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Implications of principal, risk, and returns sharing across savings vehicles

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Abstract

This study illustrates that the choice of savings vehicles [e.g., taxable account, Roth IRA, or tax-deferred accounts such as a 401(k)] affects the portions of principal effectively owned by, returns received by, and risk borne by individual investors. This study examines the implications of this analysis for (1) the calculation of an individual's asset allocation, (2) mean-variance optimizations, and (3) asset location. For example, it illustrates problems when traditional mean-variance optimization is applied to an individual's portfolio. Separately, there is broad agreement among scholars that we should distinguish between *pretax* funds and *after-tax* funds when calculating an individual's asset allocation. This study suggests an approach to measuring an individual's asset allocation.

JEL classification: G11, G12, G23

Keywords: Asset allocation; Mean variance optimization; Asset location

1. Introduction

This study illustrates that the choice of savings vehicles [e.g., taxable account, Roth IRA, or tax-deferred accounts such as a 401(k)] affects the portions of principal effectively owned by, returns received by, and risk borne by individual investors. The analysis has implications for (1) how we should perform mean-variance optimizations for individual investors, (2) the asset location decision, and (3) how we should calculate an individual's asset allocation.

For example, an individual investor in the 25% tax bracket receives all returns and bears

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all risk on bonds held in Roth IRA, but he receives only 75% of returns and bears about 75% of risk on bonds held in a taxable account. The upshot is that in mean-variance analysis bonds held in a Roth IRA are effectively a different asset than bonds held in a taxable account. This study contrasts traditional tax-oblivious mean-variance analysis with an after-tax mean-variance analysis. The differences between returns-sharing and risk-sharing across savings vehicles helps explain the asset location argument that, in general, bonds should be held in Roth IRAs and tax-deferred accounts and stocks should be held in taxable accounts.

Separately, the analysis has implications for the calculation of an individual's asset allocation. Reichenstein (1998), Reichenstein and Jennings (2003), Horan (2002), and Sibley (2002) among others agree that the traditional approach to calculating an individual's asset allocation is wrong because it fails to distinguish between *after-tax* funds in a Roth IRA and *pretax* funds in a tax-deferred account. However, these authors disagree about how we should value $1 in a Roth IRA and $1 in a tax-deferred account when calculating an individual's current asset allocation. Reichenstein (1998) and Reichenstein and Jennings (2003) argue that $1 in a Roth IRA should have a current value of $1, whereas $1 in a tax-deferred account should have a current value of $(1 - t_n)$ dollars, where t_n is the expected tax rate upon withdrawal during retirement. Sibley (2002) and Horan (2002) argue that we should calculate these accounts' taxable equivalent values. The taxable equivalent value of a Roth IRA is the amount of funds in taxable accounts that will produce the same after-tax future value as the Roth IRA. The taxable equivalent value of a tax-deferred account is defined in a parallel fashion. Sibley and Horan argue that we should use the taxable equivalent values of Roth IRAs and tax-deferred accounts when calculating an individual's current asset allocation. This study uses the risk-sharing analysis discussed earlier to review Sibley and Horan's approach and to support Reichenstein and Jennings' after-tax approach to measuring an individual's asset allocation.

There are five additional sections to this study. Section 2 develops models of after-tax future values per current dollar in TDAs, Roth IRAs, and taxable accounts. It then uses these models to illustrate how the choice of savings vehicles affects the portions of principal effectively owned by, returns received by, and risk borne by individual investors. Section 3 contrasts mean-variance optimizations with and without adjustments for taxes. In addition, it explains the asset-location argument that, in general, bonds should be held in Roth IRAs and tax-deferred accounts and stocks should be held in taxable accounts. Section 4 reviews the literature on the question about how to calculate an individual's current asset allocation. It uses the risk-sharing discussion is Section 2 to advocate the use of the after-tax approach to calculating the asset allocation. Section 5 discusses implications for the practice of financial planning and suggests topics for future research. Section 6 summarizes the study's conclusions.

