Housing and Tax-deferred Retirement Accounts*

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Abstract

Assets in tax-deferred retirement accounts (TDA) such as 401(k) and housing wealth are two major components of household wealth. These assets share similarities in terms of favorable tax treatments and liquidity constraints. In this paper, we develop a quantitative life-cycle model to examine the interactions between housing tenure choice and households' use of TDA. Consistent with the data, the model generates an increasing home ownership rate before retirement and is able to explain the patterns of the cross-sectional variation in the composition of household net worth regarding home equity, TDA wealth, and other wealth held in regular taxable accounts (TA). Counterfactual experiments are conducted to shed light on the mechanisms that jointly determine home equity and retirement savings in TDA.

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1 Introduction

Assets in tax-deferred retirement accounts (hereafter TDA) and housing wealth are two major components of household wealth. Common types of TDA in the U.S. include Individual Retirement Accounts (IRA) and employer sponsored defined contribution (DC) pension plans such as 401(k) for private-sector employees, 403(b) for nonprofit-sector employees, and 457 plans for public-sector employees. According to the Board of Governors of the Federal Reserve System (2014), the total amount of financial assets held in TDA was about $8.6 trillion dollars in 2007 (59.4% of GDP). At household level, the 2007 Survey of Consumer Finances (SCF) suggests that slightly more than 50% of US households participating in any kind of TDA with a median value of $42,000. Meanwhile, about two thirds of U.S. households own any type of home in the 2007 SCF.[1] The median home equity was about $110,000 in 2007 for homeowners who are also TDA participants.

Assets in TDA and housing wealth share similarities in terms of favorable tax treatments and liquidity constraints.[2] Since housing investment is lumpy with a down payment requirement and committed mortgage payments, housing tenure choice could have a significant impact on households' use of TDA for retirement saving. Indeed, recent studies have found that even after nearly 30 years, holdings in 401(k) plans for a substantial share of households approaching retirement remained low (Munnell, Golub-Sass, and Muldoon (2009), Munnell (2012) and Poterba (2014)). The combined 401(k)/IRA balances for a typical households are unlikely to be able to provide significant retirement support raising the concern of retirement security. On the other hand, the existence of TDA may have important implications for household debt and home ownership rate. As households benefit from the tax-deferred feature for their TDA contributions, they may choose to pay a lower down payment (and higher per-period mortgage payments) for home ownership than it otherwise would be. Without the need to accumulate a large down payment, households may become home owners earlier and borrow more. Hence, home ownership rate could be higher in the presence of TDA. The coexistence of these two items on households' balance sheets thus presents non-trivial

[1] The home ownership rate is higher for households with TDA as these households in general have higher income than those without TDA.

[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. However, early withdrawal of TDA assets (before age 59.5) is subject to a 10% penalty payment in addition to the income taxes incurred from assets withdrawal. For housing, mortgage interest payments and property taxes are income tax deductible, and the service flow from owners-occupied housing is untaxed. However, housing transaction involves significant transaction costs.

interactions. Moreover, recent housing crisis also highlights the needs of better understanding households' decisions on savings and their allocation to different assets. Surprisingly, relatively little attention has been paid to the interactions between housing and TDA.

This paper fills this gap in the literature. We undertake a quantitative examination of the interactions between housing tenure choice and households' use of TDA. In particular, we are interested in the patterns of the cross-sectional variation in the composition of household net worth regarding home equity, TDA wealth, and other wealth held in regular taxable accounts (TA). Using the 2001–2007 Survey of Consumer Finances (SCF) and looking at households that participate in the employer sponsored DC plans, we find that home ownership rate increases with age (before retirement) for these households. For homeowners who also have TDA , the home equity share of total net worth is the highest for the young, and decreases with age (before retirement). On the other hand, TDA share of net worth is the lowest for the young and increases with age (before retirement). These age-dependent patterns are the most salient feature of household portfolios. Moreover, income of renters is much lower than that of homeowners.[3]

To examine the interactions between housing and households' use of TDA, we develop a life-cycle model with endogenous housing tenure choice where households have access to both TA and TDA and face uninsurable earnings risk and housing price risk. Buying a house requires a traditional long-term mortgage with down payment requirement and committed per-period mortgage payments. Households in our model can make housing tenure choice in each period and they can choose their preferred house size and down payment ratio if they buy new houses. Moreover, adjusting the stock of housing requires the household to incur transaction costs, which are meant to capture realtor fees and other costs related to buying and selling a home. The model also features a progressive income tax system that mimics the U.S. tax codes and favorable tax treatments on TDA and home ownership. Given the interest in retirement savings, we also incorporate a public pension system (Social Security) in the model.

Consistent with the data, our benchmark model generates an increasing home ownership rate before retirement. It also does a fairly good job of matching the life-cycle patterns of homeowners' net worth composition regarding home equity, TDA wealth, and TA wealth observed in the data. The home equity-to-net worth ratio is the highest for young homeowners, and it drops as age goes up. On the other hand, TDA share of net worth increases with age

[3]For the age group 25–64 in the 2007 SCF, the median non-financial income was $86,800 for homeowners, while it was $48,000 for renters.

for homeowners and TA share is relatively small. In addition, the model is consistent with the data in that income being larger for homeowners than the renters and renters holding most of their wealth in TDA.

We then evaluate household behavior in the presence of housing and TDA based on the benchmark model. We conduct a series of counterfactual experiments to evaluate the relative impact of various factors on the housing tenure choice and the composition of household net worth. It provides a number of additional insights about the mechanisms that jointly determine home equity and retirement savings in TDA. For example, we find that in the model with TDA, households tend to borrow earlier (in terms of mortgages) and home ownership rate is higher than in the model without TDA. This is because households choose to pay lower down payments as they also contribute to TDA so that they can take advantage of preferential tax treatments for both home ownership and TDA. Hence, TDA promotes home ownership and household debt (i.e., households borrow earlier in their life-cycle and borrow more in the presence of TDA). We also find that an increase in the TDA contribution limit will increase the TDA share of household net worth, but has little impact on home ownership rate and limited effect on wealth accumulation. An increase in the minimum down payment ratio has a large impact on young households, but little impact on older households. With a higher down payment requirement, the home ownership rate drops a lot for young households and their TA share of net worth goes up significantly as many households choose to hold more wealth in TA for future down payments. Finally, when mortgage interest payments and property taxes are not income tax deductable, the home ownership rate drops significantly. Interestingly, households do not increase their use of TDA (both the median level of TDA and the TDA-net worth ratio decrease). Instead, the share of net worth in TA increases and homeowners allocate more wealth in home equity.

