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Asset location in tax-deferred and conventional savings accounts

John B. Shoven[a], Clemens Sialm[b,*]

[a] *Department of Economics, Stanford University, Stanford, CA 94305-6072, USA*
[b] *University of Michigan Business School, 701 Tappan Street, Ann Arbor, MI 48109-1234, USA*

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Abstract

This paper derives optimal asset allocations (which assets to hold) and asset locations (in which accounts to hold them) for a risk-averse investor saving for retirement. The investor can hold taxable corporate bonds, tax-exempt municipal bonds, and stocks either in a tax-deferred or a conventional taxable savings account. Taxable bonds have a preferred location in the tax-deferred account and tax-exempt bonds have a preferred location in the taxable account for investors in sufficiently high tax brackets. Tax-efficient stock portfolios (e.g. passively-managed mutual funds) should be held in the taxable account and tax-inefficient stock portfolios (e.g. actively-managed mutual funds) should be held in the tax-deferred account. We show that locating assets optimally can significantly improve the risk-adjusted performance of retirement saving.

JEL classification: G11; G23; H24

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1. Introduction

The US tax system influences the size and the composition of retirement savings by giving individuals the option of saving in tax-qualified retirement vehicles (e.g.

* Corresponding author. Tel.: +1-734-763-8101; fax: +1-734-936-0279.
E-mail address: sialm@umich.edu (C. Sialm).

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IRA, 401(k) accounts), and by exempting the interest payments of certain assets (e.g. municipal bonds) from taxable income. Taking into account these important institutional features, this paper derives optimal portfolio choices for a risk-averse individual saving for retirement. The optimal *allocation* between different asset classes such as stocks and bonds has received a lot of attention in financial theory and practice. The aspect of this general topic which has been under-studied is the asset *location* choice, that is the choice of holding assets in tax-deferred or in taxable environments.

Tepper and Affleck (1974), Black (1980), and Tepper (1981) show that companies should hold bonds as opposed to equities in their *defined-benefit* pension plans to take full advantage of the preferred tax treatment of bonds. Black (1980) demonstrates that a firm can perform an arbitrage by selling stocks and then buying bonds with the proceeds in the pension fund while issuing debt and buying back its own shares in the firm. Auerbach and King (1983) point out that this arbitrage extends to individuals making choices between tax-sheltered and taxed accounts. Our paper discusses the optimal asset location in *defined-contribution* tax-qualified accounts. Due to limitations on how much households can contribute to tax-qualified accounts, they may want or be forced to accumulate funds both inside and outside a tax-qualified environment.

This subject was introduced in Shoven (1999) and Shoven and Sialm (1998). These papers compare the simulated distributions of wealth levels at retirement for different heuristic portfolio locations and allocations. Investors tend to accumulate higher wealth levels at retirement by locating sufficiently tax-inefficient stock portfolios in the tax-deferred account and by holding municipal bonds in their taxable accounts. Poterba et al. (2001), confirm these results using data on actual returns on taxable bonds, tax-exempt bonds, and a sample of equity mutual funds over the 1962–1998 period. Our paper solves numerically for the optimal portfolio decisions of a risk-averse investor saving for retirement instead of simulating wealth accumulations for investors following simple investment rules of thumb.

Wang and Judd (2000) solve a dynamic savings allocation problem with tax-deferred and taxable accounts. Their paper focuses on numerical solution methods for dynamic portfolio allocation problems. Dammon et al. (2001) derive optimal life-cycle savings and investment choices in an environment with tax-deferred and taxable accounts capturing more completely important features of the US tax code. Huang (2000) analyzes optimal asset location choices in a multi-period model using a novel replication argument and discusses the effects of liquidity constraints. These papers analyze the optimal life-cycle savings decisions in a multi-period setting. Our model introduces in a two-period model tax-exempt municipal bonds and inflation uncertainty instead of adding more periods to the investor's decision problem. A two-period setting enables us to focus on the effects of additional assets and improves the transparency of the results.

Huang (2000) and Dammon et al. (2001) show that taxable bonds have a preferred location in the tax-deferred account and stocks in the taxable account. We show that the optimal location of stocks can switch from the taxable account to the tax-deferred account if tax-exempt municipal bonds are available and if the stock portfolio is sufficiently tax-inefficient.

The actual behavior of individuals investing in tax-qualified accounts and taxable accounts is discussed by Bodie and Crane (1997), Poterba and Samwick (2001), Barber and Odean (2001), and Bergstresser and Poterba (2001). These papers find that many investors have significant amounts of money in both tax-deferred and in conventional accounts and that a large proportion of them do not appear to take advantage of the potential benefits of optimal asset location.

The paper is organized as follows. Section 2 derives optimal asset locations in a simple setting. We show that stocks should be located in the tax-deferred account and municipal bonds in the taxable account if the effective tax rate of stocks exceeds the implicit tax rate of municipal bonds. Section 3 formulates the optimization problem of the investor. Section 4 discusses the tax-efficiency of large equity mutual funds. Stock mutual funds face very different tax burdens because the proportion of total returns distributed as taxable capital gains differs considerably between funds. Section 5 analyzes how asset characteristics and taxation influence the optimal asset location and allocation. We show that assets with high tax rates should be located in the tax-deferred environment. In particular, taxable bonds should be held in the tax-deferred environment, whereas tax-exempt municipal bonds should be held in the taxable environment. Stocks can be located in either environment depending on the tax-efficiency of the stock portfolios. Section 6 shows that optimal asset location significantly improves the risk-adjusted performance of retirement saving.

