisions. TDA promotes home ownership as households take advantage of tax benefits by accumulating wealth in TDA, paying lower down payments and becoming homeowners earlier in their lives. Further increase in TDA contribution limit only moderately raises the TDA share of net worth. We also find that housing-related factors (e.g., a minimum down payment requirement and mortgage interest deductability) affect households' housing decisions and savings in TA more than their use of TDA. This implies that the importance of TDA in households' net worth is not hindered by housing-related policy changes. TDA is still an attractive vehicle for retirement savings in spite of the tax benefits and consumption-saving purpose of housing.

Our results show the importance of the interaction between housing and TDA in household portfolios. The coexistence of TDA and housing offers an explanation to the low level of TDA holdings observed in the U.S. household data. Also, as we show that households leverage their asset portfolio by accumulating savings in TDA and taking out bigger mortgage loans, their non-housing consumption could be more sensitive to housing price shocks than previously suggested in Li and Yao (2007). While our work focuses on understanding households' life-cycle decisions on their use of TDA and housing, this serves as an important step for better understanding the macroeconomic impacts of retirement-related and housing-related policies. The existing framework can be extended to investigate the macroeconomic impacts of retirement-related policies such as social security reform with the presence of housing (Chen, 2010), and the welfare impacts of eliminating mortgage interest deductibility (Gervais, 2002). We leave this for future research.

Appendix A: The SCF Data

The Survey of Consumer Finances (SCF) provides the most complete data on household balance sheets in the United States. We use the 2001, 2004 and 2007 SCFs to construct net worth composition for defined-contribution (DC) pension plan participants that are also homeowners.

Financial assets in regular taxable accounts (TA) include checking accounts, savings accounts, certificates of deposit, money market accounts, mutual funds, bonds, directly held publicly traded stocks, brokerage accounts, trusts and managed investment accounts. TA wealth is defined as financial assets in TA net of debt associated with TA, which includes credit cards, education loans, borrowing in brokerage accounts and other consumer loans.

For households with heads aged 25–64, about 40% of them have employer-sponsored DC plans in each of the 3 waves of SCFs.[23] TDA wealth is the sum of balances in Individual Retirement Accounts (IRAs) and employer-sponsored DC pension plans from current main job (such as 401K/403B/457/SRA and Thrift Savings plans) net of loans against main job pensions. Note that TDA wealth includes holdings in IRAs because these balances in IRAs consist mostly of rollovers from 401(K) plans. Home equity is the difference between the value of principal residence and the mortgage balance on principal residence.

Finally, a household's net worth is the sum of home equity, TDA wealth and TA wealth. It excludes social security wealth and future earnings. Once we find the net worth, we compute the composition of net worth for households in each survey and then take the average.

Appendix B: Household Problem

The recursive formulation of a household's problem specified in equation (23) depends on the household's endogenous tenure choice. We specify five different scenarios with respect to a household's home ownership status last period and current tenure choice. Technically, households who do not own a house have state variables $n = 0$, $\tilde{p}_n = 0$, and $\theta_n^D = 0$.

1. Consider a household who rents in both periods $j-1$ and j (i.e., $DR_{j-1} = DR_j = 1$).

[23] If we also consider IRAs, slightly more than 50% of households have either DC, or IRAs, or both DC and IRAs in the SCFs.

The Bellman equation for this situation is given by

$$\begin{aligned}
& V(j,\eta_j,\varepsilon_j,a_j^T,a_j^D,1,h_{j-1},0,0,0) \\
= & \max_{c_j,q_j,h_j} \frac{(c_j^{1-\omega}h_j^{\omega})^{1-\gamma}}{1-\gamma} + \beta s_{j+1}E_j\left[V(j+1,\eta_{j+1},\varepsilon_{j+1},a_{j+1}^T,a_{j+1}^D,1,h_j,0,0,0)\right] \\
& +\beta(1-s_{j+1})\frac{(W_{j+1})^{1-\gamma}}{1-\gamma} \qquad (25)
\end{aligned}$$