Our paper is related to two separate strands of literature, one on housing and the other on TDA. For the large literature on housing, numerous studies have focused on the preferential tax treatment of housing, its impacts on home ownership and capital accumulation, and the interaction between housing and non-housing consumption.[4] A number of other studies have

[4]For the preferential tax treatment of housing, see Gervais (2002),Díaz and Luengo-Prado (2008), and Chambers, Garriga, and Schlagenhauf (2009b). For home ownership over the life-cycle and over time, see Chambers, Garriga, and Schlagenhauf (2009a), Attanasio, Bottazzi, Low, Nesheim, and Wakefield (2012), Bajari, Chan, Krueger, and Miller (2013), Sommer, Sullivan, and Verbrugge (2013), and Halket and Vasudev (2014). For the interaction between housing and non-housing consumption, see Campbell and Cocco (2007), Li and Yao (2007), Yang (2009), and Chen (2010). Other studies examine housing and macroeconomy and housing investment over the business cycle, see Davis and Heathcote (2005), Silos (2007), and Iacoviello and

examined the impact of housing on households' asset allocation decisions (how much of each asset to hold, i.e., portfolio choice between stocks and bonds).[5]

In this paper we incorporate the preferential tax treatment of housing. However, we do not study the asset allocation between stocks and bonds. Instead, we are interested in the composition of households' net worth regarding home equity, TDA wealth, and TA wealth and their patterns over the life-cycle (before retirement). Housing service can be obtained by different tenure choice, *i.e.* renting or owning. Buying a house requires a traditional long-term fixed rate mortgage in our model.[6] To make the model trackable, we do not allow mortgage default and refinancing, which are the subject studied in Agarwal, Driscoll, and Laibson (2013), Chen, Michaux, and Roussanov (2013), Khandani, Lo, and Merton (2013) and Campbell and Cocco (Forthcoming).

Our paper is also related to the large literature on TDA, the second strand of research mentioned above. TDAs were created with the intention to increase American households' retirement preparedness. In general, they have common features on their tax treatments and liquidity constraints.[7] The literature has extensively explored the influence of TDA on households' savings decision. Many studies have documented households' contribution to TDA and their wealth accumulation in TDA (See Joulfaian and Richardson (2001), Smith, Johnson, and Muller (2004), Engelhardt and Kumar (2007), Munnell, Golub-Sass, and Muldoon (2009), Munnell (2012), and Holden, VanDerhei, Alonso, and Bass (2013)). A large body of the literature has devoted to understand whether TDA wealth represents new savings for households and its impact on capital accumulation.[8]

A number of papers also study the portfolio choice in the presence of TDA. In this case, households need to make asset allocation decisions and asset location decision (where to hold

Pavan (2013).

[5]See Cocco (2005), Hu (2005), Yao and Zhang (2005), and Chetty and Szeidl (2010).

[6]Campbell and Cocco (2003) and Chambers, Garriga, and Schlagenhauf (2009c) study more complicate mortgage choice problem.

[7]See footnote 2.

[8]The literature provides a mixed picture. Some papers have found large and significant positive effects of TDA on household saving behavior (Poterba, Venti, and Wise (1995) and Poterba, Venti, and Wise (1996)), while others find that TDAs have little to no effect on household saving (Gale and Scholz (1994), Engen, Gale, and Scholz (1996), and Benjamin (2003)). Recent studies show that the effect of TDA on household savings varies significantly by earnings level. Contributions by lower- and middle-income households represent net additions to saving, while contributions by high-income households tend to represent asset reshuffling rather than net saving (Engen and Gale (2000) and Chernozhukov and Hansen (2004)). Within a general equilibrium framework, Imrohoroglu, Imrohoroglu, and Joines (1998) investigate the effect of TDA on capital accumulation. Kitao (2010) further endogenizes labor supply.

assets, i.e., whether in taxable or in tax-deferred accounts) simultaneously. See Amromin (2003), Dammon, Spatt, and Zhang (2004), Garlappi and Huang (2006), Huang (2008), Gomes, Michaelides, and Polkovnichenko (2009), and Zhou (2009).

Our paper incorporates the key features of TDA (contribution limit, employer matching, and liquidity constraints), but we abstract from the portfolio choice decision. We focus on the composition of net worth regarding housing equity, TDA wealth and TA wealth.

Although TDA and housing wealth are two major assets and saving vehicles for households, the existing literature provides little insights on the interactions of these two items. The large literature mentioned above has only focused on analyzing one of the two assets and abstracted entirely from considering the interactions. We are aware of only two papers that deal with the interactions. Hence, they are most closely related to our paper. However, these two papers have different focus. Using the Survey of Consumer Finances, Amromin, Huang, and Sialm (2007) document that at least 38% of households who prepay their mortgages could be better off by increasing their TDA contributions instead of prepaying their mortgages. This is because households earn pre-tax returns in their TDA and pay after-tax rates on their mortgage borrowing. Pre-tax returns could be higher than after-tax mortgage rates. Marekwica, Schaefer, and Sebastian (2013) develop a model and study asset allocation in the presence of both housing and TDA. They assume that contribution to TDA is constant and homeowners always choose the maximum possible mortgage over their lives. Hence, their paper is not able to match the composition of household net worth over the life-cycle. Our paper endogenizes TDA contributions and features a realistic long-term mortgage with committed per-period mortgage payments.

Our paper combines the two strands of literature mentioned above. The key contribution of our work is to develop a quantitative life-cycle model to study the joint decision of housing tenure choice and tax-deferred savings in the presence of income risk and housing risk. To our knowledge, our model is the first to explain the life-cycle patterns of net worth composition regarding home equity, TDA wealth and TA wealth. The results show that incorporating the detailed institutional features of TDA and housing investment plays a crucial role in explaining the patterns of cross-sectional variation in the composition of household net worth observed in the data.

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 details. Section 4 outlines the parametrization of the model. Section 5 reports the results of our benchmark model. Section 6 investigates the effects of changes in retirement-related policies and housing-related factors. Section 7 concludes.

2 Stylized Facts

In this section, we provide relevant information on TDAs and housing using the Survey of Consumer Finances (SCF). The SCF is a triennial survey conducted by the Board of Governors of the Federal Reserve System that provides the most complete data on household balance sheets in the United States. It also contains data on earnings and demographic information.[9]

Empirically, we define TDA as retirement accounts in which the owners make pre-tax contributions and can make 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). When we report home ownership, we exclude principle residence being a mobile home or on a farm/ranch.[10] This is because those households are unlikely to be covered by employer-sponsored DC pension plans.

The data summarized below are from the 2001, 2004 and 2007 SCFs. In the United States, 401(k) plans are a major component of employer-sponsored DC pension plans. Since these plans began to spread rapidly in early 1980s, we focus on more recent surveys so that prime age households surveyed have potentially more than 20 years of 401(k) coverage. Meanwhile, these 3 waves of SCF spans over many years, with which the average can minimize the influence of business cycles. Since we focus on households' saving decisions based on the tax benefits and liquidity risk associated with TDA and housing, we only consider households with heads between age 25–64 who are participating in employed-sponsored DC plans.[11]

2.1 Households with TDA and Home Ownership

We look at households with TDA in the SCF and their home ownership rate in this section. These can be viewed as the extensive margin of savings through these vehicles. For house-

[9] The SCF covers a representative cross section of U.S. households and a special sample of high-income households identified from tax returns.

[10] In the SCFs, a very small number of households reporting that they live in a mobile home or on a farm/ranch.