2. Asset location arbitrage

We begin our analysis with a generalization of the arbitrage argument of Black (1980).[1] Suppose that an investor can hold taxable bonds (B), tax-exempt municipal bonds (M), and stock mutual funds (S) in a taxable conventional savings account (CSA) or in a tax-deferred account (TDA). The investor cannot short-sell these assets. Income from municipal bonds (bonds issued by state and local governments in the investor's state of residence) is completely exempt from federal and state income taxation. Because of this tax-exempt feature, the interest rate on these securities is below the rate on equally safe taxable bonds. The pretax gross returns of the three asset classes are R_B, R_M, and R_S, where the bond returns are non-stochastic and satisfy $1 < R_M < R_B$. The implicit municipal bond tax rate equals $\tau_M = 1 - (R_M - 1)/(R_B - 1)$.[2]

The effective tax rate of stocks is assumed to be lower than the effective tax rate of taxable bonds: $\tau_S \leq \tau_B$. Bonds usually pay most of their total returns as short-term

[1] The discussion holds for a tax-*deferred* account (such as an IRA or a 401(k) account). A similar arbitrage exists also for a tax-*preferred* account (such as a ROTH-IRA).

[2] The difference between the yields on long-term municipal bonds and the yields on corresponding taxable bonds is relatively small. The average implicit tax rate on long-term municipal bonds has been approximately 25 percent during the last 30 years; this is considerably lower than the maximum income tax rate. The low implicit tax rate might reflect uncertainty about whether the tax break will continue. Slemrod and Greimel (1999) give an example of the effects of tax reform proposals on municipal bond yields.

distributions (interest payments), which are taxed at the ordinary income tax rate. Stock mutual funds pay a smaller portion of the total returns as short-term distributions (dividends and short-term capital gains). The taxation of a large proportion of the total returns of stocks can be deferred until the distributions qualify for the lower capital gains tax rate.

Contributions to a TDA can be deducted from taxable income and withdrawals from the TDA during retirement are taxed at the income tax rate during retirement τ_R, which is known in advance and equals τ_B. Thus, the after-tax value of a withdrawal of \$1 from the TDA during retirement is $\$(1-\tau_B)$. The after-tax return of a taxable asset in a CSA equals $R_i^{\mathrm{CSA}} = 1 + (1-\tau_i)(R_i - 1)$ for $i\, U\in (B,S)$.

Two asset location results are obvious. First, since taxable bonds have a higher before-tax return than tax-exempt bonds, it is optimal to locate taxable bonds in the TDA. Second, tax-exempt bonds dominate taxable bonds in the CSA if $\tau_M < \tau_B$.

The optimal location of stocks between the two accounts is more interesting. Suppose that an investor with $\tau_M < \tau_B$ holds tax-exempt bonds in the CSA, taxable bonds in the TDA, and stocks in the CSA. Consider increasing the proportion of stocks held in the TDA by $\epsilon > 0$ and reducing the holdings of taxable bonds in the TDA by ϵ. At the same time, decrease the holdings of stocks in the CSA by $\epsilon(1-\tau_B)/(1-\tau_S)$ and increase the holdings of tax-exempt bonds in the CSA by $\epsilon(1-\tau_B)/(1-\tau_S)$. This transaction involves no net investment in total financial assets, and it leaves the investor with the same amount of exposure to risky equity as the initial portfolio.

Before the portfolio shift, the value of the stock component of the total portfolio is:

$$W_S = I\left[\omega_S^{\mathrm{TDA}}(1-\tau_B)\, R_S + \omega_S^{\mathrm{CSA}}(1 + (1-\tau_S)(R_S - 1))\right], \tag{1}$$

where the proportion ω_i^j of the initial wealth I is invested in asset i in account j. The total withdrawals from the TDA are taxed at the ordinary income tax rate during retirement, which equals the tax rate of bond returns.

The riskless component of the initial portfolio equals:

$$W_B + W_M = I\left[\omega_B^{\mathrm{TDA}}(1-\tau_B)\, R_B + \omega_M^{\mathrm{CSA}} R_M\right]. \tag{2}$$

The total wealth before the portfolio shift is $W = W_B + W_M + W_S$.