2. Models of principal, risk, and returns sharing across savings vehicles

Table 1 presents models of after-tax future values per $1 currently in a Roth IRA, tax-deferred account (TDA), and taxable account. TDAs are savings vehicles where the initial investment is tax deductible in the contribution year, returns grow tax deferred until

Table 1 After-tax ending wealth models for bonds and stocks in Roth IRA, TDA, and taxable account

	Bonds	Stocks
Roth IRA	$(1 + r)^n$	$(1 + r)^n$
TDA	$(1 + r)^n (1 - t_n)$	$(1 + r)^n (1 - t_n)$
Taxable Account	$(1 + r(1 - t))^n$	Day trader: $(1 + r(1 - t))^n$
		Active investor: $(1 + r(1 - t_c))^n$
		Passive investor: $(1 + r)^n (1 - t_c) + t_c$
		Exempt investor: $(1 + r)^n$

TDA denotes tax-deferred accounts such as a traditional IRA.

withdrawal, and if withdrawn after age 59½ the deferred returns are taxed at the ordinary income tax rate. Examples include 401(k), 403(b), 457, Keogh, SIMPLE, and SEP-IRA. For assets held in a taxable account, we follow the prior literature and assume that the assets' cost bases equal their market values. The underlying asset can be a bond or stock. Bonds earn r percentage pretax rate of return, all in the form of interest. Stocks earn r percentage pretax rate of return, all in the form of capital gains. More sophisticated stock models are available, but the major conclusion do not change as long as any portion of stock returns are taxed at a rate lower than the ordinary income tax rate. For simplicity, we use r to denote an asset's pretax return, while recognizing that this pretax expected return should be larger for stocks than for bonds. The ordinary income tax rate is t for all years before withdrawal and t_n in the withdrawal year. The long-term capital gain tax rate is t_c, and t_c is lower than the ordinary income tax rates, that is, $t_c < t$ and $t_c < t_n$.

For bonds and stocks held in a Roth IRA, the after-tax future value is $(1 + r)^n$, where n is the length of the investment horizon. The account begins with $1 of after-tax funds and is worth $(1 + r)^n$ after taxes n years hence. We assume the funds are withdrawn after the Roth IRA has been in existence for at least five years and the individual is at least age 59½.

For bonds and stocks held in a TDA, the after-tax future value is $(1 + r)^n (1 - t_n)$. The account begins with $1 of pretax funds. It is worth $(1 + r)^n$ pretax and $(1 + r)^n (1 - t_n)$ after taxes n years hence. We assume the funds are withdrawn after the individual is at least age 59½.

For assets held in taxable accounts, there is one model for bonds, but for stocks there is a separate model for each stock management style. For bonds, the model is $(1 + r(1 - t))^n$. The $1 of after-tax funds earns r percentage pretax annually and grows at the $r(1 - t)$ percent after-tax rate of return.

We consider individuals with four separate stock management styles and develop a model for each. The stock management styles are those of a day trader, an active investor, a passive investor, and an exempt investor.

A day trader realizes all gains within a year and pays taxes on all returns at the ordinary income tax rate. The after-tax future value is $(1 + r(1 - t))^n$. This model is identical to the model for bonds held in a taxable account. This model slightly understates the ending wealth for traders who invest in stocks paying qualifying dividends, because the federal government is scheduled to tax these dividends at preferential capital gain tax rates through 2010. Nevertheless, the model is approximately correct for day traders.

An active investor realizes all gains as soon as they are eligible for the long-term capital

Table 2 Principal owned, returns received, and risk borne by individual investors in Roth IRA, TDA, and taxable account

	Principal	Returns	Risk
Roth IRA, bonds and stocks	100%	100%	100%
TDA, bonds and stocks	$(1 - t_n)$	100%	100%
Taxable account			
Bonds	100%	$(1 - t)$	$(1 - t)$
Stocks, day trader	100%	$(1 - t)$	$(1 - t)$
Stocks, active investor	100%	$(1 - t_c)$	$(1 - t_c)$
Stocks, passive investor	100%	$>(1 - t_c)$	$>(1 - t_c)$
Stocks, exempt investor	100%	100%	100%

For assets held in taxable accounts, cost bases are assumed to equal market values.

gain tax rate (i.e., in one year and one day) and pays taxes at t_c, the long-term capital gain tax rate. He either actively manages individual stocks or invests in an active stock fund that is managed in this style. The model is $(1 + r(1 - t_c))^n$. The \$1 of after-tax funds earns r percentage pretax annually and grows at the $r(1 - t_c)$ percent after-tax rate of return.