[11] We do not report the home ownership rate for those with heads aged 65 and above. This is because the sample size for these old households is very small in the data as we require households having DC plans. Nakajima and Telyukova (2012) report that the home ownership rate for households in the Health and Retirement Study (HRS) drops from around 90% at age 65 to just below 40% by age 95.

holds with heads aged 25–64, about 40% of them have employer-sponsored DC plans in each of the 3 waves of SCFs.[12] Thus, a significant portion of households in the population have TDAs.

For these DC participants, the average home ownership rate is 78% in the 3 waves of SCFs. The ownership rate is higher than the home ownership rate for all households aged 25–64 in the surveys. This is mainly because DC participants in general have higher income than those without TDA. Figure 1 plots the life-cycle profile of home ownership rate for the cross sectional households with DC plans in the surveys. The ownership rate is increasing with age, from 62% at age group 25–34 to 89% at age group 55–64 in the 3 waves of surveys.

2.2 Life-cycle Net Worth Composition for Homeowners

For DC participants that are also homeowners, housing wealth and assets held in TDAs are two most important components of their wealth. For these households, Figure 2 reports the composition of net worth regarding home equity, TDA wealth, and TA wealth for certain age groups over the life cycle in the SCF data. Given the skewness of the wealth distribution in the data, we therefore choose to report the median values.[13] More details on the data are provided in Appendix A.

Not surprisingly, home equity dominates households' net worth for young homeowners (a median ratio of about 61% at age group 25–34). As age goes up, home equity increases. However, households accumulate financial assets at a faster rate. As a result, the ratio of home equity to net worth drops to about 43% at age group 55–64. On the other hand, the ratio of TDA wealth to net worth increases with age. The median ratio is about 23% at age group 25–34, and it increases to 34% at age group 55–64. This suggests that TDA becomes more important as households age. Overall, the ratio of TA wealth to net worth is small, which suggests that households primarily hold their financial wealth in the TDA to take advantage of the preferential tax treatment of TDA.

To summarize, the SCF data suggest that there is a significant portion of households with TDA, and the majority of these households are also homeowners. It provides evidence that households are using these saving vehicles jointly. Furthermore, our stylized facts suggest that the composition of net worth regarding home equity, TDA wealth and TA wealth has

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

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

clear life-cycle patterns. In next section, we develop a model to understand how housing tenure choice may interact with households' use of TDA.

3 Model

The life-cycle model used for our analysis is described in this section. Households have access to both TA and TDA. Their income is subject to both aggregate and idiosyncratic income shocks. Housing services can be obtained through either renting or owning. Buying a house requires a traditional long-term fixed rate mortgage with down payment requirement and committed mortgage payments. Every period households make their decisions on housing tenure choice, house size, down payment, TDA contribution/withdrawal and consumption. 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 Preferences

Households have stochastic lifetime and at most live for J periods. They derive utility from both housing service and consumption of non-durable goods. In period j, households decide non-durable consumption, c_j, and the size of housing service, h_j. The size of the house should be interpreted broadly as reflecting both the physical size and its quality. Households also gain utility from leaving bequests. Their preferences are represented by

$$E_1 \sum_{j=1}^{J} \beta^{j-1} \left\{ \Pi_{t=1}^{j} s_t \frac{\left(c_j^{1-\omega} h_j^{\omega}\right)^{1-\gamma}}{1-\gamma} + \left(1 - \Pi_{t=1}^{j} s_t\right) \frac{(W_j)^{1-\gamma}}{1-\gamma} \right\} \tag{1}$$

where $0 < \beta < 1$ is the discount factor, γ is the coefficient of relative risk aversion, s_t denotes the survival probability in period t conditional on being alive in period $t-1$, ω measures the preference for housing relative to consumption of non-durable goods, and W_j is the estate left when a household dies in period j.

3.2 Income Process and Initial Wealth

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 they cannot borrow. Let $y_{ij} = \ln(Y_{ij})$ denote the log of income, which is defined as

$$y_{ij} = f_{ij} + \eta_j + \varepsilon_{ij} \tag{2}$$

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

$$\eta_{j+1} = \rho_\eta \eta_j + \xi^\eta_{j+1} \tag{3}$$

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

$$\varepsilon_{ij+1} = \rho_\varepsilon \varepsilon_{ij} + \xi^\varepsilon_{j+1} \tag{4}$$

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 age-earnings profile and idiosyncratic shock.[14] That is,

$$y_{ij} = \ln(\lambda) + f_{iR} + \varepsilon_{iR} \tag{5}$$

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 notation, we drop subscript i in the expression of household-specific variables 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 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 log of housing price 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. We assume that fluctuations in house prices are perfectly positively correlated with aggregate labor income shocks, and uncorrelated with household's idiosyncratic income shocks.[15]

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

[15] Using PSID data, Cocco (2005) estimates the correlation to be 0.553 and significant at the 2% level.

Housing services can be obtained either by renting or owning. Let $DR_j \in \{0,1\}$ denote 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 either a renter or an owner and make decisions on house size. After retirement ($j > R$), renters are not allowed to purchase a house and they only make decisions on their rental house sizes.[16] Retired homeowners can continue to choose to be owners or become renters. For their house size decisions, retired owners can choose to stay in their own houses or downsize to a smaller unit. We also 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

$$h_j = \begin{cases} \in \{H_1, H_2, H_3\} & \text{if } DR = 1 \text{ (renter)} \\ \in \{H_2, H_3, H_4, H_5\} & \text{if } DR = 0 \text{ (owner)} \end{cases} \tag{6}$$

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.[17] 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%. Retired homeowners who choose to downsize are required to pay their new homes in full. Down payment decision for home buyers is formulated as

$$\theta_n^D = \begin{cases} \in \{0.1, 0.2, 0.5, 0.75, 1\} & \text{if } \ n \leq R \\ 1 & \text{if } \ n > R \end{cases} \tag{7}$$

For keeping the model tractable, households are not allowed to convert home equity to liquid wealth through a "cash-out" mortgage refinancing or default.[18]

The initial housing value is captured by three parameters: the house size (h), the time 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

$$L = \begin{cases} (1 - \theta_n^D) e^{g(n-1) + \tilde{p}_n} h & \text{if } \ n \in [1, R] \\ 0 & \text{otherwise} \end{cases} \tag{8}$$

[16] As suggested in Nakajima and Telyukova (2012), only a very small proportion of renters purchase a home late in life.

[17] A 30-year fixed rate mortgage is common in the U.S. and modeled in Chambers, Garriga, and Schlagenhauf (2009a).

[18] For mortgage refinancing, see Agarwal, Driscoll, and Laibson (2013) and Chen, Michaux, and Roussanov (2013).

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. The mortgage payment in a given period j is defined as

$$M_j = \begin{cases} \frac{r_m L(1+r_m)^N}{(1+r_m)^N - 1} & \text{if } \ n \in [1, R] \ \text{ and } n \leq j \leq (n+N-1) \\ 0 & \text{otherwise} \end{cases} \tag{9}$$

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

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

and

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

Moreover, for a house size h we can compute the remaining loan principle, LL, in any period j after mortgage payment in period j. We have

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

The model generates endogenous house trades. To capture the illiquid nature of a house we assume that selling a house and buying a house are associated with a transaction cost equal to a fraction θ^S and θ^B of the 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.[19] Homeowners also pay annual maintenance costs (a proportion δ of the house value) and the property tax (at rate τ).