After the suggested portfolio shift, the values of the risky and risk-free components are:

$$W_S' = W_S - I\epsilon\tau_S \frac{1-\tau_B}{1-\tau_S} \tag{3}$$

$$W_B' + W_M' = W_B + W_M + I\epsilon(1-\tau_B)\left(\frac{R_M}{1-\tau_S} - R_B\right) \tag{4}$$

The total value of the portfolio after the shift equals:

$$W' = W'_B + W'_M + W'_S = W + I\epsilon(1-\tau_B)\left[\frac{\tau_S - \tau_M}{1-\tau_S}(R_B - 1)\right] \quad (5)$$

The suggested portfolio shift increases the wealth level if the tax rate on stock returns τ_S is larger than the implicit tax rate on tax-exempt bond returns τ_M. This portfolio shift does not involve any risk and the investor should take advantage of this profitable arbitrage opportunity until borrowing or other constraints bind. If stocks are highly taxed, then investors should replace the taxable bonds with stocks in the TDA and replace the stocks with tax-exempt bonds in the CSA. Therefore, stocks in the TDA dominate stocks in the CSA if $\tau_S > \tau_M$ and $\tau_B > \tau_M$.[3]

3. The model

This section presents a two-period model to simplify the analysis of asset location. The investor chooses her portfolio during her working career in the first period and withdraws the savings during retirement in the second period. The investor has the choice to invest her exogenous saving of I in taxable bonds, tax-exempt bonds, and stocks. These risky assets can be located either in a tax-deferred account (TDA) or a conventional savings account (CSA). The assets are well-diversified portfolios of securities and should be considered mutual funds of stocks or bonds. The investment horizon of the individual is $h > 1$ years, which corresponds to the length of the first period (i.e. the difference between retirement age and current age). Due to the limitations on how much individuals can contribute to a tax-qualified account, they may want to accumulate funds in both locations. The maximum contribution to the TDA is $\overline{C}$.

The nominal value of asset i follows a geometric Brownian motion with drift. After t years, the before-tax total return of the asset equals:

$$R_i(t) = \exp(\mu_i t + \sigma_i z_i(t)), \quad z_i(t) \sim N(0,t) \quad (6)$$

The logarithm of the total return $R_i(t)$ is normally distributed and has a mean of $\mu_i t$ and a variance of $\sigma_i^2 t$. Ito's Lemma implies that R_i is an Ito process with the following stochastic differential equation:

$$\mathrm{d}R_i(t) = \left(\mu_i + 0.5\sigma_i^2\right) R_i(t)\mathrm{d}t + \sigma_i R_i(t)\mathrm{d}z_i(t) \quad (7)$$

The return after taxes depends on the location and is denoted by R_i^{TDA} or R_i^{CSA}. Let τ_W and τ_R denote the marginal income tax rates during the work career and at the time of

[3] If tax-exempt bonds are not available, then we can modify the arbitrage example given above by simply setting $\tau_M = \tau_B$. The portfolio shift decreases the wealth level if the tax rate on stock returns τ_S is smaller than the tax rate on bond returns τ_B, which holds by assumption. Thus, stocks in the CSA dominate stocks in the TDA if tax-exempt bonds are not available. Huang (2000) shows that a similar replication argument holds in a multiple-period setting.

retirement, respectively. If the investor saves \$1 after taxes, she can contribute $\$1/(1-\tau_W)$ to her TDA after taking into account the tax-deductibility of contributions to a TDA. This investment compounds at the before-tax rate of return R_i. The withdrawn benefits at the time of retirement are taxed at the future marginal income tax rate τ_R, which is assumed to be known in advance. The TDA-returns are identical to the before-tax returns if the tax rates do not change at the time of retirement (i.e, $\tau_W = \tau_R$). The after-tax return of asset i in a TDA after h years amounts to:

$$R_i^{\mathrm{TDA}}(h) = \frac{1-\tau_R}{1-\tau_W}\, R_i(h) \tag{8}$$

Savings in a CSA are not deductible from taxable income, and withdrawals are not taxed. Distributed returns (dividends, interest income, and capital gains distributions) on assets held in a CSA are taxed continuously. A fixed proportion of the instantaneous return of asset i is paid either as a short-term distribution d_i^{st} or as a long-term distribution d_i^{lt}. The remainder $1-d_i^{st}-d_i^{lt}$ is called accrued or unrealized capital gains. Short-term distributions (i.e. interest income, dividends and short-term capital gains) are taxed at the full current marginal income tax rate τ_W and long-term distributions are taxed at the lower capital gains tax rate τ_C. The total distribution equals $d_i = d_i^{st} + d_i^{lt}$ and the average tax rate is $\tau_i^d = \left(\tau_W d_i^{st} + \tau_C d_i^{lt}\right)/d_i$. The after-tax distributions are reinvested in the CSA. The funds are withdrawn at the time of retirement and the investor pays long-term capital gains taxes on the remaining unrealized capital gains.

