Optimal Savings with Taxable and Tax-Deferred Accounts*

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November 2006

*We would like to thank Joao Cocco, Franck de Jong, Otto van Hemert, Deborah Lucas, Randi Rosenblatt, Chester Spatt, Harold Zhang and seminar participants at the Federal Reserve Board of Governors, Econometric Society meetings in Boston, U of Cincinnati, U of Houston, LSE, UT Dallas, Toulouse, and the NBER Summer Institute Capital Markets and the Economy workshop for helpful comments and discussions. Polkovnichenko acknowledges support from a McKnight Business and Economics research grant at the University of Minnesota and hospitality of the Financial Markets Group at LSE. Gomes is at the London Business School, Regent's Park, London NW1 4SA, United Kingdom. E-mail: fgomes@london.edu. Michaelides is at the Department of Economics, London School of Economics, Houghton Street, London, WC2A 2AE, United Kingdom. Email: A.Michaelides@lse.ac.uk. Polkovnichenko is at the Department of Finance and Managerial Economics, University of Texas at Dallas, School of Management SM31, P.O.Box 830699, Richardson, TX 75083-0699. E-mail: polkovn@utdallas.edu. All errors and omissions are sole responsibility of the authors.

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Abstract

We use a calibrated life-cycle model with earnings risk and liquidity constraints to study the role of tax-deferred retirement accounts (TDAs) in life cycle savings behavior. We find that they promote higher wealth accumulation but not higher net savings. Consumption increases mostly during retirement, as desired, but the effect is largest for those households with higher savings rates already. The cost of maintaining a constant TDA contribution rate is small, but the optimal rate differs substantially across households: a 'one-size-fits-all' rule does not exist. Fully exhausting employer-matching contributions, as typically recommended by financial advisors, is highly suboptimal for most households, which is consistent with the data. Moreover, employer-matching schemes actually discourage savings as the corresponding income effect dominates.

JEL Classification: E21, G11

Key Words: Tax-Deferred Accounts, Retirement Savings, Liquidity Constraints, Portfolio Choice, Uninsurable Earnings Risk.

1 Introduction

Individual tax-deferred retirement accounts in the US pension system have grown considerably during the last two decades.[1] As more households rely on defined contribution plans to finance their retirement expenditures, understanding the influence of tax-deferred accounts on individual decisions and on aggregate economic activity becomes increasingly important. In this paper we build a life-cycle model with taxable and tax-deferred accounts to study several important economic questions about tax-deferred retirement savings accounts.

We start by showing that our model captures some key features of the household-level data. In particular, it replicates several stylized facts on wealth accumulation, portfolio choice and stock market participation. The model integrates three main motives that have been identified as quantitatively important in explaining individual and aggregate wealth accumulation: a precautionary, a retirement and a bequest motive.[2] These motives vary in importance among two distinct household groups: *indirect* and *direct* stockholders. Indirect stockholders own stocks only in their tax-deferred accounts, while direct stockholders hold equities in their taxable accounts (and may also own stocks in tax-deferred accounts). Empirical evidence from the Survey of Consumer Finances (SCF) shows that these two groups have different wealth accumulation profiles and portfolio allocations. In particular, indirect

[1] According to the Investment Companies Institute 2006 Fact Book (www.icifactbook.org), as of December 2005, the defined contribution plans accounted for \$7.4 trillion which is over 50% of all retirement assets of \$14.3 trillion. Defined-contribution plans include various accounts with individually-directed asset allocation such as IRAs, Keogh plans, employer-sponsored plans 401(k) and 403(b), and 457 deferred compensation plans.

[2] Precautionary savings are induced by the desire to smooth shocks from undiversifiable labor income risk (following the literature initiated by Deaton (1991) and Carroll (1992, 1997)). The combination of precautionary and retirement saving motives has recently been shown to generate realistic wealth accumulation profiles over the life cycle (see, for instance, Hubbard, Skinner and Zeldes (1995a, 1995b), Carroll (1997), Gourinchas and Parker (2002), Dynan, Skinner and Zeldes (2002), Cagetti (2003) and French (2004)). Bequests have been identified as important for matching the skewness of the wealth distribution (see, Laitner (2002), Castañeda, Giménez, and Ròos-Rull (2003) and De Nardi (2004)).

stockholders accumulate less wealth, especially in taxable accounts. To generate the differences in wealth accumulation observed in the data between direct and indirect stockholders, we introduce preference heterogeneity. More precisely, we allow for heterogeneity in the elasticity of intertemporal substitution, and in discount rates.

We calibrate the model to replicate limited direct stock market participation, and wealth accumulation and portfolio allocation over the life cycle, for these two groups. The implied calibration is then used as a benchmark to study the impact of TDAs along a number of different dimensions. For robustness and sensitivity analysis purposes, we also consider alternative parameter values. We find that, in the presence of tax-deferred accounts, wealth accumulation increases but household net savings (total income minus consumption) actually decrease. The income effect from the tax shelter dominates the substitution effect for a large range of preference parameters based on the previously calibrated values. The tax savings from the TDA generate higher wealth accumulation for the same savings rate and therefore households can enjoy a higher wealth-to-income ratio at retirement without having to decrease their working-life consumption. As a result, early in life the consumption patterns are essentially the same with and without the TDA, and at mid-life households already start to increase their consumption. Therefore the TDA wealth accumulation comes exclusively from the combination of a crowding-out effect on the TAs, and the income effect from the tax savings. This conclusion is very important since, if TDAs only generate higher total wealth accumulation due to the tax savings effect, then this might not carry-over to a general equilibrium analysis where those tax deductions have to be financed. The analysis in the paper is partial equilibrium in nature, and therefore we not will make claims about overall increases in wealth or savings.

Our main focus is instead on the differential impact of these accounts on life-cycle profiles, as all households will face the same potential changes in rates of return and wages (or even tax rates) that might arise in a general equilibrium analysis.[3] We find that the increased consumption occurs mostly during retirement. This is important because it shows that TDAs are effective in promoting a transfer of resources from working life to the retirement period, which is what they are designed to do. So, even though they do not promote additional household savings, the tax savings are used to finance extra retirement consumption. However, the households that are most responsive to these accounts are those that would already save more in their absence. Therefore TDAs will have a smaller impact on the households that save less for retirement in the first place. In addition, for those households, the increase consumption is almost exclusively concentrated in the first 15 years of retirement, so that they are still left with very little wealth to finance their old age.

Next, we compute the optimal contribution rates over the life-cycle for a large range of plausible preference parameter values and evaluate the impact of employer matching schemes. Early in life, when households are still liquidity constrained, these contributions are quite small for most preference configurations. Households with higher risk aversion, higher elasticity of intertemporal substitution or lower discount rate will contribute more to their TDAs, while the others will optimally finance all of their retirement savings in a small number of years, very close to retirement.

Interestingly, our results show that fully exhausting employer matching contributions, as typically recommended by financial advisors, is unjustified. The vast majority of households

[3] We acknowledge that there is still potential for some differences, for example due to the progressivity of personal income tax rates.

finds it optimal to give up (part of) the matching because it forces them to save too much. This behavior is most salient early in life, when current marginal utility is very high and saving in the TDA requires postponing consumption for several years. These results not only contradict popular financial advice, but also offer an explanation for the empirical observation that a significant fraction of participants in defined contribution plans do not take full advantage of the employer match (see Choi *et. al.* (2001)).

The employer matching schemes increase the return on the TDA investments by 100% for the contributions up to the matching limit, so this scheme is effectively equivalent to an increase in the rate of return received on those contributions. This then creates both an income and a substitution effect. On one hand investors want to increase their contributions to take advantage of the much higher return, but on the other hand that high return allows them to obtain the same level of future retirement wealth with lower savings and thus higher current consumption. We explore the relative impact of these two effects by comparing the average optimal contribution rates with and without employer matching. In line with the previous results regarding the impact of TDAs, we find that the income effect dominates for all the combinations of preference parameters that we have considered. Without any employer matching, households would have to contribute much more to their TDAs, to be able to accumulate their desired retirement wealth levels. When the employer matching is introduced, they are able to significantly cut down on their contribution rates and increase their working-life consumption which they strongly prefer.