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

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

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

$$x_j = \begin{cases} \phi P_j h & \text{if } DR_{j-1} = DR_j = 1 \\ \phi P_j h_j + LL_{j-1} - (1-\theta^S) P_j h_{j-1} & \text{if } DR_{j-1} = 0 \text{ and } DR_j = 1 \\ M_j + \left(\theta^B + \theta^D_j + \tau + \delta\right) P_j h_j & \text{if } DR_{j-1} = 1 \text{ and } DR_j = 0 \\ M_j + (\tau + \delta) P_j h_j & \text{if } DR_{j-1} = DR_j = 0 \text{ and } h_j = h_{j-1} \\ M_j + \left(\theta^B + \theta^D_n + \tau + \delta\right) P_j h_j & \text{if } DR_{j-1} = DR_j = 0 \text{ and } h_j \neq h_{j-1} \\ +LL_{j-1} - (1-\theta^S) P_j h_{j-1} & \end{cases} \tag{13}$$

where M_j is the mortgage payment in period j as defined in equation (9), and LL_{j-1} is the remaining loan principle in period $j-1$ defined in equation (12).

3.4 Taxable Accounts and Tax-deferred Accounts

All households are assumed to have access to both regular taxable accounts (TA) and tax-deferred accounts (TDA).[20] In their working lives, households can contribute their pre-tax labor income to the TDA up to a limit, which is a fraction $\bar{q}$ of current income. Households are not allowed to borrow against assets held in TDA. However, assets in TDA can be withdrawn prior to certain age at the cost of a penalty rate $pen \in (0, 1)$ in addition to the ordinary income tax incurred.[21] During their retirement periods, households are not allowed to contribute to TDA. They decide the amount of withdrawals from TDA and pay tax on the withdrawals at ordinary income tax rate. There is a minimum required distribution after certain point during retirement.[22]

The amount of assets in TDA at the beginning of period j (before current contributions/withdrawals) is denoted by a^D_j . Let q_j denote a household's contributions to (withdrawal from) TDA in period j. A positive value of q_j implies the household makes contri-

[20] We do not consider retirement accounts with after-tax contributions, such as ROTH IRA.

[21] Distributions before age $59\frac{1}{2}$ are subject to penalties (with exceptions such as death and disability) for many tax-deferred accounts.

[22] According to the current regulations in the United States, individuals must begin to take withdrawals by age $70\frac{1}{2}$.

butions to TDA, while a negative value means withdrawals. Thus,

$$q_j \in \begin{cases} \left[-a_j^D, \bar{q} * Y_j\right] & \text{if } j \leq R \\ \left[-a_j^D, 0\right] & \text{if } j \geq R+1 \text{ and } j \leq R+6 \\ \left[-a_j^D, -\frac{1}{J-j+1} a_j^D\right] & \text{if } j > R+6 \end{cases} \tag{14}$$

where $\frac{1}{J-j+1}$ imposes a minimum withdrawal rate after a certain period during retirement.

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 contribution (q_j^E) is

$$q_j^E = \begin{cases} \min(\tilde{q} * q_j, \tilde{q} * 0.06 * Y_j) & \text{if } j \in [1, R] \textit{ and } q_j > 0 \\ 0 & \text{otherwise} \end{cases} \tag{15}$$

We do not consider the household's portfolio choice (stocks vs. bonds) in either account and simply assume assets earn a constant rate of return, r, in both TDA and TA. The law of motion of assets in TDA is

$$a_{j+1}^D = \begin{cases} (1+r)(a_j^D + q_j + q_j^E) & \text{if } \ j \leq R \\ (1+r)(a_j^D + q_j) & \text{if } \ j > R \end{cases} \tag{16}$$

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

$$a_{j+1}^T = (1+r)\left[a_j^T - c_j - x_j - q_j - \Gamma_j\right] + Y_{j+1} \tag{17}$$

where x_j is household's expenditure on housing defined in equation (13) 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

$$a_j^T \geq Y_j \text{ and } a_j^D \geq 0 \text{ for all } j. \tag{18}$$

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

$$W_j = \begin{cases} a_j^T + a_j^D + (1-\theta^S)P_j h_{j-1} - LL_{j-1} & \text{if } DR_{j-1} = 0 \\ a_j^T + a_j^D & \text{if } DR_{j-1} = 1 \end{cases} \tag{19}$$

3.5 Taxes

A household's tax liability consists of three parts. First, household income is taxed through a piece-wise linear progressive tax system, $T(\cdot)$. Taxable income is defined as the sum of interest income in TA, the household's labor income (net of TDA contributions), 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 taxation is defined as taxable income minus total deductions such that

$$AGI_j = \begin{cases} r\left(\frac{a_j^T - Y_j}{1+r}\right) + Y_j - q_j - I_j - \tau P_j h & \text{if } DR_j = 0 \\ r\left(\frac{a_j^T - Y_j}{1+r}\right) + Y_j - q_j & \text{if } DR_j = 1 \end{cases} \tag{20}$$

where q_j is the contributions to (withdrawals from) TDA, I_j is mortgage interest payments defined in equation (11), 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 where IC_1 corresponds to personal exemptions. 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 earnings limit up to which earnings are subject to payroll tax. Third, for households who withdraw funds from TDA before age $R-4$, the penalty payment incurred should also be included in the tax payments. Hence, the total tax liability of a household is defined as

$$\Gamma_j = \begin{cases} T(AGI_j) + \min(\tau_{ss} * Y_j, \tau_{ss} * Y_{ss}) - pen * q_j & \text{if } q_j < 0 \text{ and } j < R-4 \\ T(AGI_j) + \min(\tau_{ss} * Y_j, \tau_{ss} * Y_{ss}) & \text{otherwise} \end{cases}. \tag{21}$$

3.6 Household Problem

In each period j, households choose their consumption (c_j), contributions to (withdrawal from) TDA (q_j), housing tenure choice (DR_j), housing size (h_j), and down payment (θ_n^D). The decisions are based on ten state variables: period j, the aggregate income shock (η_j), the idiosyncratic income shock (ε_{ij}), the wealth level in the TA at the beginning of the period (a_j^T), the wealth level in the TDA at the beginning of the period (a_j^D), housing tenure choice last period (DR_{j-1}), housing size last period (h_{j-1}), the period in which 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 it made at the time of purchase (θ^D). The household's decision problem in recursive form is written as

$$\begin{aligned}
& V(j,\eta_j,\varepsilon_j,a_j^T,a_j^D,DR_{j-1},h_{j-1},n,\tilde{p}_n,\theta_n^D) \\
= & \max_{c_j,q_j,DR_j,h_j,\theta_n^D} \frac{\left(c_j^{1-\omega}h_j^{\omega}\right)^{1-\gamma}}{1-\gamma} \\
& +\beta s_{j+1}E_j\left[V(j+1,\eta_{j+1},\varepsilon_{j+1},a_{j+1}^T,a_{j+1}^D,DR_j,h_j,n,\tilde{p}_n,\theta_n^D)\right] \\
& +\beta(1-s_{j+1})\frac{(W_{j+1})^{1-\gamma}}{1-\gamma} \qquad (22)
\end{aligned}$$

subject to income processes (2) to (5) and constraints (6) to (21), in addition to the non-negativity constraint on consumption. A more detailed explanation about the decision problem conditional on 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 set at 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. The variable ω measures a household' preference for housing relative to non-durable consumption goods. Following Li and Yao (2007) and Yao and Zhang (2005), it is set at 0.2.