A passive investor buys and holds stocks for n years and realizes the gain at the end of n years. He either passively manages individual stocks or buys and holds passively managed stock funds. The model is: $(1 + r)^n \ (1-t_c) + t_c$ or, equivalently, $(1 + r)^n - t_c[(1 + r)^n - 1]$. The second version may be easier to explain. The \$1 of after-tax funds grows tax deferred at r percentage for n years. Its pretax value immediately before withdrawal is $(1 + r)^n$. Upon withdrawal, the deferred returns {i.e., $[(1 + r)^n-1]$} are taxes at t_c, the long-term capital gain tax rate; the original \$1 was already after-tax funds and can be withdrawn tax free.

As the name implies, an exempt investor never pays taxes on the capital gains. He either donates the appreciated stock to a qualified charity or awaits the step-up in basis at death. If he donates the stock, he can deduct the market value, $(1 + r)^n$, and the charity can avoid taxes because of its tax-exempt status. Alternatively, if he awaits the step-up in basis, at his death his beneficiary's cost basis is stepped-up to $(1 + r)^n$, the market value at death. No one pays taxes on the n years of unrealized capital gains. The future value is: $(1 + r)^n$.

As the models for the four stock management styles indicate, there is not one model that fits all stock investors. Rather, the appropriate model depends upon the individual's management style. The models are at least approximately appropriate for most investors and they hit the extremes: A day trader pays taxes each year on all returns at the ordinary income tax rate, while an exempt investor never pays taxes. These models depict specific advantages of being a progressively more passive investor. As we progress from a day trader to an active investor, the active investor benefits from the preferential capital gain tax rate. As we progress from an active to a passive investor, the passive investor benefits from deferring taxes until the end of the investment horizon. As we progress from a passive to an exempt investor, the exempt investor never pays taxes.

Table 2 indicates the percentage of principal effectively owned by, the percentage of returns received by, and the percentage of risk borne by individual investors in each savings vehicle. For bonds and stocks held in a Roth IRA, the investor effectively owns 100% of principal, receives 100% of returns, and bears 100% of risk. For bonds and stocks held in a

TDA, the investor effectively owns $(1 - t_n)$ of principal, but receives 100% of returns and bears 100% of risk. The government effectively "owns" the other t_n of principal.

A simple example will illustrate this insight. Suppose an individual has a TDA with a current pretax value of $1,000, and he will withdraw the funds in retirement when he will be in the 25% tax bracket. The $1,000 of pretax funds can be separated into $750 of the investor's after-tax funds plus $250, which is the government's share of the current value of the asset. Because the government will eventually receive 25% of withdrawals, it is best to think of the government as effectively owning 25% of the *current* principal. Assume the underlying asset has a cumulative 100% pretax return before withdrawal so the pretax value at withdrawal is $2,000. The investor's after-tax value has doubled to $1,500. Generalizing, the investor's after-tax value grows from $\$1{,}000\ (1 - t_n)$ today to $\$1{,}000\ (1 - t_n)\ (1 + r)^n$ in retirement; the after-tax value grows at the pretax rate of return and it grows effectively tax exempt.

Another example illustrates the same principles. The investor who will be in the 25% bracket during retirement should view $1,000 of pretax funds in a TDA as if it were $750 of after-tax funds in a Roth IRA. They both represent $750 of his after-tax funds *today*. If the cumulative pretax return is 100% then the after-tax ending wealth is $1,500 for both this TDA and Roth IRA. If the cumulative pretax return is −20% then the after-tax ending wealth is $600 for both the TDA and Roth IRA. The investor's after-tax funds effectively receive all returns and bear all risk. Finally, because the individual expects to withdraw funds during retirement, to convert funds from pretax funds to after-tax funds the applicable tax rate is t_n.

Following the prior literature, the models assume that the cost bases and market values of assets held in taxable accounts are equal. In this case, the investor effectively owns 100% of principal. When bonds are held in taxable accounts, the investor receives $(1 - t)$ of the pretax return. Moreover, the investor bears approximately $(1 - t)$ of the pretax risk, while the government bears the remaining risk.