Finally, we measure the welfare losses implied by following simple rules-of-thumb with fixed contribution rates over the life-cycle. Our main results are the following. First, the cost of following a fixed contribution rate is not large. The welfare losses are less than 0.6%

measured in certainty equivalent life-time consumption units. Second, this fixed contribution rate must be household-specific. A simple "one-size-fits-all" rule does not work: for some households the best (fixed) contribution rate is around 0.5%, while for others it is closer to 4%. As a result, the welfare losses from choosing the wrong value can be substantial. Third, if we impose a fixed contribution rate, it should be set lower than the average contribution computed from the optimal decisions. For example, households with an *average optimal* contribution rate of 5.5% would prefer a fixed contribution rate of 4% instead of 5%. This result is mostly driven by the liquidity constraints. For young households the marginal utility of current consumption is extremely high, and therefore a large transfer of resources for retirement is suboptimal.

This paper is part of a growing literature on portfolio choice with taxable and tax-deferred accounts. Dammon, Spatt and Zhang (2004) and Garlappi and Huang (2003) model endogenous capital gain realizations and are primarily concerned with normative aspects of asset location and allocation.[4] Amromin (2003) incorporates non-financial income in a stylized model and, as the above papers, also focuses on optimal asset location.[5] Our paper instead attempts to explain empirical patterns in portfolio choice, wealth accumulation and direct stock market participation, and focus on the impact of TDAs, and on the normative aspects of savings decisions and contribution rates.

[4]Additional research on the optimal asset allocation behavior in the presence of taxes and/or tax-deferred accounts includes Elton and Gruber (1978), Constantinides (1983 and 1984), Balcer and Judd (1987), Dybvig and Koo (1996), Huang (2001), Garlappi, Naik and Slive (2001), Dammon *et. al.* (2001a), Gallmeyer, Kaniel and Tompaidis (2006), and DeMiguel and Uppal (2003), among others.

[5]In Amromin (2003) each period corresponds to 5 years and labor income uncertainty is modeled exclusively as an unemployment shock. In our paper we have a realistically calibrated labor income profile, with both permanent and transitory shocks. We separately model the decisions of direct and indirect stockholders and we use Epstein-Zin (1989) preferences that enable us to disentangle risk aversion from the elasticity of intertemporal substitution. The combination of these three features is crucial for matching wealth accumulation and portfolio choice simultaneously.

The paper is organized as follows. Section 2 describes the empirical evidence on wealth accumulation and asset allocation. We present the model and calibration in section 3. Section 4 discusses the results for the baseline case and compares them with the data. Section 5 discusses the optimal contribution rates and the impact of TDAs on wealth accumulation and welfare. Section 6 concludes. In Appendix A we describe the construction of variables from SCF data, and in Appendix B we outline the numerical procedure used to solve the model.

2 Empirical Evidence

2.1 The Data

We first investigate stock ownership and TDA participation among the US population using the Survey of Consumer Finances database for 1989, 1992, 1995, 1998, and 2001.[6] We divide households into two groups based on stock ownership: (*i*) *direct* stockholders (DS) who own taxable stocks/equity funds (note that these households also may own equities in the TDA); (*ii*) *indirect* stockholders (IS) who have equity *only* in the TDA (employer stock and/or funds with equity investments). We define TDAs as account-type pension plans, i.e. defined contribution plans where participants accumulate balances.

The distinction between direct and indirect stockholders is important for our subsequent theoretical analysis and is motivated by the following considerations. We present empirical evidence that stock market participation through the TAs and TDAs is undertaken by different types of households. Buying stocks and mutual funds "on your own" in the TA requires

[6]We do not use the first survey in 1983 because it does not have information about the type of mutual funds (equity vs. fixed income) in household portfolios. In computing the reported statistics we use all SCF imputations with corresponding population weights.

a certain degree of financial sophistication as well as sufficient funds to justify paying certain transaction costs. This intuition is usually captured in the limited stock market participation literature by using a fixed cost that represents a combination of explicit and implicit hurdles such as brokerage fees, information acquisition about various type of accounts and investment opportunities, more complicated tax filing and time spent on setting up, rebalancing, and monitoring the investment. In the context of the TDAs it is hard to justify such frictions, especially in the case of employer-provided retirement plans. TDAs simplify access to capital markets by providing a uniform, simple and virtually costless vehicle in which to invest one's savings for retirement. Thus, we would expect households that participate in the stock market *only* through the TDAs to have different financial characteristics from those that hold stocks directly.

In the data we find evidence consistent with the above argument and demonstrate three specific points. First, we show that since 1989 there has been considerable growth in stock market and TDA participation. Both direct and indirect stockholders contributed significantly to this growth. Second, the level of financial wealth and its distribution across taxable and tax-deferred accounts is substantially different for direct and indirect stockholders. Finally, we construct age profiles of wealth accumulation and portfolio allocation for direct and indirect stockholders and again find them to be different.

2.2 Stock market participation and tax-deferred accounts

We begin by considering trends in TDA ownership and stock market participation. Table 1 shows population dynamics for the two types of stockholders between 1989 and 2001. The table reports both the number of households and the fraction of households in the population assigned to each type.[7] There has been considerable growth in the combined number of stockholders (direct and indirect), rising from 32.2 million in 1989 to 56.3 million in 2001. As a fraction of the population, stockholders have increased considerably as well from 34.6% in 1989 to 52.9% in 2001. The table shows that this growth has been primarily coming from the *DS* with TDAs and the *IS*. Moreover, the fraction of direct stockholders without a TDA declined slightly over the period from 7.3% to 7% of the population. Between direct and indirect stockholders the growth has been slightly higher among direct stockholders. The number of stockholders with TDAs has increased considerably over the same period from 25.5 million (27.3%) in 1989 to 48.9 million (45.9%) in 2001.[8] We conclude from Table 1 that the increase in stock market participation in the US has been primarily driven by households with access to TDAs and that both direct and indirect stockholders have contributed significantly to this process.

2.3 Balances in taxable and tax-deferred accounts

We now compare financial wealth between direct and indirect stockholders. In measuring financial wealth we include relatively liquid financial assets and provide a detailed description of this variable in Appendix A. Table 2 reports typical balances (medians) by cohort in the TAs, TDAs and the sum of the two. The DS are significantly wealthier than the IS with the difference in wealth widening over time. A notable difference exists in the TA balances across the two groups. Specifically, IS have very small liquid balances in the TAs in all years. We also compute the distribution of aggregate TDA balances. In 2001, aggregate TDA wealth

[7]By definition, there are no households who are indirect stockholders and do not have a TDA, so the corresponding cells in the table are always marked with an empty sign "–".

[8]These figures capture the majority of households with TDAs. There is a small group (3-6%) of households who have TDAs but are not stockholders.

is split as 24.4% for the *IS* and 71.6% for the *DS*[9]. Thus, IS are not only significant as a fraction of the population, but also by aggregate TDA wealth accumulation.

2.4 Wealth accumulation and portfolio allocation over the life cycle

We construct age profiles for wealth and portfolio allocations according to the following age groups: (*i*) 35 and under; (*ii*) 36-50; (*iii*) 51-65; (*iv*) over 65. Using the 2001 SCF we construct Table 3 which shows separately for the TAs and TDAs the cross-sectional medians of wealth-income ratios and means/medians of the fractions of financial assets invested in stocks.[10] To construct wealth-income ratios we use all *non-financial* income which includes wages and salaries, proprietor's income, and various sources of government aid. Appendix A provides further details.

Panel A of Table 3 shows wealth-income ratios for each age group. Wealth-income ratios increase with age. After 65, wealth-income ratios "jump up" because by that age many people retire and non-financial income (the denominator in the ratio) declines substantially. Throughout the life cycle, DS have considerably higher taxable wealth compared to IS: taxable wealth differs by a factor of about $2.5 - 5.5$ across the two types in various age groups. In contrast, in the TDAs, wealth-income ratios are closer, probably due to caps on contributions to TDAs. Further, the historical access to TDAs has not been uniform across the age cohorts. Tax-deferred retirement plans have only become widespread during the

[9] The remaining small fraction (4%) is held by the nonstockholders with TDAs. We do not consider this group here.

[10] We use only the most recent SCF to maximize the number of households in the sample who had access to the TDAs during their working life. We report median rather than mean wealth-income ratios because the wealth distribution is heavily skewed. For portfolio shares, on the other hand, we report both means and medians because this variable is not as skewed as wealth.

1980's. For many older households, therefore, these plans were not available until they were close to retirement. This becomes important when matching simulated to actual data.