4.2 Income Process

For the labor income process, we first need to specify the age-earnings profile and the median income of households in period 1.

It is a common practice to estimate different labor income profiles for different education groups (college graduates, high-school graduates, and those without a high-school degree). 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 less than high school is small, in the model 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 all period 1 households in the model is set at $38,000.

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).[23]

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 minimum house size and the distribution of house size, we look at households in the 2007 SCF that satisfy the following conditions: (1) households own houses and have assets in TDA, and (2) household heads are at age group 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 distribution 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 δ is set at 1.5% as in Yao and Zhang (2005). The house transaction cost parameter 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%. For renters, we set the rental cost at 6.5% of the value of the house, which falls in the range 6.0-7.5% used in the literature (Li and Yao (2007) and

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

Yao and Zhang (2005)).

Buying a house requires a long-term mortgage. Following Chambers, Garriga, and Schlagenhauf (2009a), we model the mortgage as a traditional fixed rate mortgage with a length of N=30 years. We set the mortgage interest premium at 2.7%, according to the average mortgage interest premium over the certificate of deposit rate from 1998 to 2007 reported by IMF (2010). As the rate of return for savings in both TA and TDA is set at 2%, the mortgage interest rate r_m is 4.7%. The minimum down payment ratio θ^D is set at 10% as in Yang (2009). However, households in the model can choose to pay a higher down payment as specified in equation (7).

4.4 Tax-deferred Accounts

Households can make contributions to TDA only during their working periods. Using data from the Survey of Income and Program Participation, Smith, Johnson, and Muller (2004) report that the median contribution rate for TDA participants between 1990 and 2001 was about 6.0%. Joulfaian and Richardson (2001) also find that 85% of households contributed less than 10% of their income and the average employee contribution rate is 5.9%. Hence, we set the contribution limit, $\bar{q}$, to 8% of annual labor earnings before retirement. We will conduct sensitivity analysis in a later section by increasing the contribution limit. 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).[24] Adding employee contributions and employer matching together, 10% of an employee's labor income can be contributed to TDA each period in the benchmark model. Following Zhou (2009), the early withdrawal penalty, *pen*, is set at 10% as stated in the US regulations.[25] We assume mandatory TDA withdrawal starts at age 70, i.e. $R + 7$.

4.5 Income and Payroll Taxes

For the income tax, our strategy is to mimic the federal income tax code in the United States, prevailing in 1993 - 2000. Table 2 describes the cutoff points of the tax brackets and marginal tax rates used. There are five tax brackets, with marginal tax rates of 15%, 28%, 31%, 36%, and 39.6%. We set the taxable income thresholds at \$40,000, \$100,000, \$150,000,

[24]The matching rate is lower than a typical matching rate, which is 50% of an employee's contributions (up to 6% of the employee's income). This reflects the fact that not all employers provide matching.

[25]We do not model penalty-free early withdrawals from TDA since the magnitude of these withdrawals is very small in reality.

and \$260,000, respectively, which were roughly the thresholds during 1993-2000. To find the corresponding tax brackets in terms of taxable income, which is the adjusted gross income (AGI) defined in equation (21), we also need to approximate personal exemptions present in the actual tax code. We take the case of a household comprised of a couple filing jointly and set total personal exemptions to \$5,600, which is the case in 2000. We normalize the median income in period 1, \$38,000, as 1.

Households also need to pay payroll tax. We use the historical payroll tax rates and maximum taxable earnings for payroll tax. The tax rates on employees from the Old-Age, Survivors, and Disability Insurance (OASDI) program in 1968–2007 are used here.[26]

5 Benchmark Results

The model is solved using numerical dynamic programming techniques. In this section we focus on the stationary distribution of simulation results in the benchmark model.[27]

The home ownership rate for each age group is presented in Figure 3. The model generates home ownership rates that are similar to the data for households between age 35 and 64. 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 homes 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 debts including student loans, which are amortized with favorable interest rates. 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, as shown in Figure 4. It generates a decreasing fraction of net worth in housing equity, an increasing fraction in TDA wealth, and 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 a lower down payments.

[26]For households' initial wealth a_0^T in the model, we look at households with heads aged 23–24 in the 2001–2007 SCFs. We 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.

[27]Simulation results and data are reported in Table 3.

Second, the TDA/net worth ratio in model is higher than that in 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 age 55-64 have TDA throughout their worklives and be able to utilize that to the full extent.[28] In this sense, our model predicts that the importance of TDA wealth for future generations will be much higher as they will spend more of their working life covered by TDA. Our model also shows that homeowners have higher income than renters. The median income for homeowners is 1.93 times of that for renters in the model, which is close to 1.81 times reported in the 2007 SCF. In general, the renters held more wealth in TDA than in TA, which is consistent with the data.[29]

Overall, our benchmark results closely resemble the facts presented in section 2. In this sense, the benchmark model performs reasonably well, especially given that our parameter values are strongly restricted to those in the existing literature. In next section we evaluate household behavior based on the benchmark model.

6 Experiments

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

6.1 Changes in TDA 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.

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

[29] Detailed results for renter's net worth composition is available upon request.

6.1.1 No Employer Matching

Employees' contributions to TDA is partially matched by most employers. Employer matching is one of the most attractive aspects for making contributions to TDA because it can be viewed as immediate returns on employees' TDA 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 households' contributions in the benchmark model to 0%, i.e. $\tilde{q} = 0$.

As expected, the median net worth for households drops after employer matching is eliminated. Overall, the median net worth decreases by 5.4%. The fraction of net worth in TDA decreases by 25.8%, while the fraction in TA increases by 19.4%. Ownership decision is affected to a lesser extent and increases by 1.2%. For homeowners, the home-equity net-worth ratio rises by 12.7% and the fraction of home equity in home value increases by 2.6%, which indicate that home equity became more important in household wealth. Overall, our results suggest that households shift part of their wealth from TDA to home equity when there is no empoyer matching.

Regarding households' life-cycle profile, TDA share of net worth drops in all age groups compared to the benchmark while TA share of net worth increases. The 25–34 age group has both the biggest drop in TDA share of net worth (57.4%) and the strongest increase in TA share of net worth (95.0%). These changes are likely 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 future down payments. 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.

6.1.2 Eliminating TDA

As shown in the above section that employer matching has significant influence on household's use of TDA, we extend our analysis to investigate how the existence of TDA affects households' savings decisions and housing tenure choice. To do this we consider the impacts of eliminating TDA from the model. In this experiment, households can no longer contribute to TDA, losing access to TDA's tax benefits and employer matching.

