Portfolio Allocation Choices in Taxable and Tax-Deferred Accounts: An Empirical Analysis of Tax Efficiency

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Abstract

Tax efficiency is the dominant consideration in theoretical portfolio models that allow for both taxable and tax-deferred accounts. Yet, empirically observed portfolio allocations are not tax-efficient. I offer a model that is designed to bridge the existing gap and validate its predictions on household-level portfolio data from the Survey of Consumer Finances. The model explicitly incorporates both the uninsurable risk in labor income and accessibility restrictions that are an institutional feature of tax-deferred retirement accounts. Together, these elements create a tension between the desire to maintain tax-efficient allocations and one's concern over the need to make costly withdrawals from retirement accounts in the event of bad income draws. This leads some low-wealth households and households facing the highest penalties on withdrawals to forgo tax-efficient allocations in favor of allocations that provide more liquidity. The empirical results provide evidence that both the choice of a tax-inefficient portfolio and heterogeneity in portfolio allocations are related to the presence and severity of accessibility restrictions and precautionary motives.

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1. Introduction

Portfolio choices of individual investors appear mysterious to economists. This paper focuses on one of the mysteries: the pervasive tax-inefficiency of individual allocations in regular and tax-deferred retirement savings accounts. Understanding this decision is particularly important in light of the active debate over whether individuals should be given more control over their social security savings. Some studies estimate that inefficient allocations result in sizable welfare losses.[1] I clarify this issue and offer a different perspective.

In recent years, individually managed retirement accounts have grown tremendously in popularity and became one of the main avenues for household savings. In the United States, as in most countries with individually financed retirement savings plans, accounts that contain assets set aside for retirement are granted favorable tax treatment. In order to ensure that these assets are used for their intended purpose, a variety of restrictions have been placed on accessibility of funds in such accounts. Because of these institutional considerations, adding retirement accounts to the menu of household investment choices has greatly increased the complexity of investment decisions faced by a typical household. Households now must choose both how much to contribute or withdraw from each of the two available investment habitats and how to allocate the resulting balances within each. This joint portfolio decision is known in the literature as the asset *location* and *allocation* problem (Shoven 1999).

The canonical problem of optimal portfolio allocation in habitats with different tax treatments is well understood. The original results date back to Black (1980) and Tepper (1981), who studied the optimal portfolio choice of a corporation interested in funding its defined-benefit pension plan. Their studies demonstrate the existence of tax arbitrage strategies whenever opportunities to shelter high-tax assets inside retirement accounts are not used fully. Similar calls for strict specialization of assets across investment habitats have been characteristic of the models that followed. In particular, individuals are advised never to hold higher-taxed assets (bonds, in the case of the U.S.) in their regular investment accounts, as long as there exists an opportunity to move such assets to tax-protected retirement accounts.

[1] For example, Shoven (1999) estimates the difference in available retirement resources between the "optimal" investors and those who make erroneous portfolio choices to be on the order of 8%.

This basic advice appears to be appropriate even in relatively complex environments. For instance, Shoven and Sialm (2001) study the portfolio decision when individuals can hold tax-exempt municipal bonds, while Huang (2001) considers a multi-period setting with borrowing constraints on investment choices. Yet both of these studies confirm the Tepper-Black advice.

The robustness of model recommendations on optimal portfolio choices presents a challenge because observed portfolios are not tax efficient. Survey data commonly show that the majority of U.S. households choose to hold bonds in their regular accounts, while also maintaining sizable equity positions in their tax-deferred plans. These households could improve their after-tax returns by simply rearranging their location and allocation choices. The goal of this paper is to provide an explanation for the behavior of these households.

I show that progress can be made by considering a model that includes uninsurable labor market risk and incorporates the institutional rules regarding the penalties on accessing money held in tax-deferred accounts (TDA). These features create precautionary savings motives for some households. The precautionary motives induce a tradeoff between the desire to maintain tax-efficient allocations[2] and concern over the need to make costly withdrawals from retirement accounts in the event of bad income draws. As a result, a model with both labor income risk and accessibility restrictions can improve on uniformly tax-efficient corner solutions of models where asset returns are the only source of uncertainty. The first challenge, therefore, is to assess whether a plausibly parameterized theoretical model that incorporates precautionary savings motives can produce tax-inefficient portfolio choices. My second task is to determine empirically whether cross-sectional heterogeneity in portfolio choices is related to the strength of precautionary motives, as implied by solutions to the theoretical model[3].

I describe the calibrations below, but the key message from the model is that stricter liquidity restrictions on retirement assets and stronger precautionary savings motives are associated with lower equity shares in regular accounts, but with higher equity shares in pension accounts. This prediction is quite intuitive, once we take into account the difference in access costs in the two accounts and allow for interaction between location and allocation choices. If

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[2] For the remainder of this paper, "tax efficiency" of portfolio allocations is defined in the very narrow sense of Tepper-Black. An allocation is said to be tax-efficient if a strict pecking order is observed – the highest-taxed asset is always located in the tax-preferred habitat before any lower-taxed assets can be placed there. *Relative* to this benchmark, any allocation in which this pecking order is violated is labeled "tax inefficient".

the retirement assets are extremely costly to access, they are only used to accumulate retirement wealth. In this case, households with a high share of wealth in their pension accounts face tighter liquidity constraints since less of their wealth is readily accessible. They satisfy their stronger precautionary motives by choosing a safer portfolio mix in the regular investment account that is much better suited for smoothing potential income shocks. Such households also decrease the size of their retirement contributions. To address their retirement savings concerns, they increase the share of equities in their pension accounts. Tax efficiency gets trumped both by precautionary motives in regular accounts and by retirement savings motives in pension accounts[4].

This explains why the range of the model's predicted portfolio choices depends on the strength of the precautionary motives. In my calibrations, these in turn depend on the size of the penalties on accessing funds in the TDA and the degree of labor income risk. My first finding is that with realistic withdrawal penalties, I can generate substantial portfolio heterogeneity provided that households face at least some amount of catastrophic labor income risk.

This example also illustrates the possible lifecycle implications of the interaction between withdrawal penalties and labor income risk. For instance, it can be argued that young households face the highest risk of needing to withdraw TDA assets prematurely both because their labor earnings are more risky (Gakidis, 1998) and because their accumulated stock of wealth is smaller. However, they also stand to benefit the most from tax deferral on TDA investment returns because of their longer investment horizon. These households resolve the problem by contributing to TDA and simultaneously rebalancing their portfolios to mitigate the probability of early withdrawal. The ability to allocate portfolios in a "tax-inefficient" way makes young households more willing to participate in pension plans.

The empirical work explores the model's prediction that there should be two distinct types of portfolio choices – "tax-efficient" allocations for households with weak precautionary savings motives (due to a high level of accumulated assets or low labor income risk), and mixed ("precautionary") asset allocations by the rest of the households. I use household-level data from

[3] Huang (2001) considers the case of deterministic liquidity needs driven by demographics, which also allow tax-inefficient holdings. This modeling choice, however, is less likely to explain the observed portfolio allocations for reasons discussed in section 3.1.

[4] However, if there are no restrictions on accessibility of assets in retirement accounts, both motives can be satisfied by assets in either habitat and tax efficiency of allocations again becomes the only concern. This should be the case

the Survey of Consumer Finances (SCF) to test whether this separation of households into two classes is reasonable. The model also suggests that the empirical implications of the precautionary savings literature can be extended to differences in habitat-specific portfolio allocations. Therefore, I next try to test whether the variables suggested by the model and those that appear in the existing precautionary savings literature have explanatory power for the observed heterogeneity in household portfolio choices.

Previous studies that have considered the empirical effects of riskiness of non-financial labor income on household portfolio composition have generated mixed results. For example, Vissing-Jørgensen (1999) finds a strong negative effect of variance of household labor income on equity participation and portfolio share in PSID data. However, Guiso et. al. (1996), using Italian household data, find that labor income risk has small effects on portfolio choice, while Hochguertel (1997) estimates that the sign of these effects may even occasionally be positive in his sample of Dutch households. As argued above, precautionary motives are likely to have opposing effects on portfolio choices in the two habitats. Since existing studies concentrate on asset composition of the overall portfolio, differentiating between account habitats provides another way to identify precautionary effects on portfolio composition.

Empirical results provide support for the key insights of the model. In particular, I find that households with a greater probability of being unemployed are more likely to choose tax-inefficient precautionary allocations even though there is little evidence that after the age of 59½, when most restrictions on TDA assets cease, all households become more likely to abandon such choices in favor of tax-efficient corner solutions. I further find that factors associated with stronger precautionary savings motives, such as having a higher fraction of one's wealth in a tax-deferred account or a riskier labor income process, are strong indicators of precautionary portfolio choices, consisting of a safer allocation in a regular account and a riskier mix in a pension account.

The only study of which I am aware that provides a systematic analysis of household portfolio allocations between and within regular and retirement accounts is Bergstresser and Poterba (2001). The authors document a high degree of heterogeneity in habitat-specific portfolio location and allocation choices in the Survey of Consumer Finances and discuss the

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with the Canadian system, which openly treats "retirement savings" as just another means to smooth consumption. I am grateful to Michael Smart for pointing out this example.

importance of effects that age, wealth, and income have on these choices. However, they stop short of offering a theoretical explanation for documented results. By contrast, the empirical investigation in the present paper is conducted on the basis of the precautionary savings theory in an environment with portfolio liquidity restrictions and uninsurable risk.

The rest of the paper is structured as follows. Section 2 briefly reviews existing theoretical literature on dual habitat portfolio decisions. Section 3 outlines the decision-theoretic model and discusses the properties of its analytical and numerical solutions. Section 4 describes the data and sets up the empirical framework, while section 5 contains results of econometric analysis. Section 6 summarizes the results and offers directions for future research.

2. Related Literature

There exists a small body of theoretical literature addressing portfolio decisions in a dual-habitat setting. The two representative papers are Shoven and Sialm (1999) and Dammon, Spatt and Zhang (2000) (DSZ). Both papers use numerical methods to solve the portfolio allocation problem of an investor who is able to invest in both regular and tax-deferred retirement accounts. As alluded to earlier, the general message that emerges from their solutions is that the primary goal of the asset location decision is to achieve tax efficiency. In the U.S., equities are tax-favored in several respects. They are taxed at lower rates than interest-paying assets, are subject to tax breaks when used for bequests, and afford a timing choice for realization of capital gains/losses and the corresponding tax liabilities or refunds. For all these reasons, it is believed to be better to locate bonds in retirement accounts which defer taxation, have no use for timing capital gains or losses and are ill-suited for bequest planning. In this context, tax efficiency means giving preference to bonds in retirement accounts whenever possible. This is the result demonstrated by DSZ and, under certain parameter assumptions, by Shoven and Sialm (1999)[5].

Recent work by Huang (2001) constructs theoretical proofs of preference for bonds in tax-deferred accounts (TDA). The proofs are based on the ability to replicate a unit of equity in a tax-deferred account by a portfolio consisting of a unit bond holding in a tax-deferred account and a leveraged position in equities in the regular account. These two assets (the original stock and the replicating portfolio) have identical risk characteristics, but the latter, which places a bond in a tax-deferred account, is strictly preferred to the former. When borrowing at the risk-free rate in regular accounts is prohibited, the proof still carries through with replication replaced by option pricing methods.

These theoretical findings translate into the following empirical prediction: there should never be any equity holdings in retirement accounts as long as there are bond holdings in regular accounts. In the extreme case of unlimited borrowing in regular accounts, the specialization of accounts is complete – the retirement account is always entirely dedicated to bonds. When there is no borrowing in regular accounts, it is possible to observe equities in pension accounts, provided the overall desired bond holdings do not exhaust the capacity of the retirement account. Conversely, if the overall desired bond holdings exceed the limits of the retirement account, the spillover goes in the other direction – the "surplus" bonds are observed in regular accounts. Both cases, however, rule out keeping equities in retirement accounts while simultaneously holding bonds in regular accounts.

Actual available portfolio allocation data do not conform to these predictions. For example, Figure 1 presents empirical portfolio allocations from the cross section of U.S. households in the 1998 Survey of Consumer Finances that had assets in both regular and retirement accounts. The horizontal axis represents the share of a regular ("outside") account held in equities, and the vertical axis – a similar measure in a retirement ("inside") account. These axes are complemented by lines at 100% allocations in both inside and outside accounts to form an "allocation box", which will be useful in further discussion. In terms of Figure 1, the "tax-efficient" theory predicts portfolios located along line segments BC – where stocks spill over into retirement accounts, and AB – where there is a spillover of bonds in the opposite direction. These segments account for only 8.2% of U.S. households (but for 31.8% of financial wealth), highlighting the empirical difficulties of the tax-efficient theory[6]. These facts are well documented by Poterba and Samwick (1999).

3. Model

[5] In cases where equities are either held directly or through tax-efficient mutual funds, Shoven and Sialm (1999) find that the preferred habitat for bonds is indeed inside retirement accounts.
[6] From Figure 1, tax efficient households (excluding those that hold no equities at all) account for 18.6% of U.S. households with self-directed pension plan assets. In turn, pension plan owners comprise 44% of all U.S. HHs.

It is clear that the existing theory needs to be augmented in some way to account for the high number of households that choose to hold interior mixes of bonds and stocks in both habitats (i.e., locate in the interior of the allocation box) or on the other two boundaries (CD and AD). One plausible mechanism for enticing households to hold bonds outside of their pension plans is to introduce further sources of risk into their environment. In the presence of risk and credit market imperfections, prudent households choose to hold buffer stocks of assets, which is commonly referred to as precautionary savings behavior (Kimball 1990, Carroll 1991)[7]. Even though the canonical precautionary savings models did not take a stand on asset composition of buffer stocks, later theoretical (Kimball 1993) and empirical studies (e.g., Bertaut and Haliassos 1997) have found that the presence of precautionary savings motives is linked to safer portfolio allocations. In the context of the dual-habitat portfolio allocation problem, such buffer stocks can be manifested through existence of safe and liquid asset holdings – that is, bonds outside of retirement accounts[8].