The savings in the CSA compound after taxes at the following rate:

$$\mathrm{d}R_i^{\mathrm{CSA}}(t) = \left(1-\tau_i^d d_i\right) R_i^{\mathrm{CSA}}(t)\left[\left(\mu_i + 0.5\sigma_i^2\right)\mathrm{d}t + \sigma_i \mathrm{d}z_i(t)\right] \tag{9}$$

The value of an investment in asset i in the CSA accumulates to the following value after $t < h$ years:

$$R_i^{\mathrm{CSA}}(t) = \exp\left[\left(1-\tau_i^d d_i\right)\left(\mu_i + 0.5\sigma_i^2\tau_i^d d_i\right) t + \left(1-\tau_i^d d_i\right)\sigma_i z_i(t)\right] \tag{10}$$

The investor liquidates the CSA at time h. She is required to pay capital gains taxes on the difference between the value of the portfolio and its cost basis. The cost basis changes continuously by the reinvested after-tax distributions. The appreciation of asset i at time t is $R_i^{\mathrm{CSA}}(t)\mathrm{d}R_i(t)/R_i(t)$. The proportion d_i of this appreciation is realized by the shareholder and is taxed at the rate τ_i^d. These after-tax distributions are reinvested and increase the cost basis B_i of the asset holdings:

$$\mathrm{d}B_i(t) = \left(1-\tau_i^d\right) d_i R_i^{\mathrm{CSA}}(t)\, \frac{\mathrm{d}R_i(t)}{R_i(t)} \tag{11}$$

The cost basis per dollar of initial investment just before the account is liquidated at time h equals:

$$B_i(h^-) = 1 + \frac{\left(1-\tau_i^d\right) d_i}{1-\tau_i^d d_i}\left(R_i^{\mathrm{CSA}}(h^-) - 1\right) \tag{12}$$

The value of asset i in a CSA after paying the capital-gains tax on the realized capital gains amounts to:

$$R_i^{\mathrm{CSA}}(h) = R_i^{\mathrm{CSA}}(h^-) - \tau_C\left(R_i^{\mathrm{CSA}}(h^-) - B_i(h^-)\right) \tag{13}$$

The initial savings I can be allocated to n assets in two locations. The corresponding weights are denoted by ω_i^j. The investor is not allowed to short-sell assets. We assume for simplicity that the investor does not have any other sources of income during retirement. The nominal wealth level at retirement amounts to:

$$W(h) = I \sum_i \sum_j \omega_i^j R_i^j(h) \tag{14}$$

The price level at the time of retirement is $P(h)$ (where $P(0) = 1$). The utility of final real wealth is given by a power-utility function with a constant coefficient of relative risk-aversion $\alpha \geq 0$:

$$U\left(\frac{W(h)}{P(h)}\right) = \frac{1}{1-\alpha}\left(\frac{W(h)}{P(h)}\right)^{1-\alpha} \tag{15}$$

The investor maximizes the expected utility of real wealth at retirement subject to short-selling constraints and the limitation of contributions to the TDA.[4] The optimization problem cannot be solved analytically. Instead, we determine the optimal portfolio weights numerically assuming a log-normal distribution for the returns of the assets. The expected utility is computed using a multi-dimensional Gauss–Hermite quadrature with 10 nodes.[5]

The base case of the following computations assumes that the investor has a time horizon h of 30 years. The coefficient of relative risk-aversion α is taken as 3, which can be characterized as moderate risk-aversion. The investor can at most contribute half of her savings to the TDA.[6] The base case tax rates on short-term and long-term distributions in the CSA are taken as 40 and 20 percent, roughly corresponding to the marginal federal income tax rate and capital gains tax rate faced by a high-income taxpayer. Some results are also computed for medium-income individuals (with tax rates of 30 and 20 percent, respectively).

In the paper we discuss the effect of different stock fund distributions on asset location. We assume that the fraction of the total returns which are distributed to the shareholders either as dividends or capital gains is identical to the fraction of those distributions which are taxed as short-term distributions. For example, funds with distributions of 75 percent

[4] Our model does not capture two institutional facts. First, mutual funds are forced to distribute realized capital gains to their shareholders but are prohibited from distributing losses. Second, the tax code limits the deduction of realized capital losses from taxable income. If the capital losses are higher than the limit, then only the limit can be deducted from taxable income. However, it is possible to carry the remaining losses forward and to deduct them from future taxable income. Mintz and Smart (2002) show that the asymmetric treatment of capital gains and losses increases the effective tax on stocks and shifts the preferred location of stocks to the tax-deferred account.

[5] See Judd (1998, pp. 261–263).

[6] The contribution limit is therefore $\overline{C} = \frac{I}{2(1-\tau_W)}$.

Table 1
Base case assumptions of real asset returns and inflation

	Mean	S.D.	Correlation			
			S	*B*	*M*	*P*
Stocks (*S*)	7	20	100			
Taxable bonds (*B*)	4	8	30	100		
Tax-exempt bonds (*M*)	2.5	8	25	95	100	
Inflation (*P*)	2.5	4	−20	−60	−60	100

The table lists the means, standard deviations (S.D.), and correlations of the logarithms of the annual real asset return relatives and of the rate of inflation. All values are in percent.

are assumed to distribute 75 percent of their returns to the shareholders and 75 percent of those distributions are dividends and short-term capital gains. Stock mutual funds are assumed to distribute 50 percent in our base case. The returns of both taxable and tax-exempt bonds are distributed completely as short-term income. We assume that the logarithms of the return relatives (i.e. one plus the simple returns) and the logarithm of the price level are jointly normally distributed and serially uncorrelated. Our assumptions regarding the probability distributions of real asset returns are shown in Table 1. The values for stocks and inflation correspond roughly to the historical record between 1926 and 1998 as summarized in Ibbotson (1999). The real return of taxable bonds is set slightly higher than the current real yield on inflation-protected bonds to reflect a compensation for default and inflation risk. The resulting equity premium is substantially smaller than the equity premium observed in the US.[7] The implicit tax rate for the municipal bonds is close to the average rate for long-term bonds over the last 30 years.[8] The returns of both bonds are risky and not perfectly correlated. This allows the ex-post implicit tax rate on municipal bonds to vary over time. The standard deviations of taxable and tax-exempt bonds are assumed to be equal. Tax-exempt bonds are therefore more risky on an after-tax basis than taxable bonds.