To illustrate the risk and returns sharing, assume bonds have a 4% pretax expected return, 6% pretax standard deviation, and the investor is in the 25% bracket. Suppose bonds earn pretax returns of −2%, 4%, and 10% in three years, that is, the mean return and one standard deviation below and above the mean. The standard deviation of these returns is 6%. Assuming the 2% loss is used to offset that year's short-term gains or taxable income, the investor's after-tax returns are −1.5%, 3%, and 7.5% for a standard deviation of 4.5%. In this case, the investor receives $(1 - t)$ of pretax returns and bears $(1 - t)$ of pretax risk. If the 2% loss is used that year to offset long-term gains then the investor's after-tax returns are −1.7%, 3%, and 7.5%, and the investor receives approximately $(1 - t)$ of returns and bears approximately $(1 - t)$ of risk. Although only approximate, we assume the individual receives $(1 - t)$ of bonds' returns and bears (1-t) of their risk in the remainder of this study.

When stocks are held in taxable accounts (with cost bases equal to market values), the investor owns 100% of principal, but the portion of returns he receives and risk he bears depends upon the stock management style. The day trader receives $(1 - t)$ of the pretax returns. The active investor receives $(1 - t_c)$. The passive investor receives $(1 - t_c)$ of returns for a one-year horizons and more than $(1 - t_c)$ for a multiyear horizon. For example, if the underlying asset earns 7% per year for 25 years then per $1 original investment the after-tax ending wealth is $4.76, $[(1.07)^{25}(1 - .15) + 0.15]$. This represents a 6.44%

after-tax rate of return, $[4.76^{(1/25)} - 1 = 0.0644]$, which is an effective annual tax rate of 8%, $[(.07 - .0644)/.07 = 0.08]$. The exempt investor receives 100% of returns.

To illustrate the risk and returns sharing, assume stocks have an 8% pretax expected return and 15% pretax standard deviation. Stocks earn pretax returns of −7%, 8%, and 23% in three years, that is, the mean return and one standard deviation below and above the mean. The standard deviation of −7%, 8%, and 23% is 15%. If the 7% loss is used to offset that year's long-term capital gains, the active investor's after-tax returns are −5.95%, 6.8%, and 19.55% for a standard deviation of 12.75%. In this case, the investor receives $(1 - t_c)$ of pretax returns and bears $(1 - t_c)$ of pretax risk. If the 7% loss is used to offset that year's short-term gains or taxable income then the active investor's after-tax returns are −5.04%, 6.8%, and 19.55%, so he receives about $(1 - t_c)$ of returns and bears about $(1 - t_c)$ of risk. We assume the active investor receives $(1 - t_c)$ of returns and bears $(1 - t_c)$ of risk in the remainder of this study.

We could relax the assumption that the cost bases equal market values on assets held in taxable accounts. In practice, an asset's cost basis could be less than its market value, in which case there is an unrealized capital gain, or the asset's basis could be more than its market value, in which case there is an unrealized loss. If there is an unrealized gain that will eventually be taxed then the investor effectively "owns" less than 100% of principal. For example, suppose an asset has a basis of $8,000 and market value of $10,000. If the gain is realized as a long-term gain today then the after-tax value would be $9,700 or 97% of principal. However, if the appreciated asset is donated to charity or the investor will pass the asset to his beneficiary after his death then there will be no taxes paid on the unrealized gain, and the investor effectively owns 100% of principal. Thus, there is not one way that is always the "right" way to treat the unrealized gain. For more discussion of tax treatment of unrealized gains and losses, see Reichenstein and Jennings (2003).

In summary, there are important differences between the tax treatments of assets held in Roth IRA, TDA, and taxable accounts. For assets held in a Roth IRA, the individual investor effectively owns all principal, receives all returns, and bears all risk. For assets held in TDA, the individual effectively owns $(1 - t_n)$ of principal, receives all returns, and bears all risk. For bonds held in taxable accounts (with cost bases equal to market values), the individual effectively owns all principal, receives $(1 - t)$ of returns and bears $(1 - t)$ of risk. For stocks held in taxable accounts (with cost bases equal to market values), the individual effectively owns all principal, but the portion of returns received and risk borne by the investor varies with the management style.