It is possible to describe "precautionary portfolio effects" for the dual-habitat problem in the spirit similar to the definition of precautionary savings. "Precautionary portfolio effects" are defined here as changes in portfolio choices in both habitats that a liquidity-constrained household makes when it faces labor income risk, as compared to the benchmark of tax-efficiency that is obtained in the certain income scenario. Note that liquidity constraints have a somewhat special meaning in the dual-habitat model. Whereas typical representation of liquidity constraints is through imposition of proportional or absolute limits on borrowing, here the limit is even tighter – only a portion of own wealth can be used for consumption prior to retirement. As will be shown later, the interaction between accessibility restrictions and risky labor income is necessary for producing habitat-specific precautionary portfolio effects.

The precautionary demand requires a tradeoff between tax efficiency and asset accessibility in deciding on portfolio allocations and asset location. On the one hand, not holding bonds inside retirement accounts results in suboptimal portfolio returns. On the other hand, locking away riskless assets in illiquid accounts may prove costly if a household is hit by a bad labor income shock coinciding with poor market returns. In such a setting, households may

[7] Precautionary savings are commonly defined as the incremental savings that a liquidity-constrained household makes when it faces labor income risk, compared to the certain income scenario.

plausibly choose to hold both bonds outside as part of their buffer stocks and bonds inside as tax-efficient investment vehicles.

This "precautionary" model of dual-habitat investment choices can peacefully co-exist with the "tax-efficient" model outlined above. In fact, I will argue that tax-efficient behavior is optimal for particular types of households in the precautionary model. This is analogous to the results reported in the traditional precautionary savings literature, whereby even with uninsurable income risk in the economy, there may be agents that are either not exposed to that risk or are wealthy enough not to be affected by credit constraints (Carroll 1997, Carroll, Dynan, and Krane 1999).

To see this in the context of the portfolio allocation problem, consider again the tradeoff between missing out on tax advantages of inside bond holdings and not having enough wealth on hand to ride out a bad shock. With a sufficient level of overall wealth, one can satisfy his precautionary savings needs with equities outside. With large outside balances, the risk of not being able to smooth shocks is smaller, and so bonds are optimally stored inside. With this reasoning, the composition of buffer stocks depends on the level of wealth: the household wants to "buffer" with safe and liquid assets unless liquidity of safe assets costs too much relative to the risks posed by equity buffers[9]. Similarly, households that are not affected by the modeled type of risk can afford to concentrate on making tax-efficient location choices.

An additional empirical advantage of using precautionary savings motives to explain interior portfolio holdings is that one can leverage the substantial precautionary savings literature. In particular, this literature defines uninsurable risk as coming from some broad income source. This definition is flexible enough to accommodate a variety of risky processes – stochastic labor income, demographic shocks, etc. – all of which can affect portfolio choice. The literature also identifies household characteristics that are related to precautionary savings behavior, such as measures of labor income uncertainty and wealth. These characteristics can be directly linked to identification of households that make their portfolio decisions using the precautionary model and can help to explain their choices. As will be discussed later, one will

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[8] Simulation results indicate that under plausible specifications of stochastic income processes, buffer stocks need to be not only liquid, but also include safe assets like bonds. Still, one needs stronger theoretical results to establish conditions under which buffer stocks necessarily contain riskless assets.

[9] Another way to think about this is to treat forgoing tax-efficiency in retirement account as a tax on wealth. The wealthier are exposed to a higher tax, and so have a stronger incentive to be tax-efficient.

also need to account for institutional characteristics of asset habitats (e.g. early withdrawal penalties) in order to explain some of the heterogeneity of the observed interior choices.

The costs of introducing uninsurable risk, and thereby precautionary savings motives, are also considerable. One nearly always has to rely on numerical solutions to obtain decision rules in such models. The two components of this decision problem – location and allocation choices – are non-separable (Huang 2001). In other words, a household cannot choose its overall desired level of equity and bond holdings first, and then decide where to hold them. The primary reason for it is that risk-return characteristics of assets change depending on their location. Thus, one needs to solve simultaneously for level and composition of wealth holdings in the two account habitats. In the next section, I turn to such a model of portfolio allocation with dual habitats in order to obtain numerical solutions that will form the framework for empirical investigation. The model builds on the earlier work of DSZ and Huang (2001), with the important difference in the choice of mechanism for effecting non-financial income uncertainty in the household environment.

3.1. Numerical Setup

Consider a household that lives for T periods. In each period, a household receives a wage draw and determines its consumption and savings policies. There exist two habitats for saving: a tax-deferred retirement account X and regular investment account Y (using the terminology of Shoven (2000), these accounts are referred to as TDA for the tax-deferred retirement account and CSA for the regular investment, or conventional savings account.). In addition to deciding on level of contributions to each account, the household chooses their portfolio composition as well. The model, therefore, is able to address both the location and allocation properties of optimal decisions.

Each account can be invested in a broadly diversified equity portfolio that returns r or a risk-free bond that returns r^f, with $E[r] > r^f$. The TDA account defers taxation on returns that accumulate on pre-tax contributions[10]. The CSA account taxes all earnings as soon as they are realized. In order to abstract form questions of option value of timing of capital gains, I assume

[10] Equivalently, one can consider a TDA setup where after-tax contributions escape further taxation altogether as is the case with Roth IRA accounts in the U.S.

that all such gains are realized automatically. Then, a $1 TDA portfolio with α^x in equities and a $1 portfolio in CSA, with α^y in equities have one-period returns described respectively by:

$$R^x(\alpha^x,\tilde{r}) = \alpha^x(1+\tilde{r}) + (1-\alpha^x)(1+r^f) = (1+r^f) + \alpha^x(\tilde{r}-r^f)$$
$$R^y(\alpha^y,\tilde{r}) = \alpha^y(1+\tilde{r}(1-\tau^c)) + (1-\alpha^y)(1+r^f(1-\tau^b)) = (1+r^f(1-\tau^b)) + \alpha^y(\tilde{r}(1-\tau^c) - r^f(1-\tau^b))$$

Here, τ^c is tax rate on capital gains and τ^b is tax rate on bond dividends (and wages), with $\tau^b>\tau^c$.

The household solves:

$$\max_{\{c_t,y_t,x_t,\alpha_t^x,\alpha_t^y\}} E\left(\sum_{t=1}^{T}\beta^{t-1}U(c_t)\right)$$
$$s.t.\quad c_t = w_t(1-\tau_t^w) - y_t - x_t(1-\tau_t^w - pen*\mathrm{I}_{x<0,t\le R})$$
$$Y_{t+1} = (Y_t + y_t)R^y(\alpha^y,\tilde{r})$$
$$X_{t+1} = (X_t + x_t)R^x(\alpha^x,\tilde{r})$$
$$x_t \le q*w_t,\quad t\le R;\quad x_t\le 0,\quad t\ge R+1$$
$$y_t + Y_t \ge 0,\ \ x_t + X_t \ge 0,\ \ \forall \mathrm{t}$$
$$0\le \alpha_t^x,\alpha_t^y \le 1,\ \forall \mathrm{t}$$
$$w_t = f(t,educ,..)*(1-s\mathrm{I}_u)\text{ where }\mathrm{I}_u = 1\text{ with prob. }p$$

where household contributions to TDA can only be made during working years ($t<R$) and cannot exceed $q\%$ of its wage w, and where borrowing isn't allowed in either account. Assets in TDA can be accessed prior to R only at a penalty *pen*[11]. Wage uncertainty of the household is modeled through unemployment shocks that occur with exogenously given probability p. In the unemployment state the household receives only a fraction s of its regular income.

This problem has a recursive representation, with state space described by $\{X_t, Y_t, t\}$. The model is solved by backward induction with MATLAB's constrained optimization routines,

[11] Even though most employer-sponsored tax-deferred plans allow borrowing against the pension account, I make no distinction between borrowing and withdrawing funds from a TDA, which represent two alternative ways of getting $x_t < 0$. In this model, households withdraw TDA assets only to smooth consumption in the event of bad labor income shocks. Under the current law, a household that loses its job while carrying a loan balance has to repay the entire loan immediately in order to avoid early withdrawal penalties. If, as postulated in the model, unemployment risk is the main source of labor income uncertainty, both ways of holding on to TDA money for financing current consumption are equivalent, i.e. both trigger early withdrawal penalties. In addition, since one is only allowed to borrow up to 50% of assets held in employer-sponsored accounts and nothing at all from other TDAs, the standard no-borrowing constraint $x_t + X_t \ge 0$ is not controversial.

using shape-preserving bivariate interpolation (Costantini and Fontanella, 1990) and evaluating expected values by quadrature methods. A solution consists of a set of policy functions for consumption, savings and portfolio composition in each account habitat.

The model is solved with T set at 10, so that each period in the model corresponds to a 5-year interval for a household that starts working at 25 and retires at the end of period 9 at 65. In retirement, the household receives no labor income and consumes an annuitized flow of total wealth available at the start of last period[12]. The choice of 5-year periods represents a compromise between computational demands of a multi-period recursive model and ability to analyze portfolio choice over the lifecycle.

The model is solved for the benchmark case of power utility with the coefficient of relative risk aversion γ equal to 3 and the annual rate of time preference β of 0.96. The rate of return on stock index is assumed to be i.i.d. lognormally distributed with mean of 0.06 and standard deviation of 0.17. The riskless asset returns 4.2% annually, so that the annual pre-tax equity risk premium is 3.5 percent. This is markedly lower than the historical risk premium, but it approximates the expected equity risk premium argued for in Fama and French (2000)[13]. The tax rate on wages and dividends, τ^b is set at 40%, while the capital gains rate, τ^c is set at 20%.

The key economic mechanism in the model is the interaction between labor income risk and restrictions placed on withdrawing assets from the TDA. The simplest way to introduce substantial labor market uncertainty is through unemployment shocks with low income replacement rates. Undoubtedly, realistic labor income processes have a much richer structure that accommodates both transitory and permanent shocks, as well as jump-like unemployment shocks. However, in this purposely simple model, unemployment shocks are the most direct way to generate labor income uncertainty. Aggregation across time greatly restricts the severity of potential income losses due to unemployment. In the sample of 1989-1993 PSID data, nearly 15% of college-educated households experienced an unemployment spell at least once. However, the vast majority of such households (9 out of 10) lost less than 6 months of work during the entire 5-year period. Yet, as the model will indicate, having a probability of a catastrophic loss of income coinciding with a poor stock market return is a major factor in generating precautionary portfolio allocations. To resolve this, I follow Carroll (1992) in

[12] In the model without bequests or mortality risk, the length of retirement period can be chosen exogenously. The lifespan here is fixed at 80, so that the final period lasts for 15 years.

assuming a very small probability (0.5%) of a catastrophic loss defined as losing 99% of one's labor income.[14]

While the assumption of catastrophic labor income shocks may seem extreme, it must be noted that many other features of decision-making environment that may bring about precautionary portfolio allocations are omitted. Examples of such features include fixed costs of accessing retirement account assets and correlation between asset returns and labor income shocks. The importance of these elements for portfolio choice had been demonstrated in a different setting by Heaton and Lucas (1997, 2000). In effect, by ignoring these factors, the model overloads its only risk source.

In the base case scenario, households are assessed a 10% penalty for early withdrawals of assets from their pension account. In reality, however, the true cost of accessing TDA assets is much higher, even after taking into account such common retirement plan features as hardship withdrawals and loan availability. For example, hardship withdrawals are allowed only for a limited range of expenses approved by the IRS and proving eligibility for them may be expensive and cumbersome. In particular, a participant needs to prove both that the need satisfies plan requirements and that there are absolutely no other assets to cover it. This means loads of paperwork, administrative fees, and especially waiting time. Even when assets are released, they are subject to immediate taxation, an additional 10% penalty (if age is less than 59½) and loss of contributing privileges for the next 12 months. Loans against 401k balances are cheaper to obtain by comparison[15], but they must be repaid immediately in case of unemployment, which is precisely when household is likely to need the assets. In all cases, the most important cost is the forfeiture of the valuable tax deferral option on the withdrawn funds.

Unlike the portfolio models of DSZ and Huang (2001), the current model abstracts from questions of timing of capital gains. Instead, it incorporates uncertainty through wage shocks, which are not proportional to the state variables of the problem. As a result, wage shocks cannot be "insured" against by non-location-specific accumulation of wealth. Rather, the responses to

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[13] The case of a higher equity premium will be briefly addressed in section 3.2.

[14] Catastrophic income drops are much more plausible at an annual horizon. For example, Gakidis (1998) reports that in his sample of PSID data from 1977-1983, 6% of all observations classified as catastrophic drops in income, had a median decline to 10% (!) of previous year's labor income. My own calculations from PSID show that a drop in total income (which includes transfer payments) was much less severe – on the order of a 40%, which is still quite a significant shock.

labor market uncertainty take the form of adjustments in the amount of TDA contributions and portfolio modifications in both the TDA and CSA accounts.

A brief comment is in order to explain the choice of modeling income uncertainty (or liquidity needs) through uninsurable labor income risk, rather than large expenditure outlays driven by predictable demographic changes in the household, as done in Huang (2001). Under the current law, liquidity needs that arise from predictable lifecycle events such as house purchase and college expenses are partially exempt from strict withdrawal restrictions on retirement accounts[16]. This isn't true in the case of withdrawals made to smooth out labor income shocks like unemployment. Lifecycle events have a strong demographic component, and so for certain ages and family combinations, one should observe uniformly tax-efficient behavior. The data, however, show heterogeneity in allocations for all age categories. With the labor market risk story, the poor and those with a history of bad shocks will be inclined to amass buffer stocks irrespective of age. In the empirical analysis that follows, I model the effects of both types of uncertainty to determine whether the data show stronger support for one of the choices.

3.2. Properties of Numerical Solutions

A simple two-period version of the model (see Appendix A) can be used to establish two generic predictions of the model. First, in the absence of either precautionary motives or accessibility restrictions a household will always choose a tax-efficient allocation of its dual habitat portfolio. Second, when both precautionary motives and accessibility restrictions are introduced, it is possible to obtain mixed portfolio allocations in both account habitats. The solutions to a multi-period model of the previous section are used to move beyond these qualitative statements and to get a better sense of the properties of optimal policies.

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[15] The costs of borrowing against one's tax-deferred account include administration fees, double taxation of loan payments, and the spread between the loan interest rate and the returns on non-borrowed assets. Tax-deferred accounts that are not employer-sponsored (including rollover IRAs) do not allow borrowing at all.