We find that households' net worth substantially decreases by 18.2% as they accumulate less savings. TA wealth as a substitute of TDA increases dramatically. The home ownership rate plummets by 31.5% and the median income of homeowners is 11.4% higher than in the benchmark. For homeowners, they allocate much bigger shares of their wealth to housing equity so as to reduce mortgage interest payments. Overall, the fraction of equity in net worth and in home value increase by 36.3% and 76.5%, respectively.

These findings suggest that in the presence of TDA, households tend to borrow earlier (in terms of mortgages) and become homeowners. They pay lower down payments and borrow more to buy houses. This is because they also contribute to TDA during the mortgage term so that they can take advantage of preferential tax treatments for both home ownership and TDA. However, when there is no TDA, a significant portion of households are delaying their home purchases. These households choose to accumulate more TA wealth for a higher down payment in the future so that they can lower their mortgage interest payments. Some other households will not be homeowners over their lifetime when there is no TDA. Hence, home ownership rate is higher when TDA exists than in the case where there is no TDA. Note that the drop in home ownership and increase in TA wealth for age groups 25–34 and 35–44 are more significant than older age groups when there is no TDA.

In contrast to the above experiment with no employer matching, eliminating TDA induces significantly more vigorous response, particularly in terms of home ownership and the equity share of home value. These results indicate that TDA's tax-deferring and tax-free compounding growth properties are more important than employer matching in influencing households' decisions.

6.1.3 Higher TDA Contribution Limit

We further investigate the effects of increasing TDA contribution limit for retirement savings in the U.S. This experiment focuses on the amount of households' savings in TDA (the intensive margin). The TDA contribution limit ($\bar{q}$) is increased by 50%, from 8% to 12% of household annual income. Employer's matching rate (33.3%) is kept the same as in the benchmark model.

Overall, an increase in TDA contribution limit has very limited impact on household wealth accumulation. The median net worth of working age households only increases slightly (0.9%), with older age groups exhibiting slightly bigger increases, which suggests that some older households reach their TDA contribution limit in the benchmark. An increase in TDA contribution limit has a larger impact on the composition of net worth. As expected, a higher TDA contribution limit allows households to increase savings in TDA. 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. When the TDA contribution limit increases, the home ownership rate and the median income of owners are the same as in the benchmark model. Only a samll decrease in the importance of home equity is observed for older homeowners. 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. Homeowners do not change their mortgage financing decisions as indicated by the home-equity-home-value ratio.

6.2 Changes in the Housing-related Factors

Housing-related factors considered in this section are categorized into those about the cost of housing service and those about housing as a saving vehicle. Results are reported in Table 5.

6.2.1 Increase in Down Payment Requirement

As shown in the life-cycle composition of net worth, homeowners have large fraction of wealth accumulated in home equity. Especially for young owners, majority of their net worth is in home equity due to the lumpy down payment they make for purchasing a home. This down payment requirement represents a significant barrier for home ownership. We investigates the impacts 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 become $\theta^D \in \{0.2, 0.5, 0.75, 1.0\}$.

Overall, raising down payment requirement reduces home ownership rate by 6.8%, while the median household net worth is down by 0.2%. 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 the results are driven by the impacts on households in age 25-34, and the effects quickly faded away with older age groups. Focusing on the 25-34 age group, home ownership rate decreases by 27.2% as households have to save more for higher down payment and defer their home purchases. The median net worth drops by 11.5% for these young households because many of them do not make the lumpy down payment anymore. The fractions of net worth in TA and TDA have increased, with a bigger increase in TA which will be reallocated for down payment 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%.

6.2.2 Increase in Rental Cost

As we showed that down payment requirement significantly affects households' saving decision, we further 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 home ownership rate increases by 6.1%, and the median household net worth rises by 6.2%. Home purchases are financed by a combination of new savings and shifting assets from other accounts. The fractions of net worth in TDA and TA decrease by 4.3% and 7.0%, respectively.

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 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 (20) becomes

$$AGI_j = r\left(\frac{a_j^T - Y_j}{1+r}\right) + Y_j - q_j \quad \text{for } DR_j \in \{0,1\}. \tag{23}$$

As a result, home ownership on average drops by 19% since the cost of ownership increases. As fewer households accumulate wealth in housing (mainly through down payments and capital gains), the overall household net worth decreases by 7.8%. The effect is strongest for households in age 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 consistent with Poterba and Sinai (2008) and Gervais (2002).

Our 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 net-worth ratio decreases by 4.4% (the level of TDA wealth also drops compared to that in the benchmark). Households first 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.[30] Overall, the fraction of equity in home value for homeowners increases by 45.0% and the home equity net-worth increases by 6.5%.

6.3 Eliminating Social Security

Social security benefits is an important source of retirement income for the majority of households. Eliminating the social security system increases households' needs of savings for retirement. The impacts of such policy change has been studied extensively (See Fuster, Imrohoroglu, and Imrohoroglu (2007) and Chen (2010) among others), but its effect on households' wealth composition is still largely unexplored. We conduct an experiment of eliminating both the payroll tax on income and social security benefits after retirement, i.e. $\tau_{ss} = 0$ and $\lambda_{COL} = \lambda_{HS} = 0$.

Results are reported in Table 6. Household net worth in all age groups increases significantly, and overall the median net worth is 88.3% higher than in the benchmark. Households are no longer required to pay payroll taxes and their increased savings needs for retirement induces them to accumulate more wealth in TDA, TA, and housing. The fraction of net worth in TDA decreases despite the level of wealth in TDA increases. This suggests that households' net worth grows faster than TDA wealth. One likely reason is that some households are bounded by the TDA contribution limit and they allocate more wealth to other assets. The amount of wealth in TA increases substantially by 76.2%. The home ownership rate rises by 15.0% as lower income households also become homeowners, with the median income of homeowners decreases by 6.0%. For homeowners, they rely more on equity to

[30] As the model abstracts from mortgage pre-payment, making bigger down payment at the time of home purchase is the way for reducing mortgage interest payments.

finance their homes, as the fraction of equity in home value increases by 30.6%. And yet, the fraction of home equity in net worth decreases by 15.0% for homeowners as the elimination of social security increases non-social security net worth for these homeowners substantially.

On life-cycle decisions, although wealth accumulated in TDA increases, the TDA-net worth ratio is generally lowered for all age groups, except age group 35–44. Changes in TA wealth level is more significant. Compared to the benchmark, the TA share of net worth is much higher when there is no social security, except for the youngest age group of 25–34. Home ownership rate for this young age group increases by 30.0% (the median household is an owner now compared to being a renter in the benchmark), which is the largest increase among all age groups. The increase in ownership comes from households with lower income. The median income of homeowners in age 25-54 is about 92% of the benchmark level while that of age 55-64 homeowners are 97.6%, which suggests that households advance their home purchase decision to earlier stage of their lives.