4. Tax-efficiency of large mutual funds

A large portion of investors hold their financial assets through mutual funds. To determine the effective taxation of stock mutual funds, we analyze the tax-efficiency of a sample of large mutual funds. Mutual funds differ considerably in their rate of asset turnover and in their proportion of total returns distributed in the form of realized capital gains. Different management styles impose very different tax burdens on investors in taxable accounts as previously shown by Dickson and Shoven (1995) and Dickson et al. (2000). Individuals can influence the net distributions by trading their shares of mutual

[7] This premium is consistent with the estimates of expected equity premia in the US from Fama and French (2002).

[8] The implicit tax rate on short-term municipal bonds is higher than the implicit tax rate of long-term municipal bonds. Green (1993) discusses an interesting model of tax-clienteles that is consistent with this fact.

funds and thereby realizing accumulated capital gains and losses. Tax-efficient trading strategies result in lower distributions and tax-inefficient strategies in higher distributions.

Table 2 summarizes the moments of the nominal log-returns and the distribution characteristics of large mutual funds over three time periods. Each panel shows the summary statistics of the five stock mutual funds with the highest total asset values at the beginning of the the three time periods according to different issues of Johnson (1962). Panel 3, covering the period between 1979 and 1998, shows in addition the characteristics of a taxable bond fund, a tax-exempt municipal bond fund, and a Standard and Poor's 500 index fund. Data for bond and index funds are not available over the two longer periods.

Table 2
Distributions of mutual funds

Fund name	Log-return			Distributions		
	Mean	S.D.	Div.	ST-CG	LT-CG	UR-CG
Panel 1: 1962–1998						
Average Top 5	10.1	14.1	30.1	4.3	46.8	18.8
MFS Mass. Inv. Trust	10.3	14.2	28.3	0.9	57.5	13.3
IDS Stock	9.2	14.4	31.6	2.9	48.8	16.7
LA Affiliated	11.2	12.9	35.4	0.8	46.2	17.6
Fundamental Inv.	10.2	14.9	27.1	1.2	36.7	35.0
United Accumulative	9.5	14.4	28.2	15.6	44.7	11.5
Consumer Prices	4.6	3.0				
Panel 2: 1969–1998						
Average Top 5	10.4	14.2	30.6	7.8	50.3	11.3
Dreyfus	9.3	13.3	31.4	15.9	51.2	1.5
IDS Stock	10.0	14.7	30.8	3.2	51.2	14.8
MFS Mass. Inv. Trust	11.0	14.8	27.3	1.0	59.1	12.6
LA Affiliated	11.6	13.3	35.9	1.0	44.7	81.6
United Accumulative	10.1	15.2	27.5	17.8	45.5	9.2
Consumer Prices	5.1	3.0				
Panel 3: 1979–1998						
Average Top 5	14.7	9.8	23.5	4.7	46.9	24.9
IDS Stock	14.2	9.8	24.0	3.3	53.9	18.8
Dreyfus	12.8	9.1	25.0	18.0	50.9	6.1
LA Affiliated	15.2	9.3	28.4	1.1	44.1	26.4
Inv. Comp. of America	15.8	9.8	20.7	0.2	31.9	47.2
MFS Mass. Inv. Trust	15.5	11.1	19.4	1.1	53.8	25.7
Vanguard Index	16.0	11.3	21.0	0.4	11.1	67.5
Vanguard LT-Bonds	10.0	7.7	90.1	0.9	4.3	4.7
Vanguard LT-Munis	7.4	10.8	91.5	1.7	9.3	−2.5
Consumer Prices	4.4	3.1				

The means and the standard deviations (S.D.) of the nominal log-returns and the proportions of the returns distributed to fund investors are summarized. Total returns are divided into dividend payments (Div.), short-term (ST-CG) and long-term capital gains (LT-CG), and unrealized capital gains (UR-CG). Each panel shows the values for the five largest equity mutual funds at the beginning of the corresponding time periods. The third panel includes as well the results for an index fund and two bond funds. All the values are in percent.