[16] Both exemptions became law in 1997, as a part of Taxpayer Relief Act. The education withdrawals can apply towards tuition, as well as room and board and they can be taken out for oneself, one's children or even grandchildren. There isn't a fixed dollar limit on such withdrawals and as long as all of it goes toward qualified education expenses, no penalties are due. The housing exemption applies to "first-time" homebuyers and is capped at $10,000 for each of the partners (up to $20,000). "First-time" is defined only as "not having owned a primary residence for the past 2 years". Both of these apply only to assets taken out of non-employer-sponsored TDAs, such as IRAs and rollover IRAs.

Policy Functions

It is easier to analyze the relationships between controls and state variables on cross sections of three-dimensional policy surfaces. Therefore, in this section, I will present the results holding one of the state variables fixed (e.g. the level of pension wealth), while varying the other.

Panel A in Figure 2 shows optimal portfolio choices in the last working period. At the time of decision, the wage income is already known and the household also knows the values of its two state variables – Y_{T-1} and X_{T-1}. The household understands that it will not face any more wage uncertainty and will have full access to its retirement assets next period. The setting is thus the same as that considered in Proposition 1 (see Appendix A) with account and asset tax differences but no labor market risk or liquidity restrictions.

Panel A confirms that households always choose tax-efficient portfolio allocations. For the selected level of TDA wealth, we observe all three possible tax-efficient asset combinations, depending on the relative size of the two accounts. Starting on the left, where households have little liquid wealth relative to retirement wealth, we observe the spillover of equities into the TDA. That is, equities take up all of the regular account and "spill over" into the tax-deferred account. By contrast, households that have relatively little in pension assets (those on the right in panel A) cannot fit all of their desired bond holdings in TDA, and so bonds spill over into the regular accounts. This is evidenced by a TDA account that is fully invested in bonds (equity share of 0%) and a CSA account that is not fully invested in equities. The intermediate case of complete specialization of each account is observed for liquid wealth values in the middle of panel A. In sum, an asset spills over from its preferred account type if the account is not large enough to accommodate this asset fully.

The location component of household decision in the last working period is also straightforward. Most households contribute the maximum amount to TDA. They finance current consumption out of remaining wages and, if needed, by selling some of their regular account holdings. Only when the amount of cash-on-hand is small relative to TDA wealth will households cut back on pension contributions or even withdraw TDA assets at a penalty. Since there is no reason to maintain a buffer stock of liquid assets in the last working period, there are no interesting interactions between location and allocation decisions – whatever is not consumed is saved in the retirement account if possible and then the appropriate tax-efficient allocation is chosen.

The nature of decisions changes significantly in all preceding periods, during which the next period wage realization is uncertain and TDA withdrawals are penalized. The mixed allocations in both account habitats can now be observed, and the degree of such precautionary portfolio effects appears to vary systematically with the composition of household endowment. In particular, households that have less liquid wealth resort to holding bonds in their regular accounts as a way to decrease the risk of withdrawing pension assets prematurely. An example of such allocations can be seen in panel B for low values of liquid wealth. For example, when liquid wealth is equal to 0.2, a household optimally chooses to hold 93% of its regular account and 23% of its tax-deferred account in equities. Recall, that the contribution decision is made simultaneously with the determination of portfolio choices. There exist combinations of state variables at which a household cuts back on its TDA contributions in order to maintain a higher level of liquid assets and then invests these liquid assets in a tax-inefficient way.

It is worth noting that the model predicts that most households should hold a sizable proportion of their wealth in risk-free bonds. Many earlier papers (e.g. Heaton and Lucas, 1997) have found that positive bond ownership is extremely rare in portfolio models calibrated on historical equity risk premium that incorporate labor income. Recently, Heaton and Lucas (2000) demonstrated that significant positive bond holdings can be obtained with historical levels of risk premia under somewhat higher levels of relative risk aversion and, more importantly, an assumption of (positively) correlated labor income innovations and labor market returns. The current model uses catastrophic shocks instead to elicit positive bond holdings, but the general idea is the same as in Heaton and Lucas (2000) – to make labor income flow an inherently risky asset and thus provide households with an incentive to maintain at least some risk-free financial assets. This result is further reinforced by the absence of an exogenous income floor in retirement, which turns planned retirement into the most severe of all labor income shocks. As long as these assumptions on labor income process are maintained, positive bond holdings obtain for historical values of equity risk premium.

Figure 3 depicts the general relationship between the type of optimal portfolio choice and state variables of the problem. Segments B and C represent combinations of state variables (levels of CSA and TDA wealth) that result in tax-efficient allocations with two different spillover types described earlier. By contrast, segment A contains pairs of state variables that produce mixed portfolio allocations[17]. As seen from the diagram, segment A describes households that hold much of their overall savings in their pension accounts. The relative size of these segments evolves over the lifecycle and also varies with the exogenous parameters of the model, such as unemployment rate, liquidity restrictions, etc. The comparative statics exercises that follow focus on how the size of segment A depends on the environment of the household.

Comparative Statics

Panel C in Figure 2 shows an example of optimal working period asset allocations in both accounts for a continuum of outside wealth levels, holding TDA wealth fixed at pre-specified levels. The main message is that there exists a strong inverse relationship between equity shares in two account habitats. As the level of liquid assets declines, so does the optimal equity share in the outside portfolio. This change is "compensated" by an increase in the inside equity share. The household wants to be prudent in its outside allocations, but does not want to completely forgo the higher return potential of equity investments. However, since equity returns have a riskier distribution inside TDA accounts, the equity share inside increases slower than the outside equity share declines.

Simultaneously with adjustment in portfolio allocations, the household changes its choices of TDA contribution (not shown). As the level of liquid assets relative to pension wealth declines, the household gradually decreases its TDA contribution from the maximum amount allowed to zero. In the instances of very low liquid assets the household may even choose to withdraw TDA assets at a penalty to finance current consumption. Such withdrawals are made only when all liquid wealth is exhausted. This is precisely the type of situation that the household tries to avoid by keeping more assets outside and investing them in bonds.

Another feature of panel C (base case scenario) is that for any given level of outside wealth, households with smaller TDA holdings choose higher equity positions outside, but lower positions inside. For example, the outside portfolio allocation line with TDA wealth fixed at 0.8 is above its TDA = 1 counterpart over the entire range of outside wealth values. The explanation for this has to do with properties of the optimal consumption function, which increases monotonically in both inside and outside wealth levels. Households with more TDA wealth consume more for every level of outside wealth. As consumption is financed from wages and

[17] Examples of typical portfolio allocations *within* each these segments are presented in Figure 2.

outside wealth, these households have less net liquid assets to invest and, therefore, choose a more cautious outside portfolio allocation.

An alternative way to state this is as follows. Households that have higher share of their overall wealth confined to TDA have stronger precautionary portfolio effects, since less of their overall wealth is readily accessible (i.e. liquidity constraint is tighter). This interpretation will be useful for empirical tests as the share of wealth in TDA allows a concise summary of both state variables of the model.

Panel D shows the effect of tightening withdrawal restrictions on portfolio choices. When TDA assets are made inaccessible (*pen* = 60%), the mixed nature of optimal allocations becomes much more pronounced. Higher withdrawal penalties increase the costs of tax-efficient rebalancing if such rebalancing results in a greater probability of needing to withdraw pension assets early. Therefore, the higher the penalty, the greater is the range of wealth values for which tax-efficient reshuffling is avoided. In terms of Figure 3, higher penalties expand segment A (from A_0A_0' to A_1A_1') so that more households in the state plane choose tax-inefficient allocations.

An increase in unemployment probability (not shown) worsens the background risk of the households and reduces their implicit holdings of riskless assets in the form of future wages. Both have an effect on location and allocation choices of the households. Since an increase in background risk strengthens the precautionary motives, one may expect it to produce the precautionary portfolio effect, i.e. decrease equity share in regular account and increase it in retirement account. The level of the overall equity holdings will also decline for most CSA-TDA wealth pairs in the state space. While equity shares in regular account decrease for the entire range of liquid wealth holdings, the model solutions produce mixed results regarding the effect of higher unemployment on the equity share inside retirement account. For low levels of liquid wealth, equity share inside increases with unemployment probability, but the opposite happens at higher liquid wealth levels. A possible explanation for this result has to do with which margins of adjustment are available for household's response to an increase in background risk. Recall that at higher levels of liquid wealth, households are making positive contributions to their TDA accounts. When unemployment risk increases, they cut back on such contributions over a significant range of liquid wealth values. Such adjustment is quite drastic – a household may go from a maximum allowable contribution to no contribution at all. In addition, these households decrease their levels of current consumption. Both of these actions increase their buffer stock holdings that are also invested in a more conservative fashion. The total equity holdings in liquid accounts do not change much – lower equity exposure is offset by higher investable asset base. Since retirement wealth is now lower (given decreased TDA contributions), a decrease in the overall equity share is accomplished without much change in TDA equity shares. To the extent these changes occur, they tend to be downward. By contrast, households that have lower liquid wealth holdings at time of the consumption-portfolio decision, optimally choose to contribute nothing to TDA under both scenarios for unemployment risk. Their already low consumption has limited scope for further downward adjustment. As a result, most of the adjustment for these households takes place through changes in portfolio allocations.

Finally, preliminary results indicate that higher equity premium (of 6%) makes equity spillover choices much more common at the expense of both bond spillovers and mixed portfolio choices. In terms of Figure 3, this is represented by the expansion of segment B and shrinking of segments A and C. More attractive equities reduce the overall bond holdings, so that smaller TDAs are sufficient to hold all desired bonds. Similarly, with a higher equity premium, one needs to move fewer bonds outside to decrease the probability of an early withdrawal. Therefore, there exist more combinations of the beginning-of-period wealth levels that do not result in tax-inefficient allocation choices.

Lifecycle Implications

Although this model is highly simplified, it produces a variety of empirically testable implications. A likely lifecycle path of inside/outside portfolio choices suggested by this model is shown in Figure 4. A household that has little accumulated (inherited) wealth early on in its lifecycle, first builds up buffer stocks through liquid assets (group 1). If pre-retirement withdrawals are costly, investments in TDAs are delayed while buffer stocks are being built up. This can be interpreted as a tradeoff between precautionary concerns and tax advantages of TDAs along the extensive margin. Once enough wealth is accumulated, the tradeoff begins to take place along the intensive margin, as the household seeks to strike a balance between its need to smooth consumption in the event of uninsurable shocks and its desire to maximize lifetime resources. Holding constant the nature of risky labor income process during working years, the diagram can be taken to represent evolution of asset location and allocation choices as households accumulate wealth.

Households with relatively little wealth that *are* able to lock up some of their savings in TDA cannot ignore the precautionary motive in allocating their outside portfolio. They choose to hold a relatively low equity share in their CSA and "compensate" with relatively high equity shares in TDA. These are households in group 2. Eventually, households maximize their TDA contributions, but the composition of both accounts still depends on the amount of liquid assets that could be used to counter a shock. When contribution limits are reached and liquid wealth starts to increase, the households become more concerned with tax-efficiency and begin rebalancing their TDAs towards bonds (group 3). Once the household either accumulates enough overall wealth or retires[18], it enters the region of tax-efficient allocation given by point 4. By comparison, households in the tax-efficient model vary their portfolios along the dotted arrows in the tax-efficient region at all times as their wealth changes.

A similar story, which is also supported by results of the model, can be told through changes in the share of household wealth held inside TDA. Since there exist restrictions on the size of retirement account contributions, the overall wealth and its share in TDA are typically inversely related. Therefore, share of wealth in TDA is a useful measure of the resources available to household in case of emergencies both in absolute and relative sense.

This sequential diagram is only suggestive as both location and allocation choices evolve simultaneously. However, simple descriptive analysis of the SCF data provides some evidence that the broad allocation classes outlined above are associated with wealth levels, household age and unemployment risk. The data tabulated at the bottom of Figure 4 indicate that moving from group 2 (households with no equities outside) to group 3 (transition households) and then 4 (tax-efficient households), we observe a rise in age and wealth, along with the decline in unemployment risk and the share of wealth held in TDA. The histograms in Figure 6 show the distribution of U.S. households by wealth decile for each of the four groups. As expected, households without retirement savings are concentrated in the lowest wealth deciles. By comparison, households that hold equities primarily in retirement accounts (group 2) are solidly in the middle of the wealth distribution (it is worth noting that a household in the sixth wealth decile in 1998 still held less than $23,000 in financial non-housing wealth). The bottom two

[18] I abstract from other important sources of risk that are undoubtedly present in retirement, primarily health risk.

panels, which represent transition and tax-efficient groups (3 and 4), are markedly different by their concentration among the highest wealth deciles. Nearly 65% of the top decile households accounting for 53% of total population wealth are either transition or tax-efficient households.

The diamonds in Figure 4 represent simulated portfolios of the base case model. The lifecycle portfolio allocations do evolve towards tax-efficient choices, although the predicted magnitudes of equity holdings rule out any observations in group 2. The households never trade off enough equities for bonds in their regular account and reach tax-efficiency by age 40. This result is largely due to low penalty values on TDA withdrawals[19]. Preliminary numerical solutions suggest that higher penalty values significantly strengthen precautionary portfolio allocations and yield predictions that are more closely aligned with the path depicted in Figure 4.

4. Empirical Framework

The obvious candidates for empirical tests of the precautionary portfolio effects are those components of the model environment that relate to precautionary motives. These include measures of labor income uncertainty and recent income history; share of wealth held in retirement accounts as a proxy for location decision and a measure of importance of size restrictions; and the overall level of wealth as a measure of household ability to handle labor market shocks.

Most of these factors have been shown to play an important role in the overall portfolio choice (Vissing-Jørgensen, 1999). Here, the goal is to show how these variables, in conjunction with others, affect the distribution of assets between and within the different components of the household portfolio. I concentrate on two predictions. First, can the choice of mixed vs. tax-efficient allocations be linked to the presence of precautionary savings motives? Second, do variables that relate to the strength of precautionary savings motives have explanatory power for heterogeneity of portfolio choices within both account habitats?