We also consider eliminating social security in a model *without* TDA to illustrate that omitting TDA could bias the analysis on household wealth accumulation and housing tenure choice. In this case, we treat the model without TDA ($\bar{q} = 0$) as the baseline and study changes in decisions when social security is removed. Results are reported in Table 7. We find that the median net worth is more than doubled and the home ownership rate increases by 27.4% when social security is removed in a model without TDA. Compared to Table 6, the results suggest that the impact of eliminating social security is much larger in the model without TDA than in a model with TDA.

7 Conslusion

We develop a life-cycle model in which households can accumulate wealth in TDA, TA, and home equity. Departing from existing literature, households' use of TDA and their housing tenure choice are both endogenous decisions. Households in the model face uninsurable earnings risk and housing price risk. Buying a house requires a traditional long-term mortgage with down payment requirement and committed per-period mortgage payments. The model also features a progressive income tax system that mimics the U.S. tax codes and favorable tax treatments on TDA and home ownership.

Consistent with the data, our model generates an increasing home ownership rate before retirement. It also accounts for the life-cycle pattern of homeowners' net worth composition regarding home equity, TDA wealth, and TA wealth. The home equity-to-net worth ratio is the highest for young homeowners, and it drops as age goes up. On the other hand, TDA share of net worth increases with age for homeowners and TA share is relatively small. In addition, the model is consistent with the data in that income being larger for homeowners than the renters.

We then evaluate household behavior in the presence of housing and TDA based on the benchmark model. We conduct a series of experiments on retirement-related polices and housing-related policies to evaluate the relative impact of various factors on the housing tenure choice and the composition of household net worth. Results of the counterfactual experiments provide new insights into households' responses to different policy changes commonly considered in the literature. This serves as an important step for better understanding the macroeconomic impacts of retirement-related and housing-related policies. We examine the interactions between housing tenure choice and households' use of TDA in a partial equilibrium setup in this paper. While extending our work to a general equilibrium framework can shed light on price effects and welfare analysis, 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. The specific variables used are given below.

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 debts associated with TA which include credit cards, education loans, borrowing in brokerage accounts and other consumer loans.

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). 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 mortgage on principal residence.

Finally, a household's net worth is the sum of home equity, TDA wealth and TA wealth. Once we find the net worth, we then compute the composition of net worth for households in each survey.

Appendix B: Household Problem

The recursive formulation of household's problem specified in equation (22) depends on household's endogenous tenure choice. We specify five different scenarios with respect to household's home ownership status and the 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 household who rents in both period $j-1$ and j (i.e., $DR_{j-1} = DR_j = 1$). The Bellman equation for this situation is given by

$$\begin{aligned}
& V(j, \eta_j, \varepsilon_j, a_j^T, a_j^D, 1, h_{j-1}, 0, 0, 0) \\
= \; & \max_{c_j, q_j, h_j} \frac{(c_j^{1-\omega} h_j^{\omega})^{1-\gamma}}{1-\gamma} + \beta s_{j+1} E_j \left[V(j+1, \eta_{j+1}, \varepsilon_{j+1}, a_{j+1}^T, a_{j+1}^D, 1, h_j, 0, 0, 0) \right] \\
& + \beta(1 - s_{j+1}) \frac{(W_{j+1})^{1-\gamma}}{1-\gamma} \qquad (24)
\end{aligned}$$

2. Consider household who owns 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

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

3. Consider 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

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

4. Consider homeowner who maintains the current house size (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 cannot be changed. The Bellman equation for this situation is given by

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

5. Consider 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 for the existing home(θ_n^D) is a state variable, but that for the new home (θ_j^D) is a choice variable. The Bellman equation for this situation is given by

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

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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%	IMF (2010)
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	see text	OASDI tax rate on employees
Y_{ss}	Earnings limit for payroll	see text	Maximum taxable earnings

Table 2: Cutoff Points and Marginal Tax Rate

Taxable Income (AGI)	Normalized Income	Marginal Tax Rate
($0, $5600]	(0, 0.187]	0%
($5600, $45600]	(0.187, 1.520]	15%
($45600, $105600]	(1.520, 3.520]	28%
($105600, $155600]	(3.520, 5.187]	31%
($155600, $265600]	(5.187, 8.853]	36%
> $265600	8.853 +	39.60%

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

Table 3: Results of the Benchmark Model for Homeowners

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

Notes: Data refers to the 2001, 2004 and 2007 Survey of Consumer Finances (SCF). TDA is defined as the sum of all assets in DC plans and IRAs. Home equity refers to that of households' principal residence. We calculate the *median* net-worth ratios in each SCF and report the average of the median values across all years. Since the net-worth 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: Changes in TDA Policies

	Age Group				
	25-34	35-44	45-54	55-64	Overall
No employer matching 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 owners	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
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 owners	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 owners	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

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. TDA net-worth ratio, TA net-worth ratio and the percentage of home ownership refer to all households, while home-equity net-worth and home-equity home-value ratios are calculated for *homeowners only.*

Table 5: Changes in Housing-related Factors

	Age Group				
	25-34	35-44	45-54	55-64	Overall
Increase 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 owners	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 owners	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 owners	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. TDA net-worth ratio, TA net-worth ratio and the percentage of home ownership refer to all households, while home-equity net-worth and home-equity home-value ratios are calculated for *homeowners only.*

Table 6: Eliminating Social Security in Model with TDA

	Age Group				
	25-34	35-44	45-54	55-64	Overall
Net worth	1.737	1.661	1.632	1.712	1.883
TDA/net worth	0.908	1.042	0.947	0.881	0.949
TA/net worth	0.871	1.308	1.588	2.965	1.762
% of home ownership	1.300	1.169	1.091	1.111	1.150
Median income of owners	0.920	0.917	0.923	0.976	0.940
Home equity/net worth	0.937	0.858	0.882	0.796	0.850
Home equity/home value	1.105	1.157	1.271	1.053	1.306