2. Consider a household who owns a house in period $(j-1)$ and rents in period j (i.e., $DR_{j-1}=0$ and $DR_j=1$). The Bellman equation for this situation is given by

$$\begin{aligned}
& V(j,\eta_j,\varepsilon_j,a_j^T,a_j^D,0,h_{j-1},n,\tilde{p}_n,\theta_n^D) \\
= & \max_{c_j,q_j,h_j} \frac{(c_j^{1-\omega}h_j^{\omega})^{1-\gamma}}{1-\gamma} + \beta s_{j+1}E_j\left[V(j+1,\eta_{j+1},\varepsilon_{j+1},a_{j+1}^T,a_{j+1}^D,1,h_j,0,0,0)\right] \\
& +\beta(1-s_{j+1})\frac{(W_{j+1})^{1-\gamma}}{1-\gamma} \qquad (26)
\end{aligned}$$

3. Consider a household who rents in period $j-1$ and chooses to buy a house in period j (i.e., $DR_{j-1}=1$ and $DR_j=0$). It requires the household to make an additional decision on down payment (θ_j^D). The Bellman equation for this situation is given by

$$\begin{aligned}
& V(j,\eta_j,\varepsilon_j,a_j^T,a_j^D,1,h_{j-1},0,0,0) \\
= & \max_{c_j,q_j,h_j,\theta_j^D} \frac{(c_j^{1-\omega}h_j^{\omega})^{1-\gamma}}{1-\gamma} + \beta s_{j+1}E_j\left[V(j+1,\eta_{j+1},\varepsilon_{j+1},a_{j+1}^T,a_{j+1}^D,0,h_j,j,\tilde{p}_j,\theta_j^D)\right] \\
& +\beta(1-s_{j+1})\frac{(W_{j+1})^{1-\gamma}}{1-\gamma} \qquad (27)
\end{aligned}$$

4. Consider a homeowner who maintains the current house (i.e., $DR_{j-1}=DR_j=0$, and $h_{j-1}=h_j$). The down payment decision (θ_n^D) made in period n is a state variable that will not change. The Bellman equation for this situation is given by

$$\begin{aligned}
& V(j,\eta_j,\varepsilon_j,a_j^T,a_j^D,0,h_{j-1},n,\tilde{p}_n,\theta_n^D) \\
= & \max_{c_j,q_j,h_j} \frac{(c_j^{1-\omega}h_j^{\omega})^{1-\gamma}}{1-\gamma} + \beta s_{j+1}E_j\left[V(j+1,\eta_{j+1},\varepsilon_{j+1},a_{j+1}^T,a_{j+1}^D,0,h_j,n,\tilde{p}_n,\theta_n^D)\right] \\
& +\beta(1-s_{j+1})\frac{(W_{j+1})^{1-\gamma}}{1-\gamma} \qquad (28)
\end{aligned}$$

5. Consider a homeowner who decides to change the housing size (i.e., $DR_{j-1}=DR_j=0$ and $h_{j-1}\neq h_j$). The down payment ratio is a state variable for the existing home (θ_n^D),

but a choice variable for the new home (θ_j^D). The Bellman equation for this situation is given by

$$\begin{aligned} & V(j, \eta_j, \varepsilon_j, a_j^T, a_j^D, 0, h_{j-1}, n, \tilde{p}_n, \theta_n^D) \\ = & \max_{c_j, q_j, h_j, \theta_j^D} \frac{(c_j^{1-\omega} h_j^{\omega})^{1-\gamma}}{1-\gamma} + \beta s_{j+1} E_j \left[V(j+1, \eta_{j+1}, \varepsilon_{j+1}, a_{j+1}^T, a_{j+1}^D, 0, h_j, j, \tilde{p}_j, \theta_j^D) \right] \\ & + \beta(1 - s_{j+1}) \frac{(W_{j+1})^{1-\gamma}}{1-\gamma} \end{aligned} \tag{29}$$