[19] When penalties are low, assets in both accounts are regarded as fairly close consumption substitutes. Therefore, the curvature of the value function in the TDA direction is almost as high as that in the regular asset direction. In simulations, the households are started off with no TDA assets, and so they choose to make the maximum contribution to their TDA and invest it mostly in bonds. They are as afraid of losing TDA assets to early withdrawals as to bad returns. The stocks do get pushed over into TDA from the regular account because of labor risk, but they are balanced with bonds to avoid losses. By the next period more regular wealth gets accumulated, the

4.1. Tests For Switching Between Allocation Types

The discussion of properties of optimal portfolio allocations in section 3.2 provides the basis for extending the numerical model results to empirical tests. The set of candidate explanatory variables is split into two distinct subsets. The first subset contains variables that are related to the presence and strength of precautionary motives, as they are typically defined in the literature. It consists of variables that refer to age, wealth, and labor income risk.

The second subset contains two variables that pertain to accessibility of household's total assets. The first variable measures the share of TDA holdings in overall financial wealth, which summarizes both of the state variables of the numerical model. All else equal, households with a higher share of wealth in TDA have stronger liquidity restrictions, since a smaller part of their overall wealth is readily available for smoothing adverse shocks. The share of wealth in TDA also serves as a proxy for the location choice. Given the non-separability of contribution and allocation decisions, it is particularly important to account for the location choice in evaluating portfolio composition. The second variable identifies households that no longer face restrictions on accessibility of their retirement wealth and don't have to pay a penalty upon access (both restrictions lapse upon reaching the age of 59½). For such households, there is no need to trade off tax efficiency for accessibility, regardless of whether or not they are still employed. The precautionary portfolio effects in the model of section 3 arise because of uninsurable labor income risk and accessibility restrictions on retirement wealth. Therefore, households with weaker precautionary savings motives or free access to their retirement wealth are more likely to make tax-efficient portfolio choices. Empirically, such households are expected to be:

(a) more wealthy, so they are effectively not liquidity constrained;
(b) have less risky labor income processes, so that lower buffer stocks are required;
(c) have a lower share of their wealth held in a retirement account, which restricts accessibility;
(d) have free access to their retirement wealth;
(e) unlike in the case of demographic liquidity needs, age should matter only inasmuch as it affects the distribution of innovations to labor income or is correlated with wealth levels.

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precautionary motives get weaker and so the share of bonds outside declines. Because of contribution restrictions, the absolute magnitude of the regular account grows fast enough to eliminate the need for bond holdings there.

The base set of regressors for these tests, therefore, consists of financial wealth[20], share of wealth held in TDA, as well as age and education category dummies. I also include measures of labor income risk (the standard deviation of wage shocks and the probability of unemployment) and an indicator of accessibility restrictions for TDA assets.

4.2. Tests For Portfolio Choices Within Allocation Types

Building on the discussion in the previous section, the same explanatory variables can also be used for empirical tests of the intensive margin of portfolio allocations in each of the two accounts. One can think of stronger precautionary savings motives as deriving from two sources: (1) higher background risk and (2) tighter liquidity constraints. The first is captured in the data by estimates of variability of labor income process and the second by the level and location of wealth holdings. Higher values of variables that indicate either precautionary savings motives or limited accessibility of household wealth would generally be associated with lower equity holdings in regular accounts. Implications for equity shares in retirement accounts are less straightforward – on the one hand, things like negative income shocks can be expected to decrease equity exposure inside as future earning prospects diminish, but equity exposure can also increase in response to rebalancing towards safer buffer stocks outside. Which effect dominates depends heavily on the overall location/allocation decision of the household.

The numerical results illustrated in Figure 2, however, indicate that the two key components of the model – the distribution of wealth between accounts and the presence of accessibility restrictions – will produce the precautionary portfolio effects summarized in the table below.

[20] In order to correct for extreme skewness in distribution of financial wealth, I use the inverse hyperbolic sine function advocated by Carroll, Dynan, and Krane (1999). This transformation is described by $g(W,\theta) = \ln(\theta W+(\theta^2 W^2+1)^{0.5})/\theta$, where θ controls the degree to which large values are downweighted. Unlike log transform, *g* can handle negative and zero observations as well.

Endogenous variable	State/regime variable	Expected sign
TDA % in equities	Share of wealth held in retirement account: (TDA / TDA+CSA)	+
CSA % in equities	Share of wealth held in retirement account	-
TDA % in equities	No accessibility restrictions (1 / 0)	-
CSA % in equities	No accessibility restrictions (1 / 0)	+

By comparison, models that only allow tax-efficient outcomes would predict a positive relationship between share of wealth in TDA and equity shares in *both* accounts, due to the asset spillovers discussed earlier. Such models would also state that accessibility restrictions have no effect on portfolio choice in either account.

4.3. Data

The data used in this study come from the two latest Surveys of Consumer Finances, conducted in 1995 and 1998. The surveys are conducted by the Board of Governors of the Federal Reserve System and cover a substantial cross-section of U.S. households in each survey year. There are 4,299 and 4,305 households, respectively, in the surveys studied here. The SCF surveys ask a wide array of questions on every aspect of each household's financial situation – amount and type of liquid and illiquid assets, nature and value of proprietary business holdings, availability and price of credit, sources of earning, etc. Of particular value for the study of household portfolio composition is the fact that the surveys oversample wealthy households, which tend to have richer portfolio structures. Each survey makes available a set of sampling factors that allow one to re-weight the sample to produce population statistics. Unless otherwise noted, all descriptive statistics utilize population weights.

The SCFs attempt to uncover precise details of composition of household financial portfolios. Unfortunately, information on allocations to narrowly defined asset classes exists only for funds kept in regular investment accounts. By contrast, the composition of holdings in tax-deferred retirement accounts, both individual (like IRA and Keoghs) and employeesponsored (i.e. 401k, 403b) has to be inferred from categorical responses. For example, the question on allocation of IRA holdings asks, "How is the money in this account invested? Is most of it in…?" Following this question, there is a table of possible answers, with separate categories for cash, stocks, and bond holdings (both direct and through mutual funds), and several additional categories that allow joint holdings of combinations of these assets. Obviously, some assumptions are needed to translate these qualitative measures into dollar figures. I use a set of mappings that assign all of the account value to a category that is indicated to be the single category in which "most" holdings are invested. If a combination of categories is chosen, the account value is allocated in equal proportions. The resulting raw allocations of assets in retirement portfolios match closely with the earlier studies (e.g. Ameriks and Zeldes, 2000).

The necessity to impute equity shares in retirement accounts in this way explains the agglomeration of observations at certain points on the y-axis in Figure 1. For example, a horizontal line at 50% TDA allocation corresponds to holdings of households with only one of two types of retirement accounts (IRA/Keogh or 401k/403b) who reported that their pension assets were split between equities and bonds.

This undoubtedly results in an additional source of measurement error in retirement account portfolio allocations. It is not clear how to improve the precision of estimates, as there are few data sources that can provide detailed information on the composition of retirement assets and on the rest of the household portfolio. It is worth pointing out that the extreme positions (e.g., non-participation in the stock market, ownership of retirement accounts, etc.) are unambiguously identified in the SCF data.

In order to conduct empirical tests, the key components of theoretical models need to be given operational meaning. I define household wealth as total quasi-liquid financial assets of the household that can be explicitly allocated between assets with equity- or bond-like properties. This includes nearly all financial instruments like checking, savings, mutual fund investments, defined contribution pension plan assets, etc. It specifically excludes housing and proprietary business wealth, as well as imputed values of future guaranteed pension income (Social Security, defined benefit plans) and human capital wealth. Some recent studies of household financial decision-making (e.g. Flavin and Yamashita, 1998) focus on the role of housing wealth. Not only does housing represent the single largest component of wealth for many U.S. households, but it also serves as an important mechanism for relaxing liquidity constraints through home equity loans and lines of credit. For these reasons, it is important to control for housing wealth in empirical work by including a measure of housing equity from the SCF as a separate wealth category. Proprietary business holdings have also been shown to be an important component of household portfolios (Heaton and Lucas, 2000). Such holdings are typically less liquid and more volatile than purely financial assets. While the current version of the paper excludes these holdings, it would be useful to conduct some robustness checks on the definition of wealth in the future.

I define as retirement assets only account balances in retirement plans that allow its participants to choose asset allocation. This category includes most of the defined contribution (DC) plans such as 401k and TIAA-CREF, as well as individual retirement accounts such as IRA and Keogh plans. A particularly important task is to define “stocks” and “bonds”. Typically, “bonds” have been interpreted directly as corporate, municipal and government bonds traded on financial markets. The ownership of such assets is extremely skewed in the population, and they don’t nearly exhaust the set of financial instruments that provide safe return and are highly liquid. Since I intend to focus on the precautionary behavior of households, I use a broader definition of “bonds” that includes money market accounts, savings accounts, and U.S. savings bonds in addition to the usual set. All of these assets face the same tax treatment as do conventional bonds.

In addition, the SCF provides information on recent household income history. Households are asked whether their income in the past year was higher or lower than “usual”. If the answer is “yes”, they are asked about reasons for deviation from the trend. Their detailed replies can be aggregated into several broad categories of income and demographic shocks. The households also report a measure of income in a “normal year”, which is taken to represent their estimate of household permanent income.

To obtain a measure of conditional moments of labor income processes, I compute estimates of standard deviations of labor income shocks from the 1985-1993 sample of the PSID data. The choices of the functional form for the labor income process and the econometric method for estimating its components are similar to Carroll and Samwick (1997) and (Vissing-Jørgensen, 1999). The details of specification and estimation, as well as data selection criteria are specified in Appendix B. After conditional moments of labor income are computed for each household in the sample, they are averaged within each occupation-education group. These group means are then used as point estimates of labor income uncertainty for corresponding cells in the SCF. Intuitively, the linkage of conditional cell means across datasets is similar to Lusardi's (1996) interpretation of two-sample instrumental variables, though it lacks its econometric rigor. I also obtain cross-sectional probabilities of unemployment for each occupation-education group from the Job Tenure Supplement of the Current Population Survey. Finally, I use SCF data on a number of other demographic variables such as levels of education and current occupation of members of the household.

5. Empirical Results

5.1. Cross-Sectional Heterogeneity In Interior Portfolio Choices

In order to analyze portfolio choices within the framework of the model with uninsurable labor income risk, I need to work with econometric models of continuous (although limited) dependent variables. The econometric model for portfolio allocation within a given habitat is described by:

$$y_i^* = \beta_1 + \beta_2 D_i + \beta_3 W_i + \beta_4 L_i + \beta_5 H_i + u_i \, ,$$

$$y_i = 0 \text{ if } y_i^* \leq 0; \; y_i = 1 \text{ if } y_i^* \geq 1; \; y_i = y_i^* \in (0,1)$$

where each of the *y*'s is limited to be between 0 and 1 by construction. The set of explanatory variables is based on the discussion in Sections 4.1 and 4.2 and is broken into several subsets for convenience. D_i is a subset of demographic variables – education dummies, a quadratic in age, and an indicator of whether a household is past the age of 59½ (i.e. not subject to pension withdrawal restrictions and penalties). W_i is a subset of wealth variables, which consists of financial wealth (transformed as in the previous section), housing wealth (also transformed), and the relative share of retirement wealth (*swlthTDA*), which was argued for in Section 4.2. L_i contains estimates of the conditional volatility of labor income by occupation, education, and age, which are estimated from PSID data. The regressors in L_i also include the probability of unemployment estimated for the same demographic groups. Finally, H_i contains indicators of the recent history of income shocks experienced by the household. These indicators denote bad income shocks such as loss of job, lower wage, and lower proprietary income; bad demographic shocks such as divorce or childcare, health, and education expenses; and good income shocks like promotion, bonus, or a higher-paying new job. Whereas L_i picks up group characteristics of wages, H_i keeps track of individual-specific wage shocks.

In reality, the allocation decisions in both accounts are made simultaneously. Hence, econometric estimates may be improved by choosing a bivariate tobit model with correlated error structure. The error terms in each equation include unobserved (or omitted) household-specific factors that may be important for allocation decisions in both habitats. An additional complication of the model is that the share of wealth in the pension account, which appears on the right-hand side, is itself endogenous. This variable represents the location choice of the households, which is determined alongside portfolio compositions. I use a variant of the estimator developed by Newey (1987) for limited dependent variable models with endogenous explanatory variables. This estimator has a form of Amemiya's (1978) generalized least squares (AGLS), where the conditional log-likelihood function for bivariate tobit (Greene, 1995) is used to obtain reduced form parameters. The general setup of the model, which can also be estimated by two-stage instrumental variables method (2SIV), is as follows:

$$y_{i,CSA}^* = \beta_1 + \beta_2 D_i + \beta_3 W_i + \beta_4 L_i + \beta_5 H_i + u_i\ ,\ i = 1,\ldots N$$

$$y_{i,TDA}^* = \gamma_1 + \gamma_2 D_i + \gamma_3 W_i + \gamma_4 L_i + \gamma_5 H_i + v_i,\ i = 1,\ldots N$$

$$swlthTDA_i = \Pi_1 X_{i1} + \Pi_2 X_{i2} + \varepsilon_i.$$

$$(u,v,\varepsilon) \sim MVN(\mu,\Sigma)$$

$$y_k = 0 \text{ if } y_k^* \leq 0;\ y_k = y_k^* \in (0,1), \text{ for } k = TDA, CSA$$

The model is estimated on a subset of households that have both account types, in order to avoid including trivial 0-portfolio choices[21]. Here, X_1 denotes instrumental variables that are included in the equity share equations, while X_2 represents excluded instrumental variables. To achieve identification, I define X_2 as size of the firm where the head of the household works. Assuming that the outcome of job search is independently distributed across hiring firm sizes, size of the firm is an exogenous attribute of household environment. However, it is likely to be an important predictor of whether a household has access to an employer-sponsored retirement

[21] In an unreported exercise, I test for non-randomness of sample selection produced by eliminating households that do not own pension accounts. The results of the Heckman sample selection model of TDA composition indicate that the TDA ownership decision is primarily a function of employment characteristics (i.e. small vs. large firm), which can be reasonably treated as exogenous to the household.

plan. This, in turn, greatly affects the share of wealth that could be assigned to tax-deferred accounts.

Aside from its econometric appeal, understanding the determinants of the location choice is of interest in its own right. Therefore, I present the results of the first stage of the 2SIV estimation in Table 1. As hypothesized, the share of wealth in TDA is strongly positively related to the size of the firm (availability of employer-sponsored pension accounts) and employer match levels (attractiveness of such accounts). Also, as expected, strict limits on contributions to retirement accounts result in a strong inverse relationship between the level of wealth and its share in TDAs. Notably, the share of wealth in TDAs is also found to depend negatively on the level of riskiness of the household's labor income. This finding is important because it shows that the location decision of a household is an active choice variable influenced by the level of uncertainty in labor income, and not just a deterministic function of household wealth. That is, of the two households with identical wealth levels, the one with greater income uncertainty will have contributed less of its wealth to the tax-deferred retirement account.