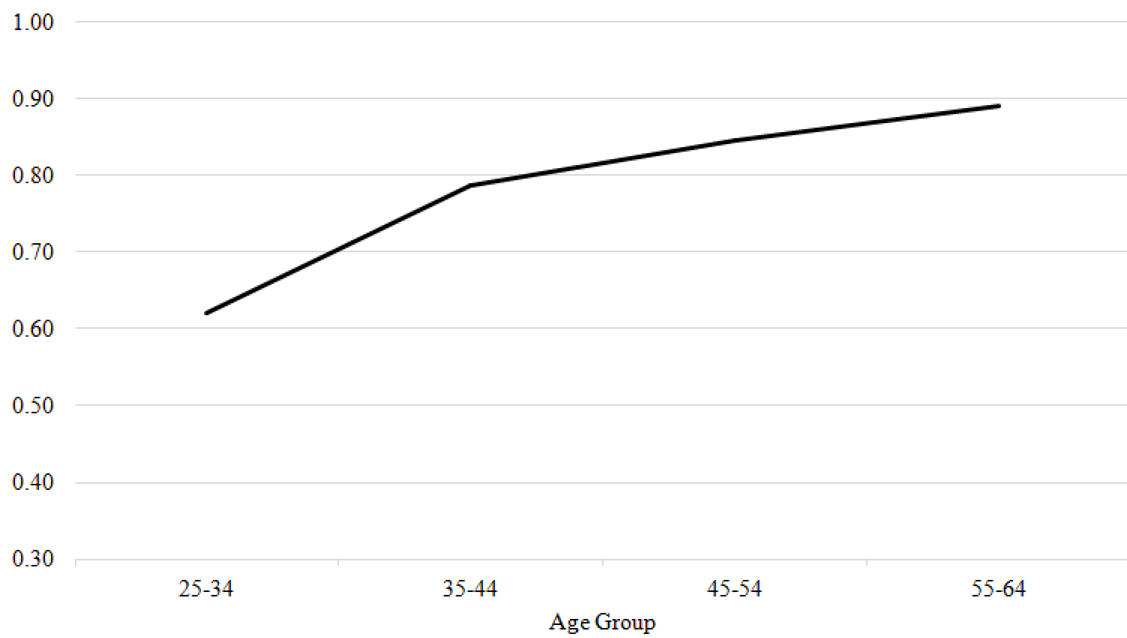
Note: All our results, except the home ownership rate, are the median values with respect to different age groups. Values for the benchmark model are normalized to 1, such that all the experiment results reported are levels relative to the benchmark model. TDA net-worth ratio, TA net-worth ratio and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

Table 7: Eliminating Social Security in Model *without* TDA

	Age Group				
	25-34	35-44	45-54	55-64	Overall
Net worth	2.235	1.916	1.793	1.855	2.226
TDA/net worth	.	.	.	.	.
TA/net worth	1.000	0.555	1.223	1.530	0.729
% of home ownership	1.247	1.292	1.321	1.229	1.274
Median income of owners	0.942	0.884	0.925	0.959	0.900
Home equity/net worth	0.941	0.916	0.784	0.648	0.770
Home equity/home value	1.394	1.058	1.000	1.000	1.000

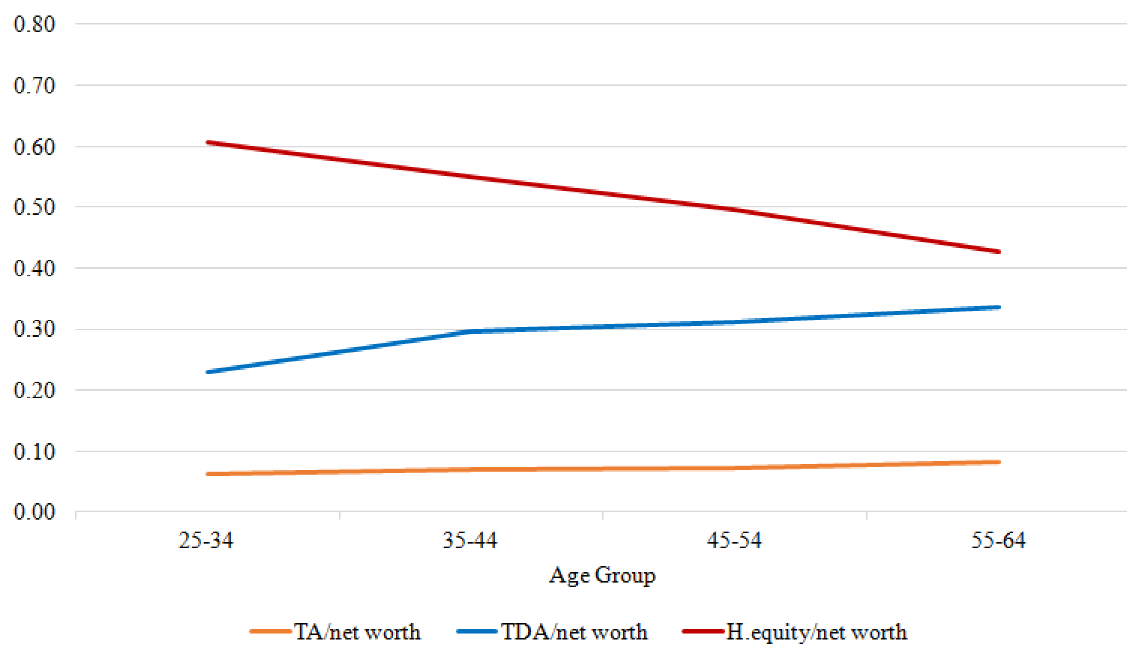
Note: All our results, except the home ownership rate, are the median values with respect to different age groups. Values for the model without TDA are normalized to 1, such that all the experiment results reported are levels relative to the economy *without* TDA. TA net-worth ratio and the percentage of home ownership refer to all households, while home-equity net-worth and home-equity 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

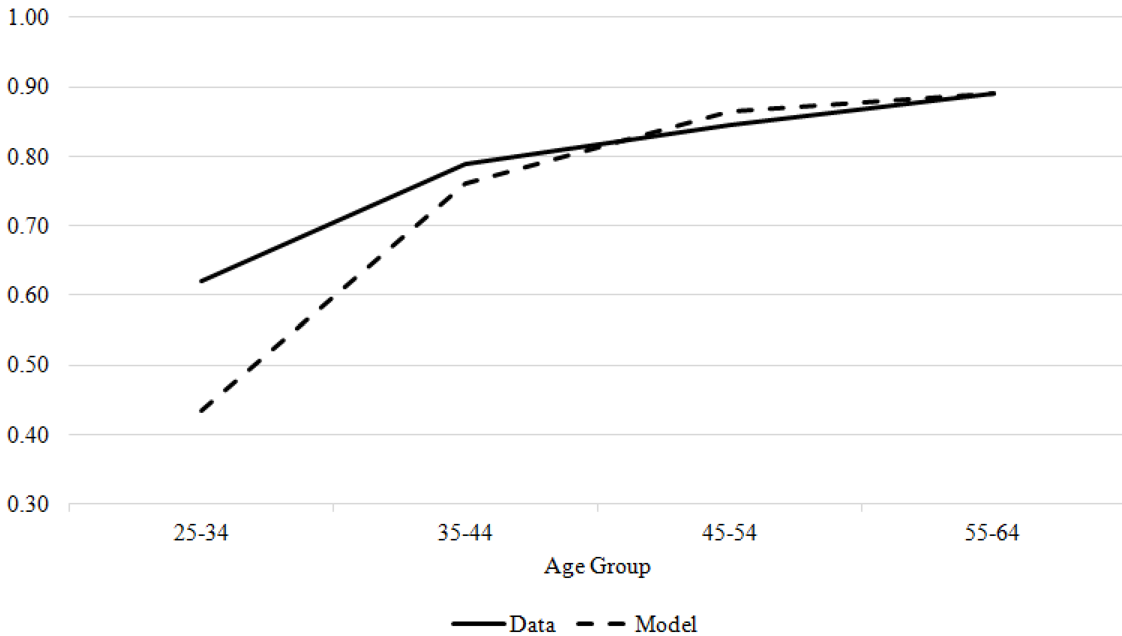


Figure 4: Net worth composition by age group for DC participants who are homeowners: median