The age profiles of portfolio allocation to stocks (shown in panel B) are moderately declining with age. Comparing the allocation in TAs and TDAs for DS, we find that TAs have more conservative portfolios. For portfolio allocations we also report medians, which are consistently higher than the means. In retirement, DS portfolios become conservative while the TDA allocation to stock for IS remains flat. It is important to mention that the results in panel B do not control for time or cohort effects. We are just reporting cross-sectional results without taking a view on the relative importance of time or cohort effects.[11] Ameriks and Zeldes (2001) obtain very different profiles when controlling for time effects versus controlling for cohort effects. Without any prior view on their relative importance it is impossible to determine the correct profile. For the same reason these life-cycle profiles are mostly indicative rather than a clear feature of the data.[12]

2.5 Summary of empirical findings

We find that significant growth of TDAs and stock market participation in the 1980's and 1990's can be attributed equally to direct and indirect stockholders (DS and IS). Households participating in the stock market exclusively through TDAs (IS) are on average poorer than those holding stocks in their TAs (DS). DS have higher wealth to income ratios than IS at any point in the life cycle. The financial wealth of these two groups is split differently across TAs and TDAs. While the TDA wealth to income ratios are similar across the two types

[11] Since age (a), time (t) and cohort (c, birth year) are linearly dependent ($a \equiv t - c$), when constructing age profiles it is impossible to simultaneously identify time and cohort effects without further identification conditions (see Ameriks and Zeldes (2001) or Poterba and Samwick (1999))

[12] This was not an issue for the wealth-income ratios where the results have been found to be quite robust to the choice of controls.

throughout working life, the DS have more significant savings in the TAs while IS concentrate their savings mostly in the TDAs. The portfolio allocation in the TDA is similar across the two groups. For the DS, the shares invested in stocks is higher in the TDA than in the TA.

In the remaining sections of the paper we construct a theoretical model and calibrate it to replicate these stylized facts about wealth accumulation and portfolio allocation over the life cycle for direct and indirect stockholders. We then use the model to perform several normative experiments.

3 Model

3.1 Preferences

Time is discrete and t denotes adult age which, following the typical convention in the life-cycle literature, corresponds to effective age minus 19. Each period corresponds to one year and agents live for a maximum of $T = 81$ periods (age 100). The probability that a consumer/investor is alive at time $(t+1)$ conditional on being alive at time t is denoted by p_t ($p_0 = 1$ and $p_T = 0$). Households have Epstein-Zin-Weil utility functions (Epstein and Zin (1989), Weil (1990)) defined over a single non-durable consumption good. Letting C_t and W_t denote respectively consumption and the sum of cash-on-hand and TDA wealth at time t, the household's preferences are given by the following recursion:

$$V_t = \left\{(1-\beta)C_t^{1-1/\psi} + \beta\left(E_t\left[p_t V_{t+1}^{1-\rho} + (1-p_t)bW_{t+1}^{1-\rho}\right]\right)^{\frac{1-1/\psi}{1-\rho}}\right\}^{\frac{1}{1-1/\psi}} \quad (1)$$

where ρ is the coefficient of relative risk aversion, ψ determines the elasticity of intertemporal substitution and β is the discount factor. The continuation payoff in the event of death (that occurs with probability $1-p_t$) is the utility of bequest. The strength of the bequest motive is determined by the parameter b. The components of wealth are defined later in the paper. DS and IS will differ in their values of ψ and β.

3.2 Labor income process

The labor income process before retirement follows the standard specification in the life-cycle literature and is given by

$$Y_t = P_t U_t \tag{2}$$

$$P_t = \exp(f(t, Z_t)) P_{t-1} N_t \tag{3}$$

where $f(t, Z_t)$ is a deterministic function of age and household characteristics Z_t, P_t is a permanent component, and U_t a transitory component. We assume that $\ln U_t$ and $\ln N_t$ are independent and identically distributed with variances σ_u^2 and σ_n^2 respectively. The log of P_t evolves as a random walk with a deterministic drift $f(t, Z_t)$.

For simplicity, retirement is assumed to be exogenous and deterministic, with all households retiring in time period K, corresponding to age 65 ($K = 46$). In retirement ($t > K$) the investor can start to withdraw wealth from their TDA and also receives a constant state pension given by $Y_t = \lambda P_K$, where λ is the replacement ratio (a scalar between zero and one). This specification facilitates the solution of the model, as it does not require the introduction of an additional state variable.

3.3 Financial assets and taxation

The investment opportunity set is constant with two financial assets: one riskless (bonds or cash) and one risky (stocks). Investors must pay a fixed entry cost before investing in stocks in the taxable account for the first time. In the TDA stock market participation is costless.[13] The fixed cost is expressed as a percentage of the household's current permanent income: $F \times P_t$. This entry fee represents both the explicit transaction cost from opening a brokerage account and the (opportunity) cost of acquiring information about the stock market. The fixed cost (F) is scaled by the current level of the permanent component of labor income (P_t) as this simplifies significantly the solution of the model. However, this specification is also motivated by the interpretation of the entry fee as the opportunity cost of time.

There are no additional transaction costs and we do not allow for short sales. Given that asset returns are taxed and taxes are paid on nominal returns, we assume a constant inflation rate (π). The riskless asset yields a constant real return (r^b). The nominal return is taxed at a rate τ_d, which is also assumed to be the tax rate on both labor income and dividends. The after-tax, real return on the riskless asset is therefore given by

$$\widetilde{r}^b = \frac{1 + [(r^b + 1)(1 + \pi) - 1](1 - \tau_d)}{(1 + \pi)} - 1 \tag{4}$$

The real return on the risky asset is given by

$$r_t^s - r^b = \mu^s + \varepsilon_t^s \tag{5}$$

where μ^s is the average, real, before-tax equity premium, and ε_t^s follows an i.i.d. $N(0, \sigma_\varepsilon^2)$, potentially correlated with the labor income shocks ($\ln N_t$ and $\ln U_t$). The random real gross stock return (r_t^s) is comprised of a constant nominal dividend yield (d) and a stochastic nominal capital gain (g_t), deflated by the inflation rate:

$$r_t^s = \frac{1 + g_t + d}{1 + \pi} - 1 \tag{6}$$

[13]The motivation for this is that the tax-deferred account bypasses the search costs, inertia and set-up costs associated with direct investment in equities.

These two components are taxable at different rates. More specifically, nominal capital gains are taxed at the rate τ_g, whereas nominal dividends are taxed at the rate τ_d. For simplicity, we assume that all income is taxed at source.[14] The after-tax real return on the risky asset is given by

$$\widetilde{r}_t^s = \frac{1 + g_t(1 - \tau_g) + d(1 - \tau_d)}{1 + \pi} - 1 \tag{7}$$

3.4 Budget constraint and wealth dynamics

Securities can be kept in two accounts: a tax-deferred retirement account (TDA) and a regular taxable account (TA). In the TA, there is no deferral of dividend and interest income taxes and all taxes are assumed to be paid at source. In the retirement account no taxes are withheld and the investor is free to rebalance her portfolio without creating a tax liability. Throughout working life the investor contributes to the TDA a fraction k_t of before-tax earnings. We set the maximum contribution rate equal to 20% and we do not allow for early withdrawals from TDAs prior to retirement.[15,16] After the age of 70, the investor faces a minimum withdrawal rate equal to the inverse of her life expectancy. She pays taxes on the withdrawals at the income tax rate (τ_d).

[14] Capital gains in the US are only taxed upon realization. Modeling this feature requires two additional state variables and substantially complicates the model. For detailed studies of the impact of tax-timing on the optimal portfolio allocation behavior in both taxable and tax-deferred accounts, see Dammon, Spatt and Zhang (2001b, 2004) and Garlappi and Huang (2003).

[15] Technically, it is possible to borrow against TDA account or withdraw money before retirement. However in practice there are restrictions and non-trivial costs of withdrawal and borrowing. First, withdrawals to finance consumption are not allowed unless justified by "hardship", e.g. loss of employment, court judgments, illness. Second, withdrawing is usually possible after a long vesting period (up to 5 years) and the amount withdrawn is subject to 10% penalty and income tax. Third, some TDAs do not allow borrowing, and those that allow it may require the transfer of the collateral balances into safe annuities. Finally, loans against TDA usually carry interest rates comparable to those on 10-15 year mortgages.

[16] Some calibrations were re-computed allowing for early withdrawals ($k_t < 0$) subject to a 10% penalty and we found that the main *quantitative* implications remained unchanged. In the simulations households virtually never take advantage of early withdrawal possibility, consistent with findings of Dammon, Spatt and Zhang (2004). In addition, the 20% contribution cap was never binding.