Outside (CSA) Portfolio Choice

Newey's asymptotically efficient estimates of the structural parameters for the outside portfolio allocations are presented in the left-hand panel of Table 2. The coefficient estimates are of correct sign and most are statistically significant. The regressors in W are found to have particularly strong effects on portfolio choice. As argued in Section 4.2, a higher share of wealth in TDA leads to lower equity shares outside, while higher levels of financial and/or housing wealth imply higher outside equity shares. That is, conditional on the overall financial wealth, a household that has more wealth held in TDA will choose a less risky outside portfolio. The parameter estimate suggests that moving a household at the 25^{th} percentile of *swlthTDA* (0.136) to the 75^{th} percentile (0.714) would decrease the equity share outside by 32 percentage points. The elimination of withdrawal penalties is found to have a positive, though not statistically significant effect on the outside equity shares. By contrast, both measures of labor income uncertainty have strong negative effects on the share of outside portfolio dedicated to equities. The lower magnitude of these effects (for example, a decline in equity share by 6.8 percentage points when std. dev. moves from the 25^{th} to the 75^{th} percentile) is not surprising in light of the first stage results.

The demographic regressors in D have the expected signs – the share of stocks outside increases with education and decreases with the number of dependents. There is also a strong positive time effect. While the results for the outside portfolio choice are suggestive, one needs to consider them jointly with those for the inside portfolio choice in order to test model predictions.

Inside (TDA) Portfolio Choice

The structural parameters for the inside portfolio allocations, shown in the right-hand panel of Table 2, provide further support for the model. The share of wealth held in TDA has a strong positive effect on the equity share inside. This result is particularly important given the finding of an opposite relationship between equity share and location in the regular account. Such differential relationships between location and allocation choices in the two account types are non-existent in portfolio models without labor income risk, but occur commonly in the augmented model of section 3. Since the distribution of returns on equities is riskier inside a retirement account, it is somewhat surprising to obtain a stronger absolute effect of TDA wealth share on the inside equity choice. Another result is that elimination of withdrawal penalties leads to lower equity shares inside, while having an opposite effect on the outside portfolio composition. Even though these effects are at best marginally significant, they are consistent with the predictions of the theoretical model.

The hypothesis that higher housing wealth levels relax household liquidity constraints by enabling access to home equity lines of credit is supported by the results in Table 2. Higher housing wealth indicates higher equity shares outside but lower equity shares inside TDA. That is, households with better access to credit markets (due to higher housing wealth) are making more tax-efficient portfolio choices. The large and positive effect of probability of unemployment on the equity share inside is puzzling in light of numerical results, which suggest that the effect of higher background risk on inside portfolio allocations is rather ambiguous. The bivariate tobit procedure estimates a strong positive correlation for the error terms in the two habitats. A possible explanation for this is the relationship between 0-limit observations – unobserved factors that influence household participation decisions in equity markets are likely to work in the same direction in both habitats. For example, households that have already incurred the costs of learning about the stock market are more likely to own equities in both accounts.

Taken together, the empirical estimates of the determinants of equity shares in the two account types paint a promising picture for our ability to understand observed portfolio allocations in the context of a portfolio model that explicitly incorporates labor income uncertainty.

Household-specific income and demographic shocks

I find that income shocks are the only ones that have a significant effect on portfolio allocations. A value of 1 for *bad_inc* means that the household experienced a bad income shock during the previous calendar year (1994 or 1997, respectively). All financial variables are current as of the time of the interview, and so I implicitly assume that recorded portfolio shares no longer reflect the immediate effects of trading assets in order to smooth out the shock. In the period following a bad labor income shock, there are two changes in household environment. First, given the limited accessibility of retirement assets, the share of wealth in TDA likely increases as consumption is smoothed primarily with liquid assets. Second, since labor income shocks tend to be quite persistent, a bad shock lowers the implicit value of safe assets embodied in human capital. This is true even when labor income is very risky, as any persistent shock affects the drift of that process as well. By contrast, many of the bad demographic shocks do not change the future distribution of labor income flows (e.g. tuition payments for a child, or housing purchase) and they can be covered by penalty-free TDA withdrawals. The observed portfolio allocations can then be regarded as indicative of choices of the household with a modified distribution of future earnings conditional on shock realization and with a different composition of wealth holdings. Hence, a negative coefficient for *bad_inc* in the regular account captures the increase in safe assets outside in response to the worsening of labor return distribution and wealth holdings that are more skewed towards TDA. The coefficient for *bad_dem* is very unstable by comparison and fluctuates between positive and negative values depending on the choice of regressor set. I interpret this as evidence for using labor risk as a source of precautionary savings in portfolio models instead of the exogenously given lumpy expenditure needs.

5.2. What Makes Tax-Efficient Choices More Likely?

I use bivariate probit analysis to study the factors that influence the qualitative choice of an investment model. Unlike the analysis in the preceding section, I discard information on the continuous choice of equity holdings in each account in an attempt to obtain a convenient summary of factors that make a tax-inefficient choice more likely. The household makes two portfolio allocation choices – one inside and one outside. Each of the choices is coded as a discrete outcome[22]:

inside (TDA) allocations $\begin{cases} \text{1, if positive equity holdings inside} \\ \text{0, if no equity inside;} \end{cases}$

outside (CSA) allocations $\begin{cases} \text{1, if } \textit{no} \text{ bonds outside (i.e. only equity outside)} \\ \text{0, otherwise.} \end{cases}$

Recall that tax-efficient behavior could be described as positions on the two edges of the allocation box – segments AB and BC in Figure 1. Therefore, the tax-efficient model accommodates (TDA,CSA) choices (1,1), (0,1) and (0,0). The same model specifically rules out the (1,0) outcome. These choices are summarized in Figure 5 and in the table below.

Inside choice	Outside choice	Description
1	1	Equity overflow: bonds and stocks inside, only stocks outside
0	1	Complete separation: only bonds inside, only stocks outside
0	0	Bonds overflow: only bonds inside, bonds and stocks outside
1	0	Precautionary portfolios: any interior choice of stocks and bonds in either account

As a result, the four outcomes of a bivariate probit are separated by the type of theoretical model that could generate them. Using the bivariate probit model for estimation allows the error structures of discrete decisions in both habitats to be correlated and represents one way to account for simultaneity in allocation decisions.

I use the same set of regressors as in section 5.1 to test whether the choice of allocation model is related to the presence of precautionary savings motives. The non-linear nature of the probit model allows identification even when both equations contain the same set of regressors. However, since it is difficult to argue that joint error distribution is precisely described as a bivariate normal, it is best to use a number of additional variables for identification. For the retirement account decision, I choose the level of employer contribution match (*emplmtch*) as an additional variable. Such matches are frequently made in the form of company stock and are non-tradable[23]. Therefore, they influence the stock ownership decision inside directly, and the portfolio choice outside only indirectly. Employer matches can be treated as an exogenous institutional parameter by the household, and so are likely to be uncorrelated with the error term. For the allocation decision in the regular account, I use the number of dependents in the household (*numdep*) as an additional variable that directly affects the choice of holding buffer stocks. The intuition for this is that households with more dependents have higher liquidity demands, and the number of dependents is taken exogenously by the household in its portfolio decisions. The standard bivariate probit model is given by:

$y_{1i}^* = \beta_1 + \beta_2 X_{1i} + u_i$, $y_{1i} = 1$ if $y_{1i}^* > 0$, 0 otherwise;

$y_{2i}^* = \gamma_1 + \gamma_2 X_{2i} + v_i$, $y_{2i} = 1$ if $y_{2i}^* > 0$, 0 otherwise

$Cov[u,v] = \rho$

The model is estimated on a subset of households that have both account types, in order to avoid including trivial 0-allocation choices. In order to account for the endogeneity of *swlthTDA*, I use Newey (1987) estimator adapted to the probit model. Table 3 presents estimation results, which are quite mixed. The marginal effects of some key regressors (share of wealth in TDA and probability of unemployment) on the likelihood of precautionary portfolio choice have the right sign and are significant. Other regressors, however, are either insignificant or contradict the testing hypothesis.

The coefficient estimates of the two estimated probit equations allow some insight into the account-specific components of the overall portfolio decision. The effect of the share of wealth held in TDA on the probability of holding stocks inside pension accounts is positive and very strong. This is consistent either with the hypothesis of tax-efficient stock spillovers or with the precautionary portfolio allocations. However, the same variable has a negative point

[22] In assigning portfolio allocations to discrete outcomes, I use a milder 90% threshold in order to mitigate some of the measurement problems. That is, a household with 91% of its outside account in equities is assigned CSA=1.

estimate in the probit of observing 100% equity allocation outside, which is contrary to the strong positive effect predicted by tax-efficient spillovers. Similarly, the point estimates of the probability of unemployment have different signs in the two equations. Age has no independent predictive power for whether bonds are held in regular accounts. This is expected, as households that are old and poor should be as interested in maintaining safe liquid buffers as households that are young and poor. By themselves, these equations only try to identify distinguishing characteristics of households that hold equities in their pension accounts from those that do not, and households that hold bonds in their regular accounts from those that do not.

In the bivariate probit model, the marginal effects of each regressor are obtained for each particular outcome by combining coefficient estimates from both regressions and scaling the result appropriately. Table 4 contains estimates of marginal effects for the precautionary (1,0) decision along with corresponding standard errors. On the net, households with higher probability of unemployment, larger share of wealth in TDA, and more dependents are more likely to hold mixed portfolios. These results agree with the hypotheses (b) and (c) of section 4.1. By contrast, I fail to detect an independent effect of removing accessibility restrictions on the likelihood of holding equities in pension accounts. There is an overall negative trend, but it does not signal that there is a markedly higher probability of an *absolute* exit from equities in the pension account at the expiration of penalties. Contrary to the strong prediction of the theoretical model, higher financial wealth implies higher probability of observing a tax-inefficient portfolio. This is likely due to the positive effect of higher wealth on overall equity participation, which gets picked up in the (1,0) choice that involves equity holdings in both accounts.

In order to get a measure of economic significance of key explanatory variables, I compute the relative impact of changing a given characteristic from its 25th to the 75th percentile value on the predicted probabilities of observing a mixed portfolio choice. Having *swlthTDA* at the 75th percentile level increases the probability of a mixed portfolio by 27 percentage points, while increasing the probability of unemployment to its 75th level, only improves the same probability by 1.7 percentage points.

The main reason that the bivariate probit model fails to produce stronger results has to do with strict categorization of households. That is, the econometric model tries to tell apart a

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[23] In its recent survey, the Investment Company Institute (ICI) reports that plan participants who receive some of their employer match in form of company stock have on average 40% of retirement assets in company stock. Those who get employer matches in cash have only an average of 6% invested in company stock.

single tax-inefficient group from several types of tax-efficient households. As a result, it does not differentiate between those households that are "en route" to a tax-efficient outcome and those who are way off any of the tax-efficient corners. When all tax-inefficient households are lumped together regardless of the degree of tax-inefficiency they display, the results are less precise. This “lumpiness” of choices is avoided in the tobit analysis of the previous section.

6. Conclusion

Observed portfolio choices in taxable and tax-deferred account habitats are inconsistent with the existing theoretical models. The households commonly fail to exploit the tax advantages of pension plans by choosing to hold high-tax-burden assets like bonds in their taxable accounts, while also maintaining sizable equity positions inside tax-deferred accounts. The two main questions that are addressed by this paper are: (1) is there a way to augment theoretical models to account for observed portfolio allocations across account habitats and (2) do the data support such theoretical specification? On the first question, the paper offers simple analytical and numerical arguments to show that uninsurable labor income shocks, together with accessibility restrictions on pension assets, can indeed support tax-inefficient portfolio choices frequently observed in the data. On the second question, the paper presents empirical evidence from the SCF on the factors that influence the type of habitat-specific portfolio choice. Both the degree of “tax inefficiency” of observed portfolio choices and, to a lesser extent, the existence of tax-inefficient portfolios are found to be related to variables associated with precautionary savings motives. These relationships are broadly consistent with implications of the numerical model. They also augment the set of existing empirical results to include account-specific response of portfolio choices to precautionary savings motives.

This paper also highlights the importance of distinguishing between account habitats in future studies of household financial decision-making. The existing institutional differences in accessibility and tax treatment, as well as distinct savings motives for each of the two account types, may hold the key to resolution of several empirical puzzles. Indeed, there exist dramatic differences in age profiles of equity participation and portfolio composition in the two accounts that can be exploited to identify the reasons for equity non-participation or to assess the degree of responsiveness to various tax incentives like the step-up in basis at death.

An immediate extension of the present paper is a study aimed at estimating whether the choice of the normative model is likely to matter in practice. For example, is allowing individuals to allocate their Social Security retirement assets likely to lead to disastrously costly outcomes? What are the welfare implications of not rebalancing the retirement accounts, even when such changes are tax-exempt? Given the pace of proliferation of individual-controlled retirement funding, these questions are likely to remain an important item on the long list of topics in portfolio allocation theory.

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Appendix A. Two-period model of portfolio choice

Consider a variant of the model in Section 3.2. where household lives for two periods. In the first period, it chooses portfolio composition of tax-deferred retirement account (X) and regular investment account (Y), given some initial values (X_0,Y_0). The household derives utility from consumption of terminal wealth *W*. The non-standard part of this setting is that before *W* can be consumed, the household may be required to pay a positive fine *F*. This fine is levied with probability *p* and it must be paid out of the available wealth in account Y (CSA). The fine cannot be insured against. The intuition for this setup is found in institutional characteristics of retirement accounts, discussed earlier. By allowing for differences in tax treatment by account and by imposing a reason to hold assets in a liquid account, this simple model roughly captures the tax-liquidity tradeoff described in the previous section.