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Table 1: Summary of parameter values

Parameters	Name	Values	Target / Data Source
Demographics			
J	Lifespan	71	Real age 25–95
R	Last working period	40	Work until age 64
s	Survival probability	see text	Life table in year 2000
Preferences			
γ	Relative risk aversion	2	
β	Discount factor	0.96	
ω	Preferences on housing	0.2	Li and Yao (2007), Yao and Zhang (2005)
Income			
f	Age earnings profile	see text	Cocco, Gomes, and Maenhout (2005)
ρ_η	Persistence of aggregate shock	0.748	Cocco (2005)
σ_η	s.d. aggregate shock	0.019	Cocco (2005)
ρ_ε	Persistence of idiosyncratic shock	0.973	Heathcote, Storesletten, and Violante (2010)
σ_ε	s.d. idiosyncratic income shock	0.133	Heathcote, Storesletten, and Violante (2010)
λ_{COL}	SS replacement rate for COL	0.4	Díaz and Luengo-Prado (2008)
λ_{HS}	SS replacement rate for HS	0.6	Díaz and Luengo-Prado (2008)
Housing			
N	Mortgage length	30	Chambers, Garriga, and Schlagenhauf (2009a)
r_m	Mortgage interest rate	4.7%	
θ^D	Down payment ratios	see text	
H	House size	see text	
g	House price growth rate	1%	Cocco (2005)
$\sigma_{\tilde{p}}$	s.d. house prices	6.2%	Cocco (2005)
θ^S	Transaction cost for seller	6%	
θ^B	Transaction cost for buyer	1.5%	
τ	Property tax rate	1%	
δ	Housing maintenance cost	1.5%	Yao and Zhang (2005)
ϕ	Rental cost of housing	6.5%	
Savings			
r	Return on saving	2%	
$\bar{q}$	TDA Contributions limit	8%	
pen	TDA penalty rate	10%	Zhou (2009)
$\tilde{q}$	Employer's matching rate	33.3%	
Tax code			
$IC_{1,\ldots,5}$	Income cutoff points	see text	Tax code in 1993–2000
$\tau_{1,\ldots,5}$	Marginal tax rates	see text	Tax code in 1993–2000
τ_{ss}	Payroll tax rate	5.6%	OASDI tax rate on employees
Y_{ss}	Earnings limit for payroll	1.952	Maximum taxable earnings

Table 2: Cutoff points of tax brackets and marginal tax rate

Taxable Income	Normalized Income	Marginal Tax Rate
($0, $52,800]	(0, 1.389]	15%
($52,800, $127,600]	(1.398, 3.357]	28%
($127,600, $194,400]	(3.357, 5.116]	31%
($194,400, $347,200]	(5.116, 9.137]	36%
> $347,200	9.137 +	39.60%

Notes: We normalize $38,000 as 1 in the model.

Table 3: Home ownership and net worth composition for homeowners: data vs. model

	Age Group			
	25-34	35-44	45-54	55-64
Home ownership				
Model	0.434	0.761	0.864	0.890
Data	0.620	0.788	0.846	0.891
TDA/net worth (median)				
Model	0.190	0.329	0.384	0.440
Data	0.229	0.297	0.311	0.336
TA/net worth (median)				
Model	0.023	0.074	0.095	0.065
Data	0.063	0.069	0.073	0.081
Home equity/net worth (median)				
Model	0.739	0.572	0.506	0.479
Data	0.607	0.549	0.495	0.427

Notes: Data refers to households with employer-sponsored defined contribution plans in the 2001, 2004 and 2007 Survey of Consumer Finances (SCF). Net worth composition is calculated for homeowners. We calculate the *median* ratios in each SCF and report the average of the median values across all years. Since the ratios are computed separately, they are not referred to the same household and thus the sum of the ratios do not necessarily add up to 1.