3.4.1 Direct Stockholders

We start by considering the budget constraint for households that have already paid the fixed cost, and therefore can invest in equities in their taxable account. Let us first consider the working life period ($t < K$). Let α_t^r and α_t^τ denote the share of wealth invested in stocks in the retirement and taxable accounts, respectively. Also let h_t be the fraction of income paid in housing expenses, which is taken exogenously from the data.[17]

The wealth dynamics equations for the taxable account (W_t^τ) and for the retirement or tax-deferred account (W_t^r) are given by:[18]

$$W_{t+1}^\tau = [\alpha_t^\tau(1+\widetilde{r}_{t+1}^s) + (1-\alpha_t^\tau)(1+\widetilde{r}^b)](W_t^\tau - C_t - k_t Y_t(1-\tau_d)) + (1-\tau_d)(1-h_{t+1})Y_{t+1} \tag{8}$$

$$W_{t+1}^r = [\alpha_t^r(1+r_{t+1}^s) + (1+r^b)(1-\alpha_t^r)](W_t^r + k_t^* Y_t) \tag{9}$$

where k_t^* includes an employer matching contribution, (one-to-one) up to a maximum (k_e), and is thus given by

$$k_t^* = \min(2k_t, k_t + k_e) \tag{10}$$

After retirement ($t \geq K$) these equations change. Let Q_t denote the withdrawal from the

[17] Details are given in the calibration section. In the model we match financial wealth accumulation and do not consider housing assets explicitly for computational reasons. This is because endogenizing housing equity is a formidable computational problem in itself, even without considering TDA-related decisions. See for example recent papers by Cocco (2005) and Yao and Zhang (2004). However, we indirectly account for housing equity accumulation by calibrating an exogenously-specified housing expenses that are paid out of labor income.

[18] If the household is paying the fixed cost for exactly this period then we need to subtract $F \times P_t$ from $(W_t^\tau - C_t - k_t Y_t(1-\tau_d))$ in the first budget constraint.

retirement account and let A_t denote the investor's life expectancy. The equations become:

$$\begin{aligned} W^{\tau}_{t+1} &= [\alpha^{\tau}_t(1+\widetilde{r}^s_{t+1}) + (1-\alpha^{\tau}_t)(1+\widetilde{r}^b)](W^{\tau}_t - C_t + (1-\tau_d)Q_t) + \\ &\quad +(1-\tau_d)(1-h_{t+1})Y_{t+1} \qquad (11) \\ W^r_{t+1} &= [\alpha^r_t(1+r^s_{t+1}) + (1+r^b)(1-\alpha^r_t)](W^r_t - Q_t) \qquad (12) \end{aligned}$$

subject to the constraint

$$Q_t \geqslant \frac{1}{A_t} W^r_t \quad , \quad t \geq 70 \qquad (13)$$

which imposes a minimum withdrawal rate equal to the inverse of life expectancy for households 70 years of age or older.[19]

We also impose the following borrowing and short sales constraints

$$\begin{aligned} \alpha^{\tau}_t &\in [0,1], W^{\tau}_{t+1} \geqslant 0 \qquad (14) \\ \alpha^r_t &\in [0,1], W^r_{t+1} \geqslant 0 \qquad (15) \\ k_t &\in [0, 0.2] \qquad (16) \end{aligned}$$

At the time of death, all funds are withdrawn from the TDA untaxed and are paid to the beneficiary together with the remaining cash on hand balance in the TA.[20]

3.4.2 Indirect stockholders

Households that have not yet paid the fixed entry cost are subject to the same constraints except that they can only invest in stocks in their tax-deferred retirement accounts. Therefore, when solving their dynamic programming problem, we only have to replace equations

[19] This minimum withdrawal requirement is part of the current US tax code, but in reality the minimum rate also depends on the age of potential beneficiary.

[20] Estate taxation would not be an active feature in the model and we omit it entirely. Estates are subject to generous exemptions ($1,000,000), which is over 30 times the peak income of high school graduates. Therefore estate tax would never be active in our simulations.

(8) and (11) with

$$W_{t+1}^{\tau} = (1+\widetilde{r}^{b})(W_t^{\tau} - C_t - k_t Y_t(1-\tau_d)) + (1-\tau_d)(1-h_{t+1})Y_{t+1} \tag{17}$$

and

$$W_{t+1}^{\tau} = (1+\widetilde{r}^{b})(W_t^{\tau} - C_t + (1-\tau_d)Q_t) + (1-\tau_d)(1-h_{t+1})Y_{t+1} \tag{18}$$

respectively, thus eliminating α^{τ} as a choice variable.

3.5 Calibration

3.5.1 Preference parameters

We use preference heterogeneity and Epstein-Zin (1989) and Weil (1990) preferences to generate predictions that are consistent with observed direct stock market non-participation and substantial wealth accumulation for households that choose to participate directly in the stock market. We consider two groups of agents which will allow us to match the wealth accumulation of the DS and the IS. Both groups have the same risk aversion, and the same bequest intensity preference, respectively $\rho = 4.0$ and $b = 1$ in the baseline calibration, but they have different EIS and different discount rates.[21]

We consider differences in the discount rates as a natural source of heterogeneity in wealth accumulation.[22] In addition, Malloy, Moskowitz and Vissing-Jørgensen (2005) and Vissing-Jørgensen (2002) obtain higher estimates of the EIS for richer stockholders, as the DS turn out to be in the data. Therefore we consider one group with an EIS (ψ) equal to

[21] We could have allowed for heterogeneity in risk aversion (ρ) and in the bequest motive intensity (b) as well, but we have decided to keep the heterogeneity in the model to a minimum. As shown in Gomes and Michaelides (2005) households with lower risk aversion will accumulate much less wealth and thus will be much less likely to pay the participation cost and invest in stocks.

[22] We have also considered heterogeneity in the bequest motive parameter (b) and lower heterogeneity in β, and the results were almost identical. We have decided to keep this calibration as it requires less unobserved heterogeneity.

0.35 and discount rate (β) equal to 0.97, and a second group with $\psi = 0.25$ and $\beta = 0.88$.[23] We use the mortality tables of the National Center for Health Statistics to parameterize the conditional survival probabilities. In our welfare analysis we will consider several other values for these preference parameters.

3.5.2 Labor income process and housing expenditures

The deterministic labor income profile reflects the hump shape of earnings over the life-cycle and the corresponding parameter values are taken from Cocco, Gomes and Maenhout (2005). The standard deviations of the idiosyncratic shocks ($\sigma_u = 10\%$ and $\sigma_n = 10\%$) are taken from Carroll (1997). It is common practice to estimate different labor income profiles for different education groups (college graduates, high-school graduates, households without a high-school degree). In our paper we only report the results obtained with the parameters estimated from the sub-sample of high-school graduates, as the implied results for the other two groups are very similar. The replacement ratio (λ) is set at 60% of net earnings which is slightly lower than the 66% estimated by Cocco et al. (2005), since households with TDAs have lower average state pension replacement ratios. Finally, to account for housing expenses we subtract exogenous housing payments from the household's labor income. These exogenous housing payments are taken from Gomes and Michaelides (2005), who compute using the SCF 2001 data the ratio of annual housing related expenditures to annual labor income as a function of age.

[23] In our model households are also heterogeneous with respect to their labor income histories and this will also impact their participation decisions. However, such a mechanism is not enough to generate significant wealth heterogeneity, and thus it would not suffice to endogeneize the participation decision (the same result is shown by Gomes and Michaelides (2005) in a different context).

3.5.3 Asset returns, taxes, participation cost and contributions

The real bond return r^b is set at 2%. For the stock return process we consider a mean equity premium (μ^s) equal to 4% and a standard deviation (σ_{ε^s}) of 20%. We consider 4% as opposed to the historical 6% to take into account transaction costs (e.g. mutual fund and brokerage fees). The nominal dividend yield d is set at 3.2%.[24] The proportional tax on dividends and labor income (τ_d) is 25% and the tax on capital gains, τ_g, is 20%. We consider a labor income tax of 25% to reflect the average income tax of the typical household in our sample. Inflation rate is set at 3.15% corresponding to the average from CRSP data from 1926 to 1999. The fixed cost of stock market entry is set at 5% of current permanent income (P_t).[25] We set the cap on employer matching (k_e) equal to 3%, based on two sources of information. First, numbers from the SCF indicate that approximately only 50% of TDAs have employer-matching. Second, Mitchell (2000) reports that, for those plans with some degree of matching, the mode of employer contributions is 6%. The correlation between stock returns (ε_t) and permanent labor income shocks ($\ln N_t$) is set equal to 0.15, based on the results from Campbell et al. (2001), while the correlation with transitory labor income shocks ($\ln U_t$) is set equal to 0.

[24] We have scaled down the historical dividend yield by the same factor as the equity return.