Formally, the household problem is given by:

$$\max_{\{\alpha^x,\alpha^y\}} E[U(X_0 R^x(\alpha^x,\tilde{r}) + Y_0 R^y(\alpha^y,\tilde{r}) - F(s)] \qquad (1)$$

$$F(s) = 0 \text{ with prob.} (1-p);\ F(s) = F \text{ with prob. } p$$

$$Y_0 R^y(\alpha^y,\tilde{r}) - F(s) \geq 0, \forall s, \tilde{r}$$

with associated compl. slackness condition

$$\phi(Y_1,s)\left(Y_0 R^y(\alpha^y,\tilde{r}) - F(s)\right) \geq 0, \quad \phi(Y_1,s) \geq 0 \qquad (2)$$

and restrictions on asset allocation

$$\alpha^j \in [0,1],\ j = x,y \quad \text{with multipliers } \overline{\varphi}^j, \underline{\varphi}^j \qquad (3)$$

$$X_0, Y_0 \text{ given}$$

$$R^x(\alpha^x,\tilde{r}) = \alpha^x(1+\tilde{r}) + (1-\alpha^x)(1+r^f) = (1+r^f) + \alpha^x(\tilde{r} - r^f)$$

$$R^y(\alpha^y,\tilde{r}) = \alpha^y(1+\tilde{r}(1-\tau^c)) + (1-\alpha^y)(1+r^f(1-\tau^b)) = (1+r^f(1-\tau^b)) + \alpha^y(\tilde{r}(1-\tau^c) - r^f(1-\tau^b))$$

Proposition 1: in the model with no uncertainty or liquidity needs (*F*=0 or *p*=0), a household will always choose a tax-efficient allocation of its dual-habitat portfolio. As long as $\tau^b > \tau^c$ and there is no borrowing in regular account, a tax-efficient allocation will be manifested as one of the following: (a) *complete separation*: all bonds in TDA (inside) and all stocks in CSA (outside), (b) *bond spillover*: all bonds inside, stocks and bonds outside, (c) *stock spillover*: all stocks outside, stocks and bonds inside. If borrowing restrictions are removed, (b) represents the optimal portfolio choice, with levered stock positions financed by borrowing at the risk-free rate. This result does not depend on choices of preferences or return distributions.

Proof. The proof is a standard application of Kuhn-Tucker theorem. When $F = 0$, the first order conditions of (1) imply:

$$r^f + \frac{(\overline{\varphi}^x - \underline{\varphi}^x)}{X_0 EU'(W)} = r^f \frac{1-\tau^b}{1-\tau^c} + \frac{(\overline{\varphi}^y - \underline{\varphi}^y)}{(1-\tau^c) Y_0 EU'(W)} \qquad (4)$$

A mixed portfolio allocation requires $r^f = r^f (1-\tau^b)/(1-\tau^c)$, which is impossible as long as the tax rates differ. This is just a restatement of a tax arbitrage argument that as long as assets have different tax rates and accounts offer different tax treatments, the opportunities for tax sheltering have to be exploited to the fullest.

Under the assumption of $\tau^b > \tau^c$ (dividend tax rate > capital gains tax rate), a quick check of (4) allows us to eliminate certain portfolio choices. In particular, we rule out scenarios where equities occupy all of the tax-deferred account, partially spilling over into the regular account and where bonds spill over into the tax-deferred account after making up all of the regular account (case $\{\alpha^x = 1, \alpha^y \in (0,1)\}$ and $\{\alpha^x \in (0,1), \alpha^y = 0\}$). This leaves cases (b) and (c), where an asset spills over from its preferred account type – bonds spill over from TDA, or equities from CSA. If one allows there to be unlimited borrowing in the regular account, it is easy to show that an optimal solution requires $\underline{\varphi}^x > 0$. That is, the retirement account should always be 100% in bonds. These arguments do not depend on particular assumptions about asset return distribution or on choice of the utility function.

The scenarios in Proposition 1 are driven by the same principle: tax-efficient allocations never place an asset with higher tax burden into a high-tax habitat as long as the location choice still exists. When borrowing in the regular account is prohibited, the location choice is limited by size restrictions on tax-advantaged accounts. Once borrowing is allowed, tax advantages of inside accounts are exploited to the fullest.

Proposition 2: In the model with precautionary demand motives it is possible to obtain interior portfolio allocations in both accounts as long as the present value of the fine does not exceed the endowment of liquid wealth.

Proof. Assuming that the incidence of fine is independent of equity returns, the first-order conditions of (1) are restated as:

$$r^f\left(1-\frac{1-\tau^b}{1-\tau^c}\right)\left(pEU'(W-F)+(1-p)EU'(W)\right)=$$

$$=-pE\left[\phi(Y_1)\left(r-\frac{1-\tau^b}{1-\tau^c}r^f\right)\right]+\frac{(\overline{\varphi}^x-\underline{\varphi}^x)}{X_0}+\frac{(\overline{\varphi}^y-\underline{\varphi}^y)}{(1-\tau^c)Y_0} \qquad (5)$$

The left-hand side of (5) is positive by the concavity of the utility function. To establish whether an interior solution is feasible, we need to find a sign of the expectation term on the right-hand side. Since ϕ is function of $Y_1 = Y_0R(\alpha^y,r)$, the expectation is taken over the density function of the after-tax equity premium $\Delta r^\tau \equiv (1 - \tau^c)r - (1 - \tau^b)r^f$, conditional on Y_0 and α^y. For a given penalty F,

$$\phi(Y_1)>0, \text{if } \Delta r^\tau \le \frac{1}{\alpha^y}\left(\frac{F}{Y_0}-(1+(1-\tau^b)r^f)\right)\equiv Q(\alpha^y, Y_0, F)$$

Therefore, if $f(\Delta r^\tau)$ is a density function of the after-tax equity premium, the RHS of (5) in the case of interior solution can be written as:

$$-p(1-\tau^c)^{-1}E\left[\phi(Y_1)\Delta r^\tau \mid \alpha^y, Y_0\right]=-p(1-\tau^c)^{-1}\int_{z\le Q(\alpha^y,Y_0)}\phi(Y_1)zf(z)dz \qquad (6)$$

Assumption 1: for a given initial endowment in the regular account, Y_0, the size of the fine F is such that it can be covered by investing Y_0 fully into the riskless security.

Assumption 1 rules out environments in which there exist a positive probability of being bankrupted by a fine, no matter what portfolio allocation is chosen. One possible interpretation for this is limited liability on real and financial assets of individual investors. Assumption 1 implies $(1 + (1 - \tau^b)r^f)Y_0 \ge F$ and thus $Q(\alpha^y,Y_0,F) \le 0$. But in this case the domain of the integrand in (6) consists solely of non-positive numbers and so the right-hand side of (5) is trivially positive.

Appendix B. Estimation of non-financial income moments from PSID

The methodology for estimating conditional moments of non-financial income is very similar to Vissing-Jørgensen (1999) and Carroll and Samwick (1997). The income process of household is a product of a permanent component and a transitory shock: $Y_t = P_t\,\varepsilon_t$, where log permanent shock follows a random walk with a drift. Switching to log notation, we obtain:

$y_t = p_t + \varepsilon_t$; $p_t = g_t + p_{t-1} + u_t$; $\varepsilon_t \sim N(0,\sigma_\varepsilon^2)$; $u_t \sim N(0,\sigma_u^2)$,

where both u_t and ε_t are i.i.d. and are mutually uncorrelated at all leads and lags. The drift term, g_t, is predictable on the basis of information available at time t-1, i.e. $g_t = f(Z_{t-1})$.

Differencing of log income produces:

$y_t - y_{t-1} = g_t + u_t + \varepsilon_t - \varepsilon_{t-1}$.

$y_t - y_{t-2} = g_t + g_{t-1} + u_t + u_{t-1} + \varepsilon_t - \varepsilon_{t-2}$.

The d-year conditional variance is then given by $v_d = d\sigma_u^2 + 2\sigma_\varepsilon^2$.

In order to remove the predictable drift component, I regress detrended first difference of log non-financial income on a vector variables known at time t-1: age of household head, age-squared, occupation and industry dummies, number of children, race dummy, marital dummy, and education category dummies. The resulting residuals are then used to construct sample 1- and 2-year conditional variances for each household: v_1 and v_2. With these estimates in hand, one can theoretically separate sample variances of permanent and transitory shock components. However, I don't attempt to do this, using instead an estimate of one-year conditional variance as a regressor.

For estimation I use 1985-1993 PSID data, restricting the sample to households that remained intact over the entire sample period and provided complete responses in each of the survey years. I further exclude households in poverty and Latino subsamples. The resulting sample consist of 2,404 households, each of which has 9 observations. When estimating the predictable component of labor income growth rate, I exclude records which show unemployment spells of more than 4 weeks as well as records with suspiciously low non-financial income relative to household sample average (< 10%). Sample variances are computed for all households which did not have unemployment spells in any of the 9 sample years.

Table 1
2-Stage Instrumental Variable/AGLS Model
First-stage regression coefficients

	Share of wealth in tax-deferred account (TDA)			
	Coeff.	Std.Err.	t-ratio	P-value
Intercept	0.6632	0.0626	10.59	0.00
Financial wealth*	-0.2398	0.0098	-24.38	0.00
Housing wealth*	0.0063	0.0037	1.69	0.09
Over 59 1/2 ?	0.0105	0.0205	0.51	0.61
Cond. std. of labor income	-0.1024	0.0369	-2.77	0.01
Prob (unempl)	-0.0792	0.1877	-0.42	0.67
Firm size	0.0165	0.0026	6.46	0.00
Number of dependents	0.0022	0.0034	0.63	0.53
Employer match	0.0068	0.0008	8.76	0.00
Less than HS	-0.0030	0.0229	-0.13	0.89
Some college	-0.0179	0.0131	-1.37	0.17
College	-0.0038	0.0126	-0.30	0.77
Age of head	0.0232	0.0025	9.13	0.00
Age of head^2	-0.0002	0.0000	-7.99	0.00
Year Dummy (1995)	-0.0121	0.0085	-1.43	0.15
Good labor inc. shock	-0.0099	0.0154	-0.64	0.52
Bad labor inc. shock	-0.0290	0.0155	-1.86	0.06
Bad dem. shock	-0.0515	0.0403	-1.28	0.20
Number of observations	4,535			
R-squared	0.21			

* transformed

Table 2
2-SIV/AGLS Bivariate Tobit Model of Equity Shares in Each Habitat
Estimates of structural coefficients

	Outside (CSA) Allocation Equation				Inside (TDA) Allocation Equation			
	Beta	Std. Err.	t	P>|t|	Beta	Std. Err.	t	P>|t|
Intercept	-2.9204	0.2322	-12.58	0.00	-1.2603	0.3652	-3.45	0.00
Share of wealth in TDA	-0.4990	0.2566	-1.94	0.05	1.6836	0.4233	3.98	0.00
Financial wealth*	1.0385	0.0691	15.03	0.00	0.7401	0.1066	6.95	0.00
Housing wealth*	0.0571	0.0071	8.02	0.00	-0.0349	0.0120	-2.92	0.00
Over 59 1/2 ?	0.0407	0.0356	1.14	0.25	-0.0778	0.0504	-1.54	0.12
Cond. std. of labor income	-0.3226	0.0691	-4.67	0.00	0.1208	0.0963	1.25	0.21
Prob (unempl)	-0.9706	0.3290	-2.95	0.00	1.4324	0.5343	2.68	0.01
Number of dependents	-0.0501	0.0060	-8.33	0.00				
Employer match					-0.0071	0.0040	-1.77	0.08
Less than HS	-0.0682	0.0417	-1.64	0.10	-0.2983	0.0741	-4.02	0.00
Some college	0.1160	0.0238	4.87	0.00	0.1294	0.0397	3.26	0.00
College	0.3305	0.0226	14.61	0.00	0.2584	0.0356	7.25	0.00
Age of head	-0.0044	0.0078	-0.56	0.57	-0.0300	0.0118	-2.54	0.01
Age of head^2	-0.0001	0.0001	-1.04	0.30	0.0002	0.0001	1.49	0.14
Year Dummy (1995)	-0.2302	0.0156	-14.76	0.00	-0.1936	0.0238	-8.13	0.00
Good labor inc. shock	0.0604	0.0275	2.19	0.03	0.0969	0.0428	2.27	0.02
Bad labor inc. shock	-0.1244	0.0294	-4.23	0.00	0.0736	0.0489	1.51	0.13
Bad dem. shock	0.0874	0.0714	1.22	0.22	0.0616	0.1169	0.53	0.60
Disturbance Variances and Correlation								
Sigma(1)	2.307	0.008	279.116	0.000				
Sigma(2)	2.106	0.013	158.691	0.000				
RHO(1,2)	0.209	0.029	7.147	0.000				
Number of observations		4,535						
Nonlimit obs. (TDA)		2,510						
Nonlimit obs. (CSA)		3,479						

* transformed

Table 3
2-SIV/AGLS Bivariate Probit Model
Estimates of structural coefficients

STK_PEN = 1 if there are equities inside, 0 otherwise
GOODCSA = 1 if there are no bonds outside, 0 otherwise

Portfolio choice in retirement account

stk_pen	Beta	Std. Err.	t
Financial wealth*	1.274	0.232	5.480
Share of wealth in TDA	4.251	0.976	4.354
Age	-0.073	0.024	-2.979
Age squared	0.001	0.000	2.282
Over 59 1/2 ?	-0.167	0.116	-1.432
Cond. std. of wages	0.284	0.234	1.212
Prob (unempl)	2.288	1.237	1.849
Employer match	0.010	0.011	0.953
Less than HS	-0.080	0.146	-0.546
Some college	0.189	0.081	2.344
College	0.214	0.076	2.821
Year 1995	-0.215	0.053	-4.045
constant	-3.567	0.794	-4.494
rho	0.069	0.035	
Number of obs.	4,338		

Portfolio choice in regular account

goodcsa	Beta	Std. Err.	t
Financial wealth*	0.270	0.209	1.294
Share of wealth in TDA	-1.241	0.879	-1.411
Age	0.017	0.023	0.740
Age squared	0.000	0.000	-0.989
Over 59 1/2 ?	-0.085	0.110	-0.776
Cond. std. of wages	0.063	0.219	0.287
Prob (unempl)	-1.227	1.273	-0.964
Num. of dependents	-0.076	0.021	-3.676
Less than HS	0.042	0.157	0.269
Some college	-0.007	0.081	-0.082
College	0.083	0.076	1.082
Year 1995	-0.230	0.050	-4.609
constant	-1.518	0.726	-2.091