The data until 1995 on the equity funds were taken from Dickson and Shoven (1995). Their dataset was updated using the dividend reports of Moody's (1993) and Standard and Poor's (1993) and Morningstar. Consumer price inflation was taken from Ibbotson (1999). The summary statistics include the mean and the standard deviation of the logarithm of the annual nominal returns of the funds, the proportions of the nominal returns which are distributed annually either as dividends, short-term capital gains, long-term capital gains, and the proportions of the nominal returns which are not distributed (unrealized capital gains).[9]

The moments of the log-returns indicate that real stock returns were low and variable in the 1970s and high and more stable in the 1980s and 1990s. The large mutual funds distributed most of their total returns to their shareholders. The five largest funds at the end of 1961 distributed 81.2 percent of their annual returns over the period from 1962 to 1998. A total of 34.4 percent were dividends and short-term capital gains that were taxed at the marginal income tax rate and 46.8 percent were long-term capital gains that were taxed at the lower capital gains tax rate. The proportions distributed were higher in the 1970s when stock markets performed poorly and were lower in the 1980s and 1990s when they performed very well.

Large stock mutual funds differ significantly in the proportion of the total returns which are distributed to their shareholders. The Dreyfus fund distributed on average 93.9 percent of its annual returns over the period from 1979 to 1998, whereas the Investment Company of America fund distributed only an average of 52.8 percent over the same period. Actively managed funds with high asset turnover tend to distribute more than index funds. The Vanguard Index fund distributed on average only 32.5 percent of its annual total return over the period between 1979 and 1998. It is not surprising that the two bond funds distributed most of their annual nominal returns as interest payments and short-term capital gains. The ex-post implicit tax rate on long-term municipal bonds relative to long-term corporate bonds was 26.0 percent. It is interesting that the standard deviation of the municipal bond fund is considerably higher than the one of the corporate bond fund.

5. Optimal portfolio choice

We compute in this section the optimal portfolio choices using the assumptions from Table 1. Panels 1 and 2 of Fig. 1 show the optimal portfolio choices in the TDA and the CSA for a high-income individual at different distribution levels of the stock fund. Irrespective of the characteristics of the stock portfolio, it is always optimal to contribute the maximum amount of 50 percent to the TDA. If the stock fund distributes 50 percent of its total returns, then the TDA consists of 19.7 percent stocks and 80.3 percent taxable bonds whereas the CSA is completely invested in stocks. This high-income individual

[9] The proportion of short-term capital gains is probably biased downward. The data sources do not always indicate whether a capital gain distribution is short- or long-term. In this case we assumed that these distributions were all long-term.

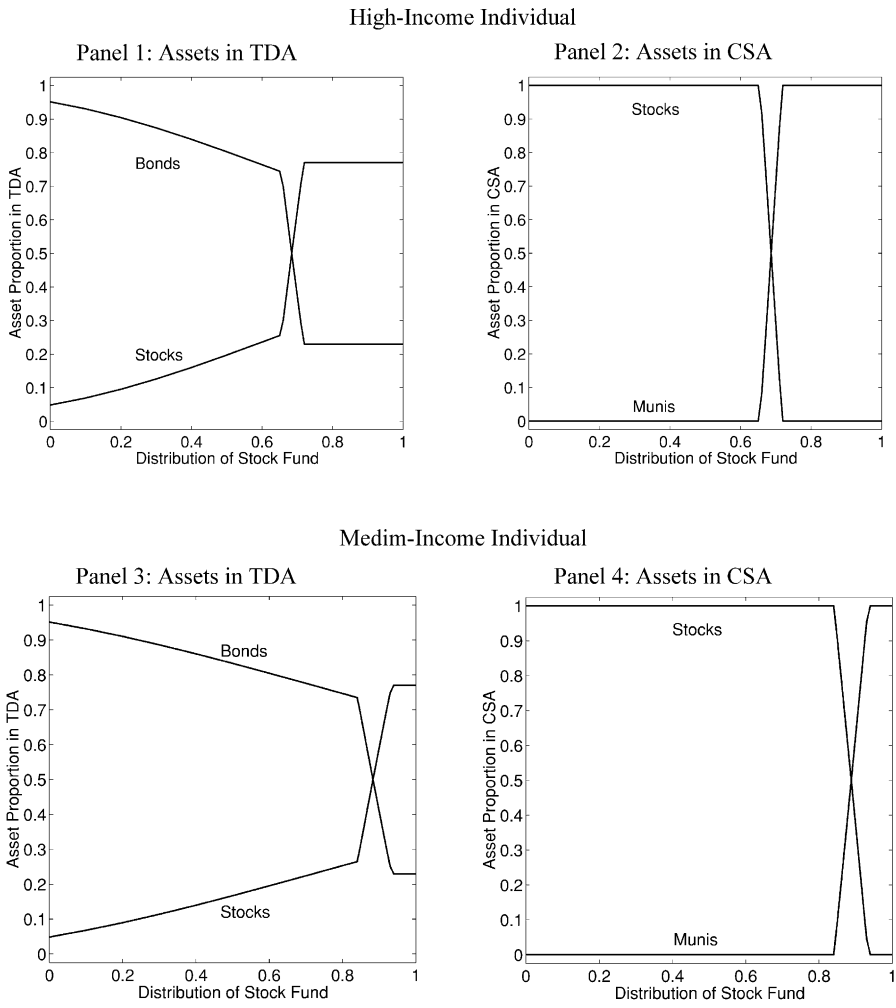

Fig. 1. Optimal portfolio choice. The optimal portfolio choices are depicted for a high- and medium-income individual for stock portfolios with different distribution levels. Panels 1 and 2 show the portfolios for individuals in the high tax bracket and panels 3 and 4 are for individuals in the middle tax bracket. Panels 1 and 3 show the asset allocations in the TDA and panels 2 and 4 in the CSA. The investor cannot hold more than 50 percent of the wealth in the TDA.