[25] Alan (2006) estimates a (one-time) stock market participation cost between 3%-5% (F in our model) of the permanent component of labor income (P_t), in the context of a (life-cycle) structural model with the same labor income process. For the typical household in the PSID sample the average yearly permanent income is around \$30,000, so that our current calibration of the fixed costs corresponds to a *one-time* fee of \$1,500. Paiella (2001) and Vissing-Jørgensen (2001) have estimated the implied participation costs from household-level consumption Euler equations. They obtain *per-period* costs in the \$75 to \$200 range. In present-value terms our calibration is quite comparable to those numbers.

3.5.4 Distribution of years since first access to TDA

According to the data, even among stockholders, a significant fraction of households does not have a tax-deferred account. Moreover, even within those that have a TDA, most of them have only had one for a small number of years. Therefore, to replicate the average wealth accumulation of households aged 50 to 65, for example, we cannot assume that all of them have had access to a TDA since age 20.

From the 2001 SCF we have information on the number of years each household has contributed to an employer-provided retirement plan, including the years of contributions in any previous plans provided that these have been rolled over to start the current one. Thus, this variable provides us with a lower bound on the number of years that the household has had access to a TDA (θ).[26] We can now use this variable to compute a distribution of θ and use this as an input for the model.

For simplicity, we consider groups with three different values of θ. Table 4 reports the different groups and their corresponding population weights, both in the SCF and in the model. The values of θ used in the model correspond roughly to the mean of each interval in the data, and produce an average θ of 7.25, which is higher than in the data (6.26).[27] Finally, we set the percentage of households without a TDA to 25% to approximate the corresponding figure from the SCF for direct stockholders, since nonstockholders without a TDA are excluded from our analysis.

[26] This constitutes a lower bound both because some households might not have rolled over previous accounts or they had started non-employer provided accounts, such as IRA's, earlier.

[27] We calibrate the average TDA participation years slightly higher than in the data because, as mentioned earlier, the SCF counterpart is biased downwards.

4 Results for the baseline model

We initially solve a version of the model that captures the main features of the data presented in section 2. In particular, we want to replicate the wealth accumulation profiles and asset allocation decisions of both DS and IS. The numerical method is described in Appendix B.

4.1 Wealth accumulation and contribution rates

Table 5 (panel A (B) for DS (IS)) shows the median wealth to income ratios in the model and the data for different age groups, while Table 6 (panel A (B) for DS (IS)) reports the average contribution rate in the TDA. The results from the model are obtained by simulating 20,000 individual life histories and taking the medians across households and across age groups. We report medians instead of means since the wealth distribution exhibits significant skewness.

Young households face a high expected future labor income, against which they cannot borrow. Therefore, they prefer to consume most of their income, and a very modest saving is done for precautionary reasons. Saving for retirement starts later on in the life-cycle, and the contribution rates to the TDA start to increase, as shown in Table 6. These contributions are especially high for the DS (Panel A) who care more about retirement savings due to their higher discount rate.[28] Nevertheless, despite their very high contribution rates from age 35 onwards, Table 5 shows that most wealth is still accumulated in the TA. The data also shows this seemingly counterintuitive pattern. This occurs because within each age group, there are households that have only had access to the TDA for a small number of years, and therefore they do not have much wealth in that account.[29] This shows the importance

[28] We do not compare the contribution rates implied by the model with the data since there is no comprehensive survey data on household contribution rates as a function of age.

[29] For example, consider a 55-year old household that has only had access to a TDA at age 50. Naturally, in the last 5 years, she will have contributed significantly to this account. However, the vast majority of

of accurately calibrating the distribution of θ if we want to match the data. Overall, our results are broadly consistent with their empirical counterparts (columns 3-4 in Table 5).

The behavior of IS is also consistent with the data. With a weaker savings motive, they accumulate a low level of wealth in the taxable account and therefore optimally choose not to invest in equities. Comparing these results with those obtained for DS (panel A) we find something even stronger: wealth accumulation is now smaller in both accounts. In the model this is matched by the fact that IS have lower discount rate than the DS. Consequently, they care less about retirement savings, which is consistent with the low wealth accumulation throughout the lifecycle observed in the data. This is also visible in panel B of Table 6. Although IS have a stronger incentive to use their TDAs because they do not directly invest in equities, they still have lower contribution rates than the DS (panel A of the same table). Comparing panel A with panel B of Table 5 we find that, as we would expect, the differences in wealth accumulation are stronger in the TA because of the participation constraint.

4.2 Portfolio allocations

We now look at the asset allocation decisions, and again we start by focusing on the DS. Table 7 shows the average share of wealth invested in stocks in the TA, the TDA, and in total wealth for DS, and compares them with the corresponding numbers from the 2001 SCF. Our generated portfolios are more aggressive (higher proportion invested in stocks) in both accounts than their empirical counterparts by an average of around twenty percentage points. In terms of life cycle behavior, the predictions are similar to previous results in the literature. Specifically, young households invest a larger component of their financial wealth in stocks:

her (retirement) savings will still be in her taxable account where she had been saving for about 30 years already.

the implicit riskless asset in the form of human capital is still quite high (see Jagannathan and Kocherlakota (1996) or Heaton and Lucas (1997)). As retirement approaches, the present value of future labor income decreases. Households respond by reducing their exposure to the stock market. This pattern is visible in overall portfolio allocation across the two accounts and in each account separately, both in the model and in the data.[30]

We next compare the portfolio allocations across the two accounts. Black (1980), Tepper (1981) and Dammon *et. al.* (2004) show that when the capital gains tax is lower than the interest income tax (as is the case in the US, and in our model), it is tax-efficient to receive capital gains income in the taxable account and interest income in the tax-deferred account. As a result, a direct tax-arbitrage argument implies that households should invest their stocks primarily in the TA, and their bonds primarily in the TDA, implying that a mixed portfolio of stocks and bonds should exist at most in one account. However, in the data, the average portfolio allocation includes both bonds and stocks in both accounts (Poterba and Samwick (2002), Ameriks and Zeldes (2001) and Bergstresser and Poterba (2002)). We have to be clear that our model does not fully address this puzzle. We are able to generate some mixed portfolios in both accounts due to the presence of uninsurable labor income risk which creates a demand for bonds in the TA. However, this is still a very small effect when compared with the data. Another effect contributes to the observed mixed portfolios in the cross-sectional averages in the data. Some households without TDAs hold balanced portfolios in the TA, as they only get access to the TDA later in the lifecycle. Therefore, in a cross section that contains a combination of IS and DS (with and without TDAs), the

[30]In the model the portfolio allocation in the TA is essentially 100% in equities until age 50 (as we explain below), so the pattern is only visible after that.

average portfolio allocation in the TA and in the TDA would be mixed, as is in the data, even if individual asset location were tax-efficient. Consistent with this observation, Bergstresser and Poterba (2002) find from the SCF that at the individual level the asset location efficiency is much better than it appears from the cross-sectional averages.[31]

The IS hold very little financial wealth in their TAs because they have a higher discount rate and their retirement saving is done explicitly through their TDA. Therefore, a small cost of stock market participation is sufficient to prevent these households from investing in equities. As a result their only relevant portfolio decision occurs in the TDA account. These results are shown in Table 8. In the model, these households invest almost all of their TDA wealth in stocks. In the data the same pattern is visible if we consider medians, but slightly less so if we look at means.

5 The impact of tax-deferred accounts

Given the relative empirical success of the model in matching limited direct stock market participation, and in simulating reasonable life cycle profiles for wealth accumulation and portfolio allocation (to a first approximation), we can now proceed to study the impact of TDAs along a number of different dimensions. In this analysis we use the calibration from the previous section as a baseline guide for the preference parameters but we also consider alternative values for robustness and sensitivity analysis purposes. The welfare measures are computed as the change in certainty equivalent life-time consumption, evaluated at age 20.

[31] They report that the households with inefficient asset location constitute a relatively small fraction of all households with TDAs and that average wealth reallocations that bring portfolios back to efficiency for most of these households are not large.

5.1 Contribution rates

We now solve the model for the case of an investor that has access to the TDA from age 20, and chooses the optimal contribution (k_t) every year. Then, we also solve the model, under different fixed contribution rates. In all cases, we have kept the cap for the employer matching (k_e) equal to 3% as in the baseline model, but later on we will study the impact of this feature as well.

5.1.1 Optimal contribution over the life cycle and the impact of the employer matching scheme

The average optimal contribution rate for each set of parameters for different age groups is shown in table 9. In all cases contributions are smaller during the first life-cycle stage, when households are still liquidity constrained. As expected, the households with higher risk aversion, and/or higher EIS, and/or lower discount rate contribute more to their TDAs. Investors with a high discount rate ($\beta = 0.88$) only have significant contributions in the last 15 to 20 years before retirement. The average contribution rate among investors with the strongest savings incentive ($\rho = 5$, $\psi = 0.45$ and $\beta = 0.97$) is close to 2% from early on, and the average after age 50 exceeds 8%.