Table 4: Experiments on TDA-related policies

	Age Group				
	25-34	35-44	45-54	55-64	Overall
Eliminating TDA					
Net worth	0.468	0.758	0.878	0.872	0.818
TDA/net worth	.	.	.	.	.
TA/net worth	7.981	8.355	3.270	4.969	7.781
% of home ownership	0.380	0.564	0.746	0.900	0.685
Median income of homeowner	1.122	1.261	1.085	1.020	1.114
Home equity/net worth	1.169	1.376	1.478	1.410	1.363
Home equity/home value	1.504	2.414	1.520	1.053	1.765
Higher TDA contribution limit					
Net worth	1.016	1.009	1.020	1.026	1.009
TDA/net worth	1.103	1.045	1.093	1.113	1.087
TA/net worth	0.835	0.838	0.786	0.634	0.752
% of home ownership	0.999	1.001	1.004	0.999	1.001
Median income of homeowner	0.999	0.999	1.000	1.000	1.000
Home equity/net worth	0.996	1.001	0.978	0.959	0.985
Home equity/home value	1.006	1.003	0.994	0.981	0.996
No employer's match on TDA					
Net worth	0.921	0.926	0.936	0.934	0.946
TDA/net worth	0.426	0.755	0.770	0.814	0.742
TA/net worth	1.950	1.014	1.105	1.226	1.194
% of home ownership	1.031	1.010	1.010	1.006	1.012
Median income of homeowner	0.993	0.996	0.990	0.999	0.995
Home equity/net worth	1.151	1.132	1.131	1.119	1.127
Home equity/home value	1.023	1.016	1.031	1.039	1.026

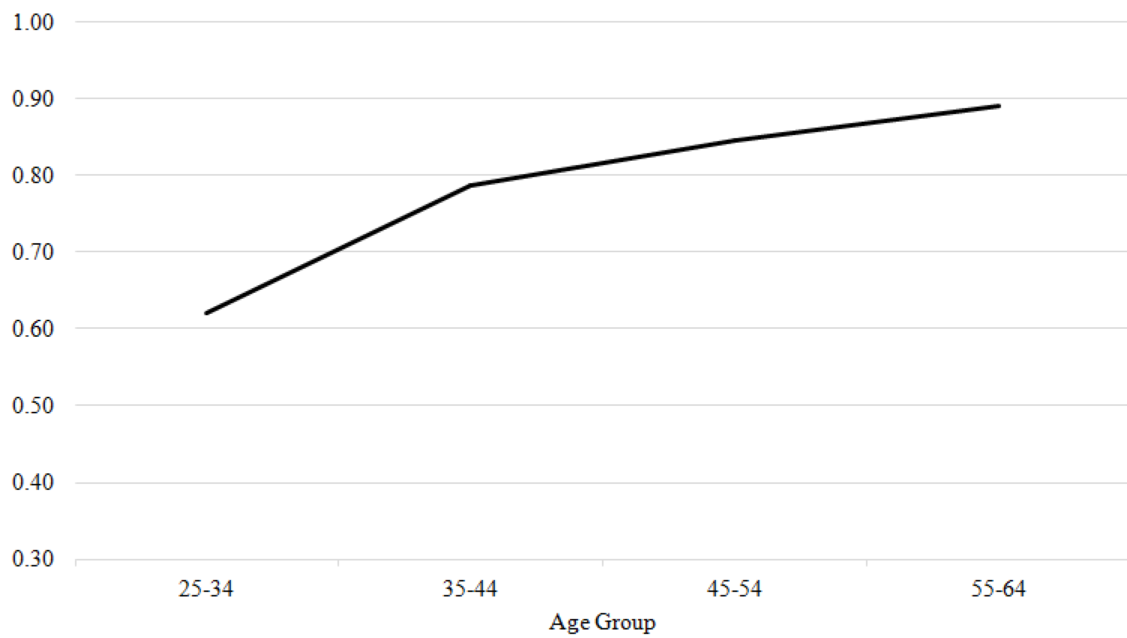
Note: All our results, except the home ownership rate, are the median values with respect to different age groups. Values for the benchmark model are normalized to 1, such that all the experiment results reported are levels relative to the benchmark model. Net worth, the TDA-to-net worth ratio, the TA-to-net worth ratio and home ownership refer to all households, while home equity-to-net worth and home equity-to-home value ratios are calculated for *homeowners* only.