* transformed

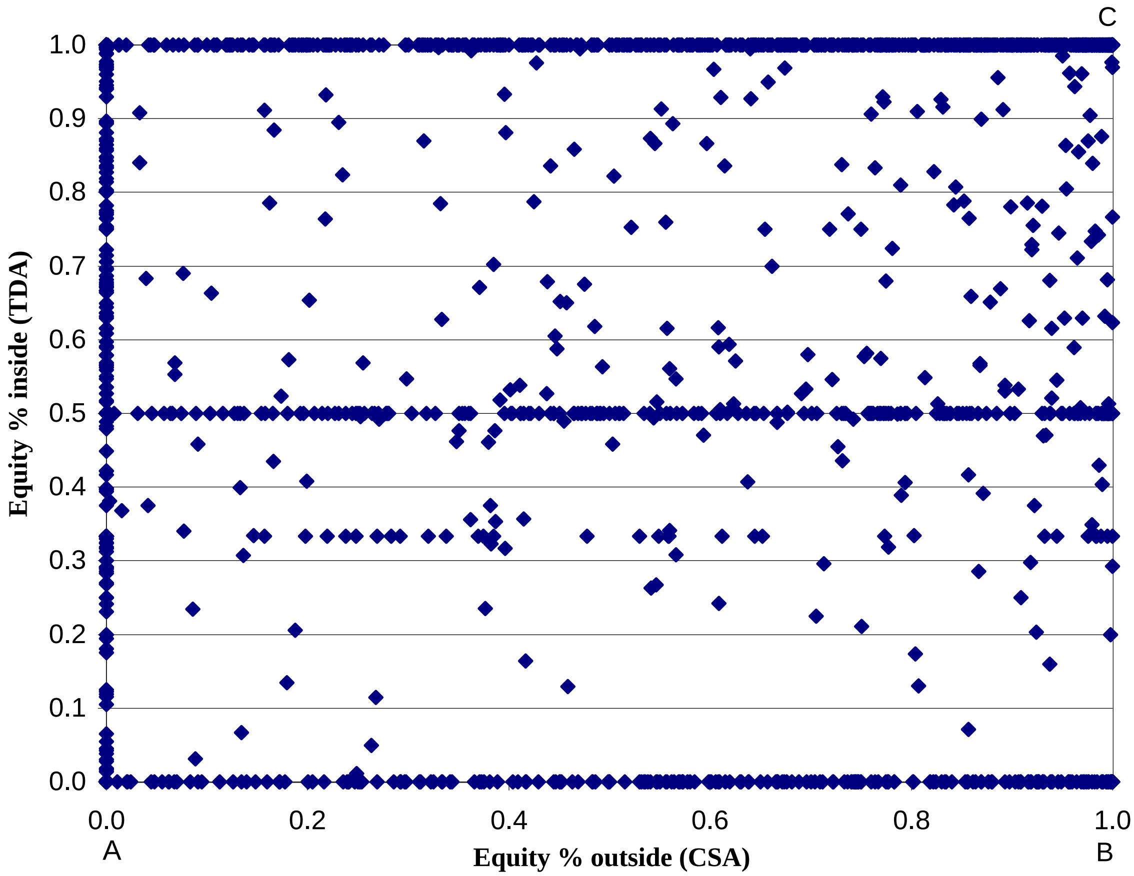
Table 4. Total Marginal Effect (at median values)

	(1,0)			
on choice	Marg. Eff.	Std. Err.	t	P>|t|
Financial wealth*	27.79%	7.42%	3.75	0.00
Share of wealth in TDA	134.95%	31.70%	4.26	0.00
Age	-2.23%	0.78%	-2.84	0.00
Age-squared	0.02%	0.01%	2.43	0.02
Over 59 1/2 ?	-2.66%	3.68%	-0.72	0.47
Cond. std. of wages	6.15%	7.37%	0.83	0.41
Prob (unempl)	83.63%	41.62%	2.01	0.05
Employer match	0.27%	0.28%	0.95	0.34
Num. of dependents	1.49%	0.41%	3.60	0.00
Less than HS	-2.91%	4.88%	-0.60	0.55
Some college	5.04%	2.69%	1.88	0.06
College	3.94%	2.57%	1.53	0.13
Year 1995	-1.06%	1.67%	-0.64	0.53
constant	-62.85%	25.21%	-2.49	0.01

(1,0) represents a choice based on the precautionary model

Figure 1

Portfolio Allocation Choices in Both Habitats
(cross-section of 1998 SCF data*)



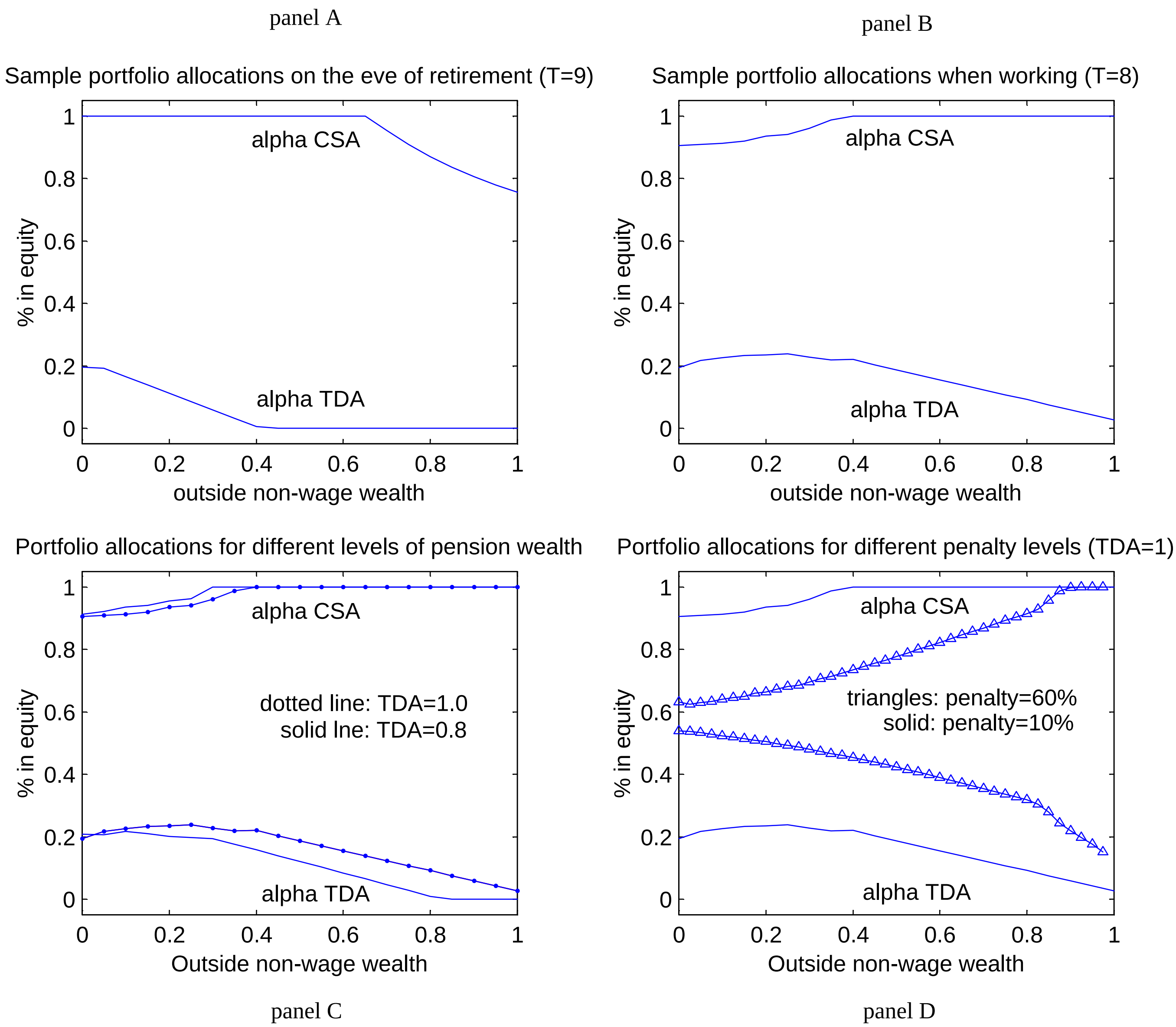
* Households that own both regular and pension investment accounts

1995 & 1998 SCF data

	Unweighted		Weighted
Bond spillovers	638	14.1%	9.0%
Stock Spillovers	550	12.1%	7.7%
Complete specialization	122	2.7%	1.9%
0-0 corner (no equities at all)	541	11.9%	16.1%
HHs with interior allocations	2,684	59.2%	65.3%
Total Households with both inside and outside assets	4,535	100%	100%
% of total HHs	53%		44%
Total Households in 1995 & 1998 SCF	8,604		

Figure 2

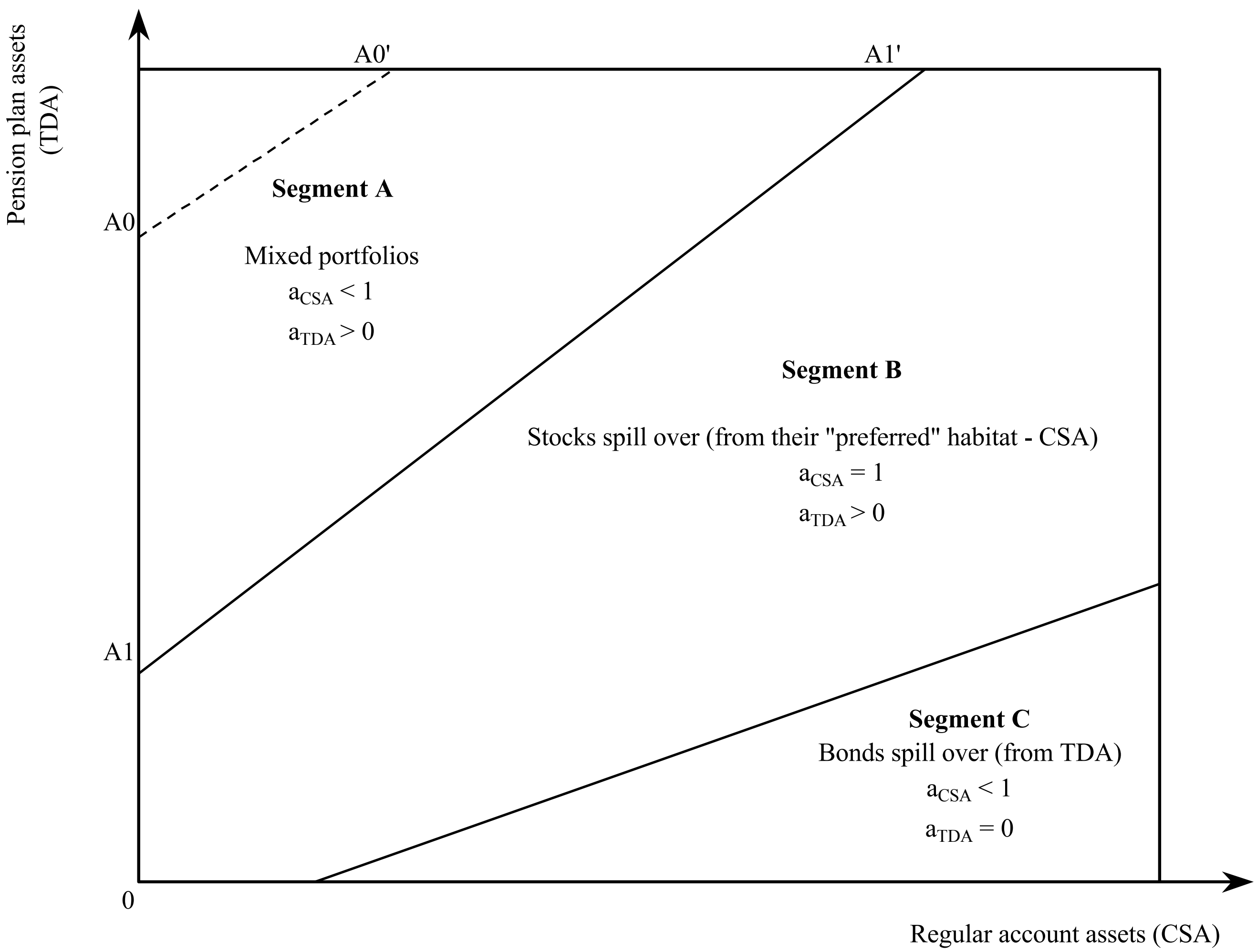
Policy Functions for Portfolio Allocation



Each of these panels depicts the optimal portfolio choice in a tax-deferred (TDA) and a regular (CSA) account as a function of liquid wealth, holding the level of retirement wealth fixed. The top lines, labeled "alpha CSA", represent the share of the CSA account invested in equities. The lines on the bottom, labeled "alpha TDA", are for a corresponding quantity in the TDA account. The relative position of account-specific allocations reflects the inherent "bias" of the tax-deferred account towards higher-taxed bonds.

In panels A and B, the level of TDA holdings is fixed. Hence, for any level of liquid wealth, we can read off the optimal portfolio choice in both accounts conditional on the known level of TDA wealth. In panel C, the two sets of lines (dotted and solid) correspond to two different levels of TDA wealth. Therefore, allocations can be compared for different levels of retirement wealth, holding liquid wealth fixed as well as for different levels of liquid wealth, holding retirement wealth fixed. Finally, panel D contrasts optimal portfolio allocations made under different assumptions on the level of penalties for early TDA withdrawals. With the exception of panel D, all figures reflect allocations obtained under the base case scenario.