Interestingly, the vast majority of the numbers in this table are below 3%, which corresponds to the limit of the employer matching scheme. If all households within a preference/age group were taking full advantage of this scheme, then the average should exceed 3%. This shows that households may actually find it optimal to give up (part of) the matching if it leads them to save much more than they would otherwise like. Saving more in the TDA implies higher marginal utility of consumption during working life and lower marginal utility of consumption during retirement. For young households the first element of this trade-off is much more important.[32,33]

From the results in table 9 we thus find that the standard practitioner advice that workers should always take full advantage of employer matching schemes is rejected for a very significant fraction of the population. In each category the vast majority of households finds it optimal to give up part of the employer matching and thus increase working-life consumption, except when they are very close to retirement. In fact, even at that stage of the life-cycle, such recommendation is suboptimal for a large percentage of households, namely those with a high discount rate or low risk aversion.[34] These results not only contradict popular financial advise, but also offer an explanation for the empirical observation that a significant fraction of participants in defined contribution plans do not take full advantage of the employer match (see Choi *et. al.* (2001)).

The matching scheme increases the return on the TDA investment by 100% for the first contributions (up to the matching limit), so it is effectively equivalent to an increase in the rate of return received on those contributions. Therefore, it creates both an income and a substitution effect. On one hand investors want to increase their contributions to take advantage of the much higher return, but on the other hand that high return allows them to

[32]Moreover the discount rate for the marginal utility of consumption at retirement is higher due to the survival probabilities.

[33]It is sometimes possible to either borrow against your TDA account or withdraw TDA balances subject to a 10% penalty. Therefore, one might think that low-saving households would prefer to fully exploit the employer match, and then withdraw the money (or borrow) immediately to finance current consumption. However, in reality, there are substantial hurdles preventing withdrawals and borrowing. Withdrawals have to be done after a vesting period of up to 5 years, they have to be justified by a "hardship" and furthermore 10% penalty and income tax are due upon withdrawal. Loans against TDAs typically carry interest rates comparable to those on 10 to 15 year mortgages. The last feature would prevent practically all households in our model from borrowing even if it was realistically modeled. Only households that have zero balance in TA would be willing to borrow and there are very few such households in simulations.

[34]For employer matching schemes that have a cap higher than 3% or a matching ratio less than 1:1, such recommendation will lead to even more suboptimal savings decisions.

obtain the same level of future retirement wealth with lower savings and thus higher current consumption. We explore the relative impact of these two effects by computing the optimal contribution rates without employer matching, and comparing with the ones in table 9. The results are shown in table 10. Interestingly we find that the income effect dominates for all cases being considered. In the absence of the matching scheme households would have to contribute much more to their TDAs, to be able to accumulate their desired retirement wealth levels. When the employer matching is introduced, they are able to significantly cut down on their contribution rates and increase their working-life consumption.

5.1.2 Cost of suboptimal contribution rates

It is clear from table 9 that the optimal contribution rate over the life-cycle is not constant. However, investment advisors often recommend fixed contributions (e.g. ones that fully utilize employer matching) and investors often follow simple rules of thumb when determining their contribution rates. Therefore, we now evaluate the potential welfare cost associated with these suboptimal decisions. We have considered six different fixed contribution rates, $k = 0.5\%$, 1%, 2%, 3%, 4% and 5%. The results are shown in Table 11.[35] In the last column of the table we report the average optimal contribution for each group (reproduced from table 10).

The main results from this analysis are the following. First, the cost of following a "good" fixed contribution rate is small. For all households, the minimum welfare loss is about 0.6%.[36] Second, a simple "one-size-fits-all" rule does not work. For example, if we

[35] For this analysis we are setting the employer matching cap equal to zero, so as not to distort the conclusions.

[36] This is despite the fact that we have only considered six different possibilities. Naturally, if we further increased the number of alternative fixed rules this value would be even smaller.

set $k = 1\%$, households with a high discount rate would have moderate welfare losses (less than 1%) but others would lose up to 4.2%. If instead we minimize the welfare cost of the households with the higher savings motive, by setting $k = 4\%$, households with a high discount rate face a welfare loss of more than 4%. Third, if we impose a fixed k, it is better to set it *below* the average k computed from the optimal decisions. For example, for the first group ($\rho = 5/\psi = 0.45/\beta = 0.7$), the average k is 5.62%, but the welfare loss from $k = 5\%$ is actually larger than that from $k = 4\%$ (0.98% versus 0.62%). This pattern is present in all cases. This strong result is explained by the liquidity constraints. For young households the marginal utility of current consumption is extremely high, and therefore transferring significant resources for retirement is highly suboptimal.

5.2 Consumption and Savings

We next measure the impact of TDAs by comparing two versions of the model: with and without a TDA. For the purpose of this analysis we exclude the employer matching feature, to focus exclusively on the properties of the TDA, namely the trade-off between tax benefits and illiquidity.

An important policy debate about TDAs asks the following question. Do these accounts only crowd-out taxable savings, or does the preferential tax treatment effectively induce extra savings for retirement, and if so by how much? In our model, in the absence of tax benefits, the optimal investment in the TDA would be zero, since this account would be dominated by the TA which offers liquidity before retirement. Therefore, by comparing the two models, we are measuring the impact of this tax incentive on household-level savings.

Table 12 shows the percentage change in mean consumption across the two models, for different age groups and different preference parameter combinations.[37] We find that TDAs promote higher life-time consumption but not additional net savings. The changes in consumption for the age group 20-35 are virtually zero for all preference parameter combinations. At mid-life, when most households typically start to save for retirement, we actually observe an increase in consumption: the income effect from the TDA dominates the substitution effect.[38] Households actually increase their current consumption knowing that they will still reach retirement with higher wealth, by investing in the TDA. These results show that TDAs partially crowd-out TAs but not fully.[39] Naturally these conclusions could be reversed if we were to consider alternative extreme preference parameter values. However, those values would not generate realistic life-cycle savings and consumption profiles as discussed in the previous sections. This highlights the importance of having a well-calibrated model when conducting these experiments.

In addition, the largest increases in consumption occur at retirement across all preference parameter combinations. This is important because it shows that TDAs are effective in promoting a transfer of resources from working life to the retirement period, which is what they are designed to do. So, even though they do not induce additional household savings, the tax savings are used to finance extra retirement consumption. Finally, households with a high discount rate are the ones that respond less to the TDAs. The results in table 12 show that they will increase consumption at retirement by less, so these accounts will have a smaller impact on those that save less for retirement in the first place. In addition, for these

[37]The same quantitative patterns arise if we consider medians instead

[38]This is in line with the results in the previous section regarding the impact of the employer matching schemes.

[39]We have not included the wealth accumulation numbers for space reasons, but they are available upon request.

households, the increase in consumption during retirement is almost exclusively concentrated in the first 15 years, so that they are still left with very little wealth to finance their old age.

6 Concluding remarks

We have analyzed a model of life-cycle consumption and portfolio allocation with a taxable and a tax-deferred account (TA and TDA) in the presence of uninsurable labor income risk and borrowing constraints. The model generates plausible wealth accumulation and portfolio choice for direct and indirect stockholders conditional on age and account tax status and generates an endogenous separation between these two groups. Our findings support the hypothesis that TDAs increase wealth accumulation, and generate a distinct life-cycle upward-sloping profile for optimal TDA contributions. However, these accounts do not induce households to increase their net savings, as the income effect dominates the substitution effect. As a result they partially crowd-out wealth accumulation in the taxable account. The additional wealth accumulation is used to generate higher consumption during retirement, consistent with the intention of the tax subsidy embedded in these accounts. However, households with the lowest savings incentives are exactly the ones that will respond less to these accounts. In particular, those households that were not accumulating significant retirement wealth will continue to do so. We also find that, due to the presence of liquidity constraints, high TDA contributions early in life cycle are strongly suboptimal, even in the presence of an employer match. In fact, employer matching schemes typically decrease the optimal TDA contribution, as once again the income effect dominates the substitution effect.