Table 5: Experiments on housing-related factors

	Age Group				
	25-34	35-44	45-54	55-64	Overall
Increase min. down payment to 20%					
Net worth	0.885	0.997	0.995	0.995	0.998
TDA/net worth	1.117	0.938	0.967	0.985	0.981
TA/net worth	1.378	1.212	1.081	1.073	1.157
% of home ownership	0.728	0.924	0.982	0.998	0.932
Median income of homeowner	1.070	1.032	1.009	1.000	1.023
Home equity/net worth	1.044	1.037	1.011	1.002	1.007
Home equity/home value	1.339	1.094	0.997	0.957	1.062
Higher rental cost (7%)					
Net worth	1.161	1.063	1.034	1.025	1.062
TDA/net worth	0.883	0.967	0.976	0.984	0.957
TA/net worth	0.848	0.915	0.955	0.970	0.930
% of home ownership	1.169	1.059	1.036	1.030	1.061
Median income of homeowner	0.966	0.975	0.975	0.995	0.981
Home equity/net worth	1.016	1.017	1.014	1.012	1.024
Home equity/home value	1.011	1.034	1.023	1.028	1.005
No tax benefits on home ownership					
Net worth	0.728	0.892	0.946	0.971	0.922
TDA/net worth	1.175	0.863	0.901	0.957	0.956
TA/net worth	1.488	1.304	0.990	1.230	1.191
% of home ownership	0.600	0.756	0.864	0.918	0.810
Median income of homeowner	1.006	1.020	1.028	1.014	1.031
Home equity/net worth	1.054	1.131	1.107	1.040	1.065
Home equity/home value	1.138	1.248	1.394	1.053	1.450

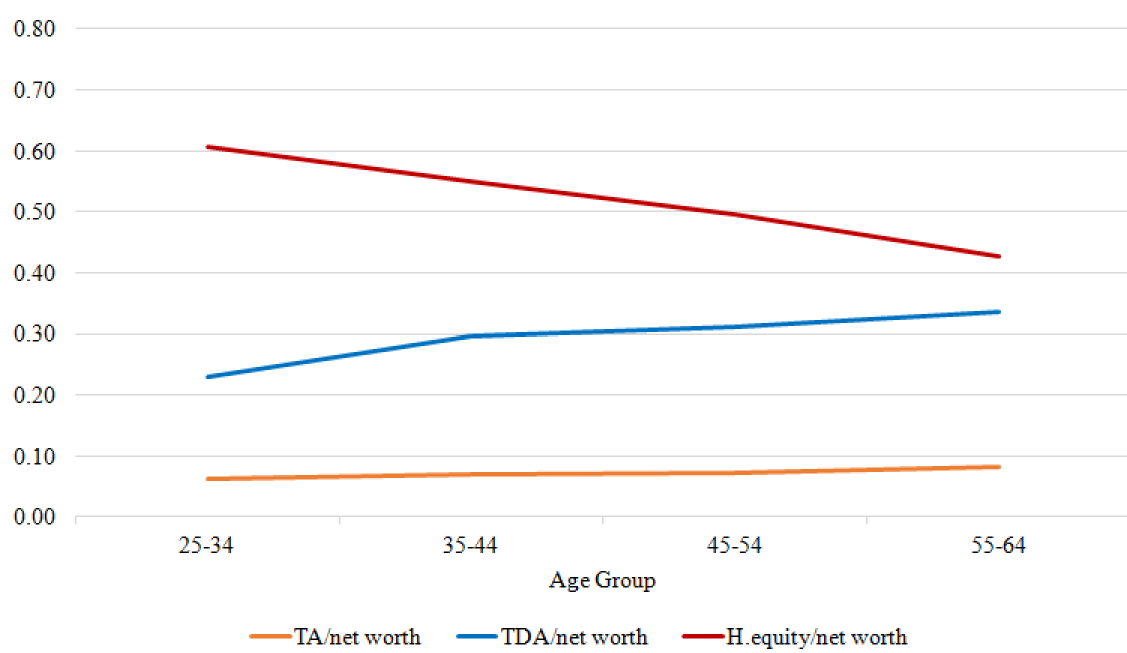
Note: All our results, except the home ownership rate, are the median values with respect to different age groups. Values for the benchmark model are normalized to 1, such that all the experiment results reported are levels relative to the benchmark model. Net worth, the TDA-to-net worth ratio, the TA-to-net worth ratio and home ownership refer to all households, while home equity-to-net worth and home equity-to-home value ratios are calculated for *homeowners* only.