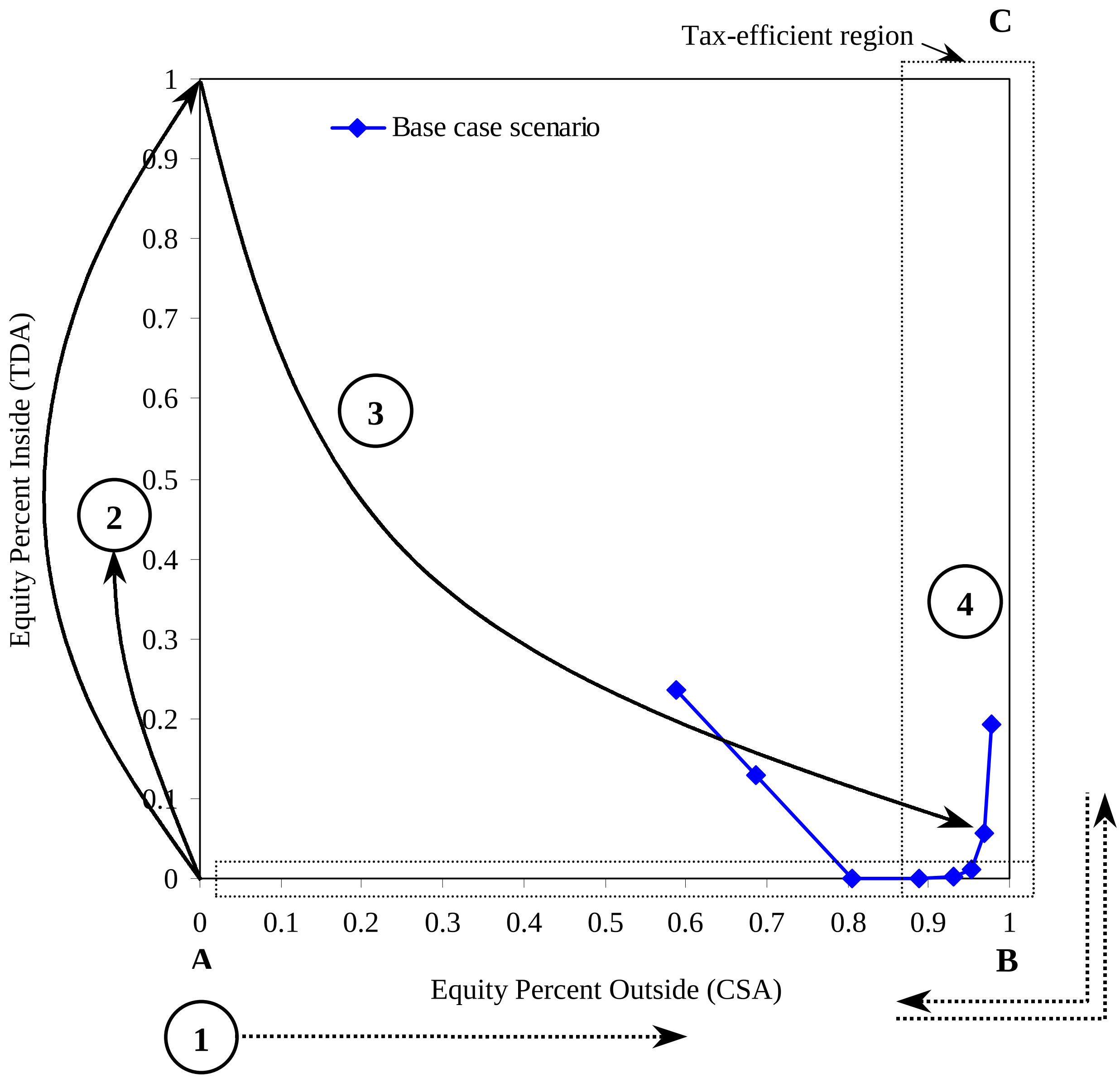
Figure 3
Diagram of portfolio allocation choices as a function of state variables



The axes represent levels of household saving in each of the two accounts at the beginning of the period. These are the state variables of the problem. a_{CSA} and a_{TDA} are equity shares in CSA and TDA, respectively.

Segment A denotes those combinations of state variables that result in an optimal mixed portfolio allocation. Such combinations typically consist of low liquid wealth levels and high pension wealth levels. Segment B represents pairs of state variables that result in stock spillover allocations described in section 3, and segment C represents bond spillovers.
The relative positions of the regions do not change with exogenous variables of the problem, but their relative sizes do. For example, segment A shrinks from A1A1' to A0A0' in response to a decrease in withdrawal penalty.

Figure 4.
Evolution of Portfolio Allocations in Regular and Tax-Deferred Accounts



	Group	SCF obs.	Mean Age*	Mean Wealth*	Mean TDA**	Prob. of Unempl.**	Mean Share in TDA*
2	No equities outside	1,417	44	70,813	39,950	3.99%	60%
3	Transition	1,211	47	296,659	98,269	2.94%	43%
4	Tax-efficient	1,242	51	406,870	103,336	2.82%	35%
1	No pension savings	1,557	53	46,384	-	3.31%	-

* All differences between groups 2, 3, and 4 are statistically significant (p<.01)

**Group 2 is significantly different from groups 3 and 4 (p<.01). Groups 3 and 4 differ significantly (p<.1)

Figure 5
Predictions of the Tax-Efficient and Precautionary Models

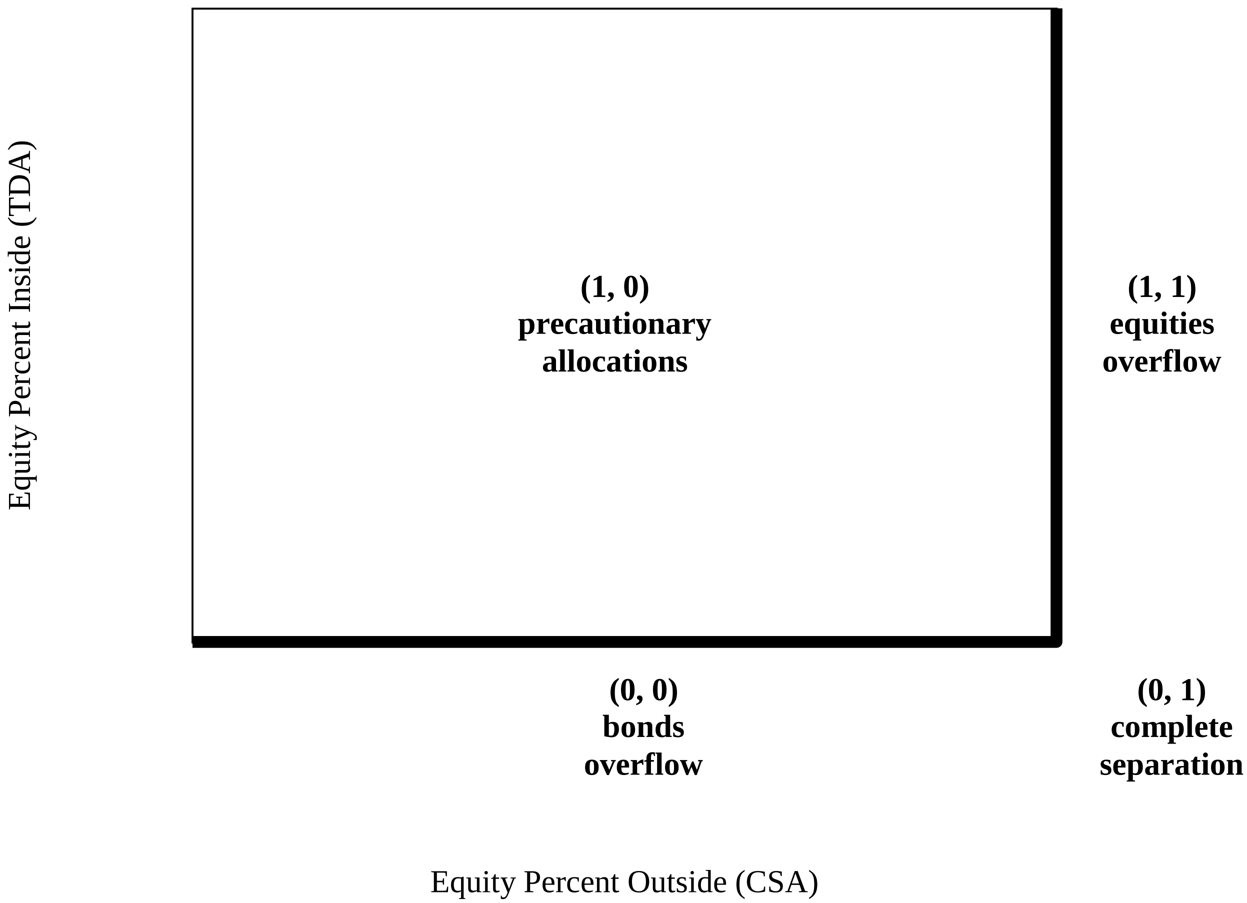
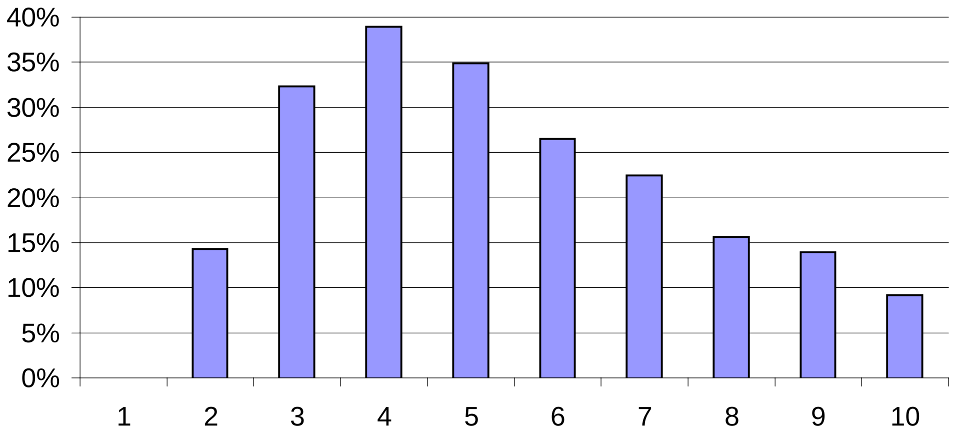


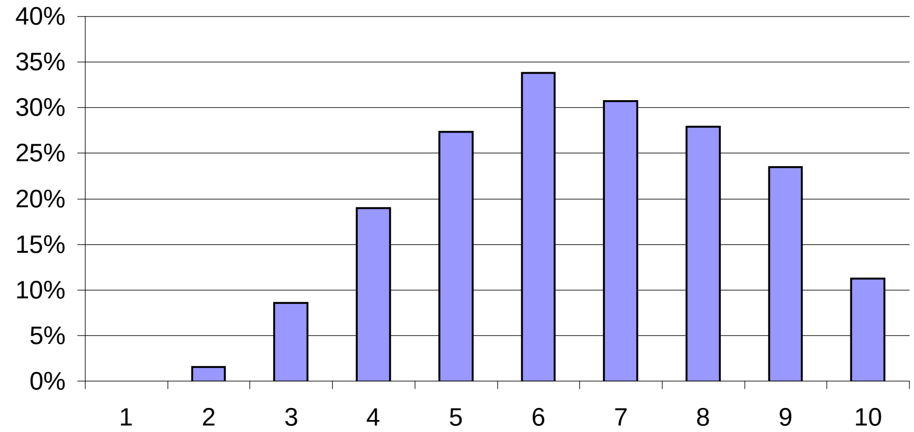
Figure 6

Group 1 - no TDA assets, less than 50% of CSA assets in stocks* (by population wealth decile)



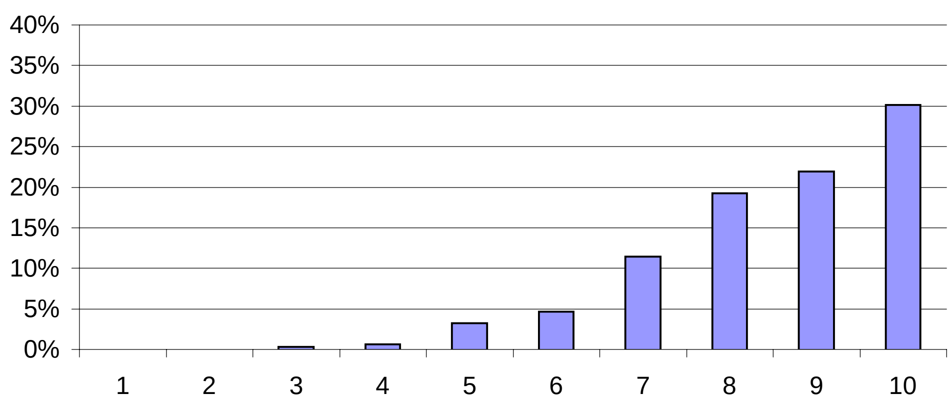
* qualitatively, the distribution is unchanged for any equity share cutoff
1557 HHs

Group 2 - Equities in TDA, but hardly any outside (by population wealth decile)



1473 HHs 32% of HHs with TDA

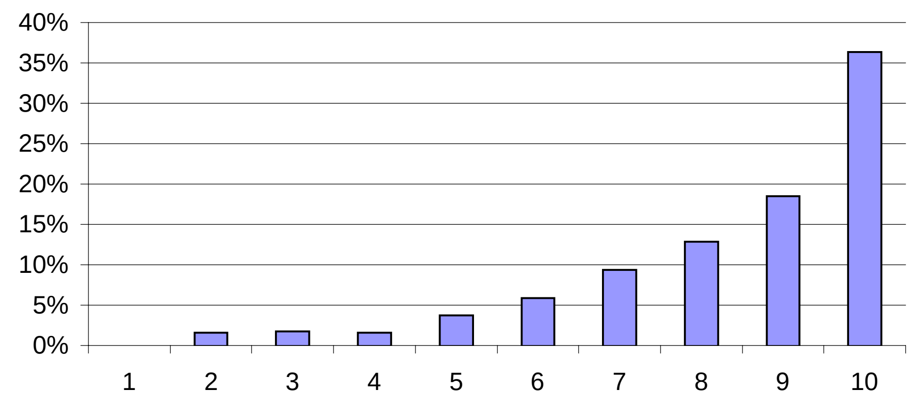
Group 3 - Transition households: highly mixed equity holdings (by population wealth decile)



These are hard to classify, can be catch-all for HHs at different stages of tradeoff between liquidity and tax-efficiency.

1211 HHs 27% of HHs with TDA
Note: of 4,535 HHs with TDA balances only 541 do not participate in the stock market (12%)

Group 4 - Tax-efficient* households: CSA is almost completely in equities or there are no equities in TDA



* Efficiency is defined as only holding equities inside pension accounts (TDA) if there are no bonds outside (in CSA). Also, HHs with mostly tax-exempt bonds outside are tax-efficient.
1310 HHs 29% of HHs with TDA