The results in the paper could naturally change if we were to consider alternative extreme preference parameter values. However, those values would not generate realistic life-cycle savings and consumption profiles as shown in the paper. This highlights the importance of having a well-calibrated model for these quantitative evaluations. Our model has several natural extensions, which can be implemented in future research. First, we use a flat tax rate while in reality the tax code is progressive. Modeling this feature would likely increase the benefits from the TDAs as retirees tend to face lower tax rates than workers. Second, capital gains realizations in the TA could be explicitly considered, as in Dammon *et. al.* (2001b, 2004) and Garlappi and Huang (2003). This would incorporate the value of the tax-timing option and its interaction with labor income risk. Finally, the general equilibrium implications of introducing TDAs in a heterogeneous agents model with aggregate uncertainty remain to be explored.

Appendix A The Survey of Consumer Finances Data

The SCF is probably the most comprehensive source of data on U.S. household assets. The SCF uses a two-part sampling strategy to obtain a sufficiently large and unbiased sample of wealthier households (the rich sample is chosen randomly using tax reports). To enhance the reliability of the data, the SCF makes weighting adjustments for survey non-respondents; we used these weights to compute the values reported in the tables. The specific names in the codebook and the acronyms used by the net worth program supplied by the SCF are used below.

We construct a measure of non-financial income to match the process for Y_{it} (earnings) in the model. Non-financial income is defined as the sum of wages and salaries (X5702), business/practice/farm income (X5704), rent and royalties (X5714), unemployment or worker's compensation (X5716), child support and alimony (X5718), food stamps and welfare income (X5720), Social Security or other pensions, annuities, or other disability or retirement programs (X5722) and other income (X5724).

We next construct measures of bonds and stocks held in the taxable and tax-deferred accounts. Bonds in the TA are made up of SAVING and MMA (savings and money market accounts), CDS (certificates of deposit), GBMUTF (government bond mutual funds), OBMUTF (other bond mutual funds), BOND (corporate bonds), SAVBND (saving bonds), TFBMUTF (tax free bond mutual funds) and COMUTF (combination mutual funds), for which we assume that half is allocated to bonds. We also include annuities (ANNUIT) and trusts (TRUSTS) that are allocated to bonds.[40] We subtract non-credit card and non-residential real estate debt (variables ODEBT and OTHLOC which include unsecured loans and loans secured by pensions).

Stocks in the taxable account consist of STOCKS (directly held stocks), STMUTF (stock mutual funds), half of COMUTF (combination mutual funds), annuities (ANNUIT) and trusts (TRUSTS) that are allocated to stocks. Bonds (stocks) in the TDA include bonds (stocks) from IRA/KEOGH plans, bonds (stocks) in other future pensions (FUTPEN) and bonds (stocks) in account-type retirement plans for which we have information on asset allocation. For example, for the first pension plan of the respondent we require that variable X4216 is less than or equal to 18 (various account-type plans) and X4324 equals $1, 2, 3$ or -7 (known asset allocation), and for all the other pension plans of the respondent and spouse the requirement is the same. The shares of wealth invested in stocks in each account are constructed by averaging across the shares of individual households. To construct total

[40]For annuities, trusts, mutual funds, pension funds and IRA and KEOGH plans in which the allocation between bonds and stocks is mixed, we assume an equal allocation between bonds and stocks.

taxable wealth, we add bonds and stocks in the taxable accounts, checking and call accounts (CHECKING plus CALL) and subtract revolving credit card debt (CCBAL). To construct total TDA wealth we add bonds and stocks in the TDAs.

Appendix B Numerical Solution

We exploit the scale-independence of the maximization problem and rewrite all variables as ratios to the permanent component of labor income (P_t). The laws of motion and the value function can then be rewritten in terms of these normalized variables, and we use lower case letters to denote them (for instance, $w_t^\tau \equiv \frac{W_t^\tau}{P_t}$). This normalization allows us to reduce the number of state variables to three: liquid wealth in the taxable account, accumulated wealth in the tax-deferred account and age. The problem is solved (lower case variables normalized by P_t) as follows. The household needs to decide whether to incur the fixed cost at time (age) t or not and therefore compares the two value functions associated with direct stock market participation or not:

$$v_t(w_t^\tau, w_t^r, I_t) = MAX_{0,1}\{v_t(w_t^\tau, w_t^r, I_t = 0), v_t(w_t^\tau, w_t^r, I_t = 1)\}$$

where $I_t = 1$ and $I_t = 0$ denote direct and indirect participation, respectively. In turn,

$$v_t(w_t^\tau, w_t^r, I_t = 1) = \underset{c_t, k_t, \alpha_t^\tau, \alpha_t^r}{MAX} \left\{ (1-\beta) c_t^{1-1/\psi} \right.$$

$$\left. + \beta \left(E_t \left\{ \left(\frac{P_{t+1}}{P_t} \right)^{1-\rho} \left(p_t [v_{t+1}(w_{t+1}^\tau, w_{t+1}^r, I_{t+1} = 1)]^{1-\rho} + (1-p_t) b \left(w_{t+1} \right)^{1-\rho} \right) \right\} \right)^{\frac{1-1/\psi}{1-\rho}} \right\}^{\frac{1}{1-1/\psi}}$$

and for indirect stock market participation

$$v_t(w_t^\tau, w_t^r, I_t = 0) = \underset{c_t, k_t, \alpha_t^r}{MAX} \Bigg\{ (1-\beta) c_t^{1-1/\psi}$$

$$+\beta \left(E_t \left\{ \left(\frac{P_{t+1}}{P_t} \right)^{1-\rho} \left(p_t [v_{t+1}(w_{t+1}^\tau, w_{t+1}^r, I_{t+1} = 0)]^{1-\rho} + (1-p_t) b \left(w_{t+1} \right)^{1-\rho} \right) \right\} \right)^{\frac{1-1/\psi}{1-\rho}} \Bigg\}^{\frac{1}{1-1/\psi}}$$

We solve the model recursively backwards starting from the last period. In the last period ($t = T$) the policy functions are trivial and the value function corresponds to the bequest function.[41] We need to solve for four control variables in every year: the fraction of taxable wealth being saved, or equivalently, current consumption (c_t), the fraction of the taxable portfolio allocated to stocks (α_t^τ), the fraction of retirement wealth allocated to stocks (α_t^r) and the contribution rate (k_t). For every age t prior to T, and for each point in the state space, we optimize using grid search. From the Bellman equation the optimal decisions are given as current utility plus the discounted expected continuation value ($E_t v_{t+1}(.)$), which we can compute since we have just obtained v_{t+1}. We perform all numerical integrations using Gaussian quadrature to approximate the distributions of the innovations to the labor income process and the risky asset returns. We discretize the state-space along the two continuous state variables and use tensor product splines to perform the interpolation of the value function for points which do not lie on the state space grid, with more points used at lower levels of wealth where the value function has high curvature. Equivalently, we use a more dense set of grid points for low values of wealth for the two accounts because the consumption function exhibits a kink at the points where liquidity constraints are no longer binding. Once we have computed the value of each alternative we pick the maximum, thus

[41]Note that in $T-1$ the life expectancy is exactly one year and the agent is required to withdraw all retirement funds and invest them in the taxable account so that $w_T^R = 0$.

obtaining the policy rules for the current period. Substituting these decision rules in the Bellman equation, we obtain this period's value function ($v_t(.)$), which is then used to solve the previous period's maximization problem. This process is iterated until $t = 1$.

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Table 1: Stockholders by TDA ownership and direct/indirect type. Households are classified as follows: (i) *direct stockholders* own some equities/equity funds in TA's (also may have some equity in the TDA) – labeled "DS", (ii) *indirect stockholders* own equities/equity funds *only* through TDA's – labeled "IS". We use SCF sample weights to compute reported statistics.

SCF year/ TDA status	*Millions of households* DS	IS	*Percent of population* DS	IS	Combined, mil/%
1989					
No TDA	6.7	–	7.3	–	6.7/7.3
Have TDA	12.8	12.7	13.7	13.6	25.5/27.3
Combined	19.5	12.7	21.0	13.6	32.2/34.6
1992					
No TDA	6.8	–	7.2	–	6.8 /7.2
Have TDA	14.3	16.2	14.9	16.9	30.5/31.8
Combined	21.1	16.2	22.1	16.9	37.3/39.0
1995					
No TDA	7.1	–	7.2	–	7.1/7.2
Have TDA	15.8	18.0	16.0	18.2	33.8/34.2
Combined	22.9	18.0	23.2	18.2	40.9/41.4
1998					
No TDA	7.9	–	7.7	–	7.9 /7.7
Have TDA	22.0	20.6	21.5	20.1	42.6/41.6
Combined	29.9	20.6	29.2	20.1	50.5/49.3
2001					
No TDA	7.4	–	7.0	–	7.4/7.0
Have TDA	26.1	22.8	24.5	21.4	48.9/45.9
Combined	33.5	22.8	31.5	21.4	56.3/52.9

Table 2: Components of financial wealth (medians) for groups of households by TDA ownership and stockholding status. Included components of wealth and non-financial income are defined in the text. Households are classified by stock ownership as follows: (*i*) *direct stockholders* own some equities/equity funds in TA's (also may have some equity in the TDA) – labeled "DS", (*ii*) *indirect stockholders* own equities/equity funds *only* through TDA's – labeled "IS". We use SCF sample weights to compute reported statistics.