does not invest in municipal bonds although the implied tax on municipal bonds is considerably smaller than the marginal income tax rate. Municipal bonds always have a preferred location in the CSA and taxable bonds in the TDA. The proportion of stocks increases in the TDA and decreases in the CSA as the stock funds become more tax-inefficient. If stocks are sufficiently tax-inefficient and distribute more than 68.6 percent of their annual returns, their preferred location shifts from the CSA to the TDA. Most of the actively managed equity funds in Table 2 distributed more than 68.6 percent, and should

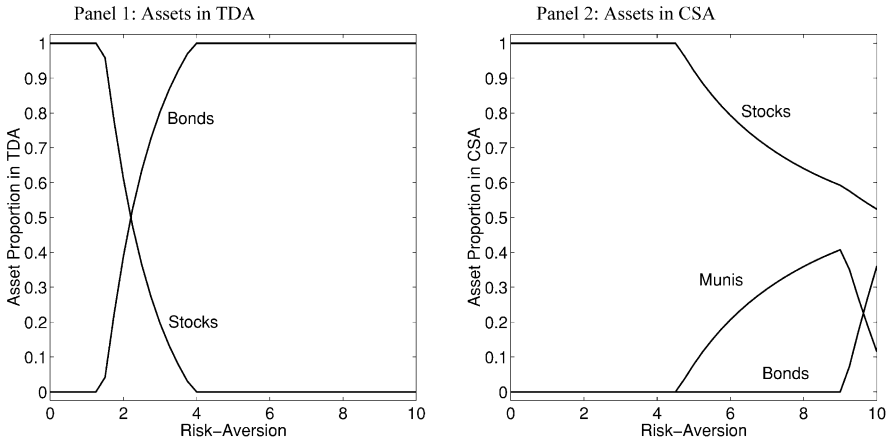

Fig. 2. Changes in risk aversion. The optimal portfolio choices are depicted for a high-income individual for different levels of risk-aversion. The investor cannot hold more than 50 percent of the wealth in the TDA. The stock mutual fund distributes 50 percent of its annual returns.

therefore be located in the TDA. Passively managed index funds should be located in the CSA.[10]

Individuals will be better off if they hold stock portfolios with low distribution levels unless these portfolios have considerably lower before-tax returns. It is well-documented that most actively-managed mutual funds underperform passively-managed funds before taxes.[11] Investors should therefore hold taxable bonds in their TDA and tax-efficient stocks in the CSA if they have the possibility to hold sufficiently tax-efficient portfolios.

The asset allocation and location is similar for a medium-income individual and is depicted in panels 3 and 4 of Fig. 1. This investor holds 16.7 percent stocks and 83.3 percent taxable bonds in the TDA, and 100 percent stocks in the CSA if stocks distribute 50 percent. Medium-income individuals hold fewer stocks than high-income individuals because the tax advantage of stocks is relatively smaller for medium-income individuals than for high-income individuals. The point of asset location reversal occurs for medium-income individuals at considerably higher levels of stock distributions. The preferred location of stocks shifts to the TDA and municipal bonds in the CSA replace taxable bonds in the TDA if stocks distribute more than 88.5 percent.

We have performed several sensitivity analyses to check the robustness of our results. Fig. 2 shows the portfolio composition at different levels of risk-aversion for a high-income individual if stocks distribute 50 percent of their returns. Investors hold

[10] Our analysis does not take into account the 'step-up' of the cost basis of assets at the time of death. This tax provision decreases the effective tax rate of stocks relative to bonds. The 'step-up' of the basis is less important for tax-inefficient stock portfolios, because the unrealized gains of tax-inefficient portfolios are relatively small. Introducing this provision will increase the critical distribution level where the optimal location of stock switches from the CSA to the TDA. However, stocks should still be located in the TDA if their distributions are sufficiently high. Note that the 'step-up' provision does not affect the effective tax rate of stocks if all the stock returns are distributed.

[11] See for example, Carhart (1997).

exclusively stock funds if their risk-aversion is lower than $\alpha = 1.4$. Asset location is irrelevant in this case unless the investors can choose between different equity funds. As their risk-aversion increases, they increase their holdings of taxable bonds in the TDA. At a risk-aversion of $\alpha = 4$, the TDA includes only taxable bonds and the CSA includes only stock funds. Municipal bonds replace some stocks in the CSA as the risk-aversion increases further. At very high levels of risk-aversion, individuals substitute taxable bonds in the CSA for the tax-exempt municipal bonds because the after-tax returns of taxable bonds are less variable than the returns of municipal bonds.