Figure 1: Home ownership rate by age group for DC participants



Note: Home ownership rate for DC participants is the average of the 2001-2007 SCFs.

Figure 2: Net worth composition by age group for DC participants who are homeowners: median



Note: This figure shows the average of median ratios for DC participants in the 2001-2007 SCFs.

Figure 3: Home ownership rate by age group for DC participants

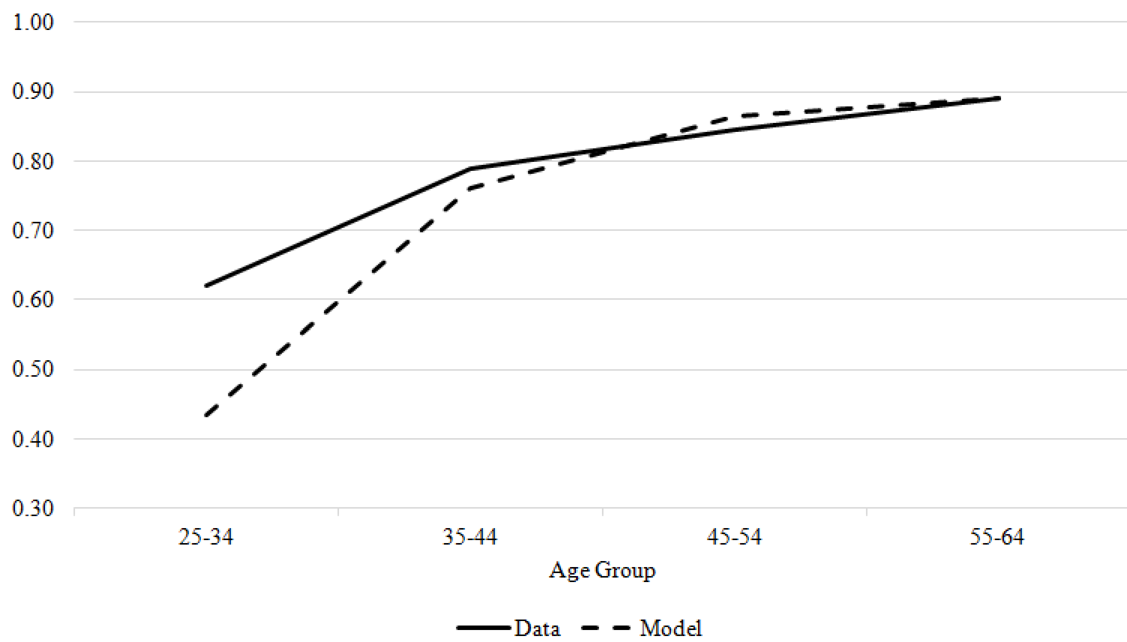


Figure 4: Net worth composition by age group for DC participants who are homeowners: median