	Financial Wealth ($)		
SCF year/	Stockholder status		
account	DS	IS	Combined
1989			
TA+TDA	55,550	16,500	31,920
TA	32,290	2,800	13,440
TDA	7,000	9,560	8,000
1992			
TA+TDA	59,930	15,810	36,480
TA	32,650	2,600	12,830
TDA	9,000	10,000	9,300
1995			
TA+TDA	65,500	17,000	35,400
TA	34,050	1,450	10,500
TDA	11,000	12,500	12,000
1998			
TA+TDA	96,300	19,400	52,800
TA	49,350	1,670	16,200
TDA	19,800	14,000	16,200
2001			
TA+TDA	133,950	25,900	66,690
TA	66,000	2,350	18,710
TDA	29,000	18,000	24,000

Table 3: Wealth-income ratios (medians) and portfolio allocation (means and medians) by account, age and stockholding status. Included components of wealth and income are defined in the text. Households are classified by stock ownership as follows: (*i*) *direct stockholders* own some equities/equity funds in TA's (also may have some equity in the TDA) – labeled "DS", (*ii*) *indirect stockholders* own equities/equity funds *only* through TDA's – labeled "IS". We use SCF sample weights to compute reported statistics.

Panel A, Wealth/Income ratios

	DS		IS	
Age	Taxable	Tax-Def.	Taxable	Tax-Def.
< 36	0.27	0.11	0.02	0.12
36 - 50	0.56	0.43	0.04	0.44
51 - 65	1.44	0.84	0.08	0.70
> 65	5.75	0.56	0.44	1.98

Panel B, Portfolio share in stocks (mean/median)

	DS		IS	
Age	Taxable	Tax-Def.	Taxable	Tax-Def.
< 36	0.72/0.79	0.77/1.00	0.0/0.0	0.80/1.00
36 - 50	0.65/0.68	0.78/1.00	0.0/0.0	0.74/0.89
51 - 65	0.61/0.62	0.72/0.94	0.0/0.0	0.76/0.92
> 65	0.58/0.58	0.55/0.50	0.0/0.0	0.76/0.91

Table 4: Distribution of years of participation in employer-provided tax-deferred retirement plans from the 2001 SCF and the corresponding three-point distribution assumed in the model. SCF data includes years of participation in current plans and any previous retirement plans rolled over to the current plans.

Years	% in the SCF	θ	% in the model
1 - 5	48	3	50
6 - 10	23	8	25
> 10	29	15	25

Table 5: Wealth-income ratios (medians) from simulations and SCF data. Preference parameters (discount rate and EIS) for DS are $\beta = 0.97$ and $\psi = 0.35$, for IS are $\beta = 0.88$ and $\psi = 0.25$, and risk averion $\rho = 4$ is common. The rest of the parameters is described in the calibration section 3.5.

Panel A, Direct Stockholders

	Model		Data	
Age	Taxable	Tax-Def.	Taxable	Tax-Def.
< 36	0.18	0.14	0.27	0.11
36 - 50	1.38	0.43	0.56	0.43
51 - 65	2.21	1.20	1.44	0.84
> 65	2.37	0.53	5.75	0.56

Panel B, Indirect Stockholders

	Model		Data	
Age	Taxable	Tax-Def.	Taxable	Tax-Def.
< 36	0.03	0.00	0.02	0.12
36 - 50	0.08	0.12	0.04	0.43
51 - 65	0.12	0.59	0.08	0.70
> 65	0.07	0.81	0.44	1.98

Table 6: Average contribution rates (in percentage of income) for direct and indirect stockholders with different time of access to TDA (θ). Preference parameters (discount factor and EIS) for DS are $\beta = 0.97$ and $\psi = 0.35$, for IS are $\beta = 0.88$ and $\psi = 0.25$, and risk averion $\rho = 4$ is common. The rest of the parameters is described in the calibration section 3.5.

Panel A, Direct Stockholders

Age	$\theta = 15$	$\theta = 8$	$\theta = 3$
< 36	1.92	2.00	2.20
36 - 50	3.54	5.35	5.98
51 - 65	11.81	15.82	16.22

Panel B, Indirect Stockholders

Age	$\theta = 15$	$\theta = 8$	$\theta = 3$
< 36	0.14	0.14	0.14
36 - 50	0.92	1.11	1.84
51 - 65	2.73	3.96	8.82

Table 7: Fraction of portfolio invested in stocks from simulations and SCF data for direct stockholders. Preference parameters (discount factor, risk aversion, and EIS) for DS are $\beta = 0.97$, $\rho = 4$, and $\psi = 0.35$. The rest of the parameters is described in the calibration section 3.5.

	Model (mean)			Data (mean/median)		
Age	Taxable	Tax-Def.	Total	Taxable	Tax-Def.	Total
< 36	0.98	1.00	0.99	0.72/0.79	0.77/1.00	0.79/0.83
36 - 50	1.00	0.84	0.96	0.65/0.68	0.78/1.00	0.70/0.78
51 - 65	0.98	0.61	0.81	0.61/0.62	0.72/0.94	0.66/0.70
> 65	0.85	0.57	0.82	0.58/0.58	0.55/0.50	0.59/0.63

Table 8: Fraction of portfolio invested in stocks in the TDA account from simulations and SCF data for indirect stockholders. Preference parameters (discount factor, risk aversion, and EIS) for IS are $\beta = 0.88$, $\rho = 4$, and $\psi = 0.25$. The rest of the parameters is described in the calibration section 3.5.

Age	Model (mean)	Data (mean/median)
< 36	1.00	0.80/1.00
36 - 50	1.00	0.74/0.89
51 - 65	0.93	0.76/0.92
> 65	0.91	0.76/0.91

Table 9: Average contribution rates (in percentage of income) for different preference parameters.

ρ	5	4	4	2	4	2
ψ	0.45	0.35	0.25	0.35	0.25	0.25
β	0.97	0.97	0.97	0.97	0.88	0.88
21-30	1.94	1.73	1.44	1.45	0.00	0.00
31-40	2.19	2.30	2.38	2.05	0.71	0.43
41-50	2.37	2.36	2.42	2.11	1.35	1.15
51-65	8.11	5.71	5.18	3.63	2.27	2.28

Table 10: Contribution rates with and without empoyer match.

Utility parameters			Match cap (%)	
ρ	ψ	β	$k_e = 3$	$k_e = 0$
5	0.45	0.97	3.94	5.62
4	0.35	0.97	2.97	4.31
4	0.25	0.97	2.68	3.94
2	0.35	0.97	2.33	3.42
4	0.35	0.88	0.92	1.17
2	0.25	0.88	0.90	1.11

Table 11: Welfare loss from following fixed contribution rule for direct stockholders. The loss is expressed as a percentage of certainty equivalent flat life-time consumption.

Utility Parameters			Fixed contribution rate (%)						Average Optimal Contribution (%)
ρ	ψ	β	5	4	3	2	1	0.5	
5	0.45	0.97	-0.98	-0.62	-0.78	-1.77	-4.22	-5.46	5.62
4	0.35	0.97	-1.02	-0.60	-0.60	-1.35	-3.57	-5.84	4.31
4	0.25	0.97	-1.24	-0.69	-0.55	-1.20	-3.58	-6.39	3.94
2	0.35	0.97	-1.53	-0.92	-0.60	-0.76	-2.07	-3.29	3.42
4	0.35	0.88	-5.43	-4.22	-3.04	-1.89	-0.84	-0.40	1.17
2	0.25	0.88	-5.54	-4.34	-3.16	-2.06	-0.97	-0.46	1.11

Table 12: Consumption changes after gaining access to a TDA.

Utility parameters			Age group			
ρ	ψ	β	20-35	36-65	66-80	81-100
5	0.45	0.97	-0.3	4.2	27.6	19.6
4	0.35	0.97	0.2	5.4	27.2	21.1
4	0.25	0.97	0.4	5.4	25.5	21.9
2	0.35	0.97	0.3	5.2	28.6	19.9
4	0.35	0.88	-0.1	1.2	20.6	2.9
2	0.25	0.88	0.0	1.0	18.2	2.0