The optimal asset location choice depends on the investment horizon. Fig. 1 shows that the proportion of stocks is identical in both accounts for high-income individuals at the critical distribution level of 68.6 percent for an investment horizon of 30 years. Stock mutual funds should have a preferred location in the TDA if they distribute more than this critical level. The reversal of the optimal location of stocks results at higher distribution levels if investors plan to hold their assets for a longer period. For example, the critical distribution level equals 54.0 percent if the horizon is 5 years and 73.1 percent if the horizon is 50 years. This effect is justified by the relatively lower effective taxation of stock mutual funds at longer time horizons. The effective taxation of stock mutual funds decreases relative to the effective taxation of municipal bonds as the investment horizon lengthens, because the tax on the unrealized capital gains of stocks can be deferred for a longer period.

6. Gains from asset location

To determine whether asset location is economically significant, we compare the gains from asset location to the gains from the existence of a tax-deferred account. We compute the expected utility of an investor in four different environments. In the first environment investments can only be made in a taxable CSA and municipal bonds are not available (No TDA, No Munis). The second environment allows investments in a TDA, but restricts investors to hold the same relative proportions of the taxable bond and the stock in the CSA and the TDA. This environment does not allow an investor to locate the assets optimally (No Location, No Munis). The third environment does not restrict the asset location between the TDA and the CSA (Optimal Location, No Munis). The fourth environment adds tax-exempt municipal bonds as an additional asset class. This environment corresponds to the optimization problem described in Section 3. For a better comparison of the three environments we compute the certainty equivalents *CE* of the expected utilities:

$$CE(E(U)) = U^{-1}(E(U)) = ((1-\alpha)E(U))^{\frac{1}{(1-\alpha)}} \tag{16}$$

Panel 2 of Table 3 shows the certainty equivalent retirement wealth levels (as a proportion of initial after-tax saving) for a high-income individual facing the same tax rates during the working career and during retirement. The certainty equivalent in the environment without the possibility of investing in a TDA and without municipal bonds equals 241.1 percent of the initial saving I with an equity fund distributing 50 percent of its total return. The availability of a TDA increases the certainty equivalent

Table 3
Certainty equivalents

	Distributions of stocks				
	0	25	50	75	100
Panel 1: Medium income tax ($\tau_W = \tau_R = 0.3$)					
No TDA, No Munis	273.6	268.7	260.5	245.5	232.3
No Location, No Munis	326.0	323.3	319.1	313.1	307.2
Optimal Location, No Munis	349.2	342.8	333.6	322.2	309.3
With Munis	349.2	342.8	333.6	322.2	315.3
Panel 2: High income tax ($\tau_W = \tau_R = 0.4$)					
No TDA, No Munis	257.6	252.4	241.1	222.3	195.0
No Location, No Munis	316.9	313.6	307.6	299.2	289.2
Optimal Location, No Munis	349.2	341.2	327.9	310.6	291.2
With Munis	349.2	341.2	327.9	315.3	315.3

The certainty equivalents are computed in different investment environments. The environments are characterized by different restrictions facing the investors. 'No TDA, No Munis' is an environment where individuals can only invest in stocks and taxable bonds in the CSA. 'No Location, No Munis' is an environment where an investor is restricted to hold the same proportion of stocks and taxable bonds in the TDA and the CSA. 'Optimal Location, No Munis' is an environment with optimal location of the stocks and taxable bonds in the two accounts. 'With Munis' adds tax-exempt municipal bonds to the investment choices. The certainty equivalents are expressed in percent of the initial (after-tax) savings.

by 27.6 percent to 307.6 percent of initial savings. Asset location affects the performance of a portfolio significantly. Optimal asset location adds an additional 6.6 percent to certainty equivalent wealth in the base case. Allowing investors to hold tax-exempt municipal bonds has no effect on the utility level because individuals should not hold munis if stocks distribute just 50 percent of their returns.

The gains of asset location are particularly high if the available assets differ considerably in their characteristics, that is if stocks differ from bonds by distributing considerably less than 100 percent. If the stock fund distributes 25 percent of the returns, the investor increases her certainty equivalent by 8.8 percent by optimally locating assets, or if the stock fund distributes 75 percent by 3.8 percent. The benefits of asset location are computed relative to a symmetric asset location. Other sub-optimal asset locations can reduce retirement wealth considerably more. The benefits of municipal bonds are limited and increase with the distributions of the equity fund.

Panel 1 of Table 3 shows that a medium-income individual has a slightly higher certainty equivalent than the high-income individual. The gains of a TDA and asset location are lower because tax-deferral is less valuable if investors face lower taxes. Marginal income tax rates vary substantially over time, as discussed in Sialm (2001). Introducing tax uncertainty does not affect the main results of this paper substantially.

7. Conclusions

This paper derives optimal asset locations and allocations for a risk-averse investor saving for retirement. It confirms the desirability of accumulating assets in tax-deferred

accounts and suggests that certain assets are best suited to either taxable or tax-deferred accounts. The most important determinant of asset location is the proportion of returns distributed as income and capital gains. The paper shows that corporate bonds and stocks with high distributions have a preferred location in the tax-deferred environment, and that tax-exempt municipal bonds and stocks with low distributions have a preferred location in conventional savings accounts. One of the key findings of this paper is that asset location choice can affect welfare in retirement by significant amounts.

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