One implication of this analysis is that the individual's share of an asset's after-tax risk varies by savings vehicles. For example, bonds held in a Roth IRA or TDA are riskier to the individual than bonds held in a taxable account. Thus, a bond held in a Roth IRA or TDA is effectively a different asset than a bond held in a taxable account. The next section examines the implications of this risk sharing for mean-variance optimization.

3. After-tax optimization and asset location

The purpose of this section is to demonstrate how taxes should affect mean-variance optimizations. In addition, these optimizations illustrate the asset-location argument that, in general, bonds should be held in Roth IRAs and TDAs and stocks in taxable accounts. For more on asset location, see Reichenstein (2001) and Dammon, Spatt, and Zhang (2004). In addition, Horan (2005) reviews much of the tax-and-investment literature including a discussion of the asset-location literature.

All financial advisors use the mean-variance analysis framework when recommending an asset allocation. Some planners explicitly use this framework by inserting into an optimizer their best estimates of expected returns, standard deviations, and correlation coefficients. Other planners implicitly use this framework. They may prefer not to base allocations on explicit estimates because of potential errors in estimates, but they make sure their recommendations reflect the key ideas of Markowitz' Nobel-laureate work. Thus, whether financial advisors explicitly or implicitly use mean-variance analysis, their advice is based on this framework. Consequently, it is instructive to compare traditional (i.e., tax oblivious) and after-tax (i.e., tax aware) applications of mean-variance analysis. This comparison will reveal several shortcomings of the traditional approach. In addition, Reichenstein (2001) and Dammon et al. (2004) are based on after-tax optimizations, and their conclusions do not necessarily follow from traditional optimizations.

Each individual investor must make an asset-allocation decision and an asset-location decision. Asset allocation in this study's simplified two asset-class world refers to the allocation of funds between stocks and bonds. Asset location refers to the decision to locate stocks in taxable accounts and bonds in Roth IRAs and TDAs or vice versa, while attaining the target asset allocation. Henceforth, Roth IRAs and TDAs are called retirement accounts.

This section presents traditional and after-tax optimizations for a hypothetical investor. Assume she pays taxes at a 25% flat rate and expects to remain in this bracket. She has \$600,000 of pretax funds or \$450,000 of after-tax funds in TDAs and \$550,000 of after-tax funds in taxable accounts; the cost bases and market values are the same for assets held in taxable accounts. Stocks' pretax return is 8%, all capital gains, and pretax standard deviation is 15%, whereas bonds' pretax return is 4% and pretax standard deviation is 6%. The correlation coefficient between stocks and bonds is 0.1. Following Sharpe (1990), the utility function is $U = ER - SD^2/RT$, where ER denotes expected return, SD denotes standard deviation, and RT is the level of risk tolerance. Reichenstein (2001) and Dammon et al. (2004) consider other utility functions, so the conclusions are not sensitive to the choice of utility functions.

Table 3 presents the investor's traditional mean-variance optimization. Because the traditional approach ignores taxes, it considers her portfolio to be worth \$1,150,000, the sum of the \$600,000 pretax and \$550,000 after taxes. In addition, because it ignores taxes it inserts in the optimizer stocks and bonds' pretax returns and pretax standard deviations. The usual portfolio constraints apply: There can be no short trading, and the sum of the two assets equals 1. Table 3 sets her risk tolerance at 49.9 because this is the level that produces an optimal stock allocation of 52.2% (or \$600,000/\$1,150,000) stocks and 47.8% bonds.

Although the traditional approach is silent on the issue of asset location, we assume she

Table 3 Traditional mean variance optimization

	Market values	Optimal weights	Expected returns	Standard deviations
1. Stocks in TDAs	$600,000	52.2%	8%	15%
2. Bonds in taxable accounts	$550,000	47.8%	4%	6%
	$1,150,000			

TDA denotes tax-deferred accounts such as 401(k).

Maximize Utility = ER − SD^2/RT, where ER is portfolio expected returns, SD is portfolio standard deviation, and RT, the investor's risk tolerance, is set at 49.9.

Constraints: S, B ≥ 0 and S + B = 1.0, where S and B denote portfolio weights in stocks and bonds.

The correlation coefficient between stock and bond returns is 0.1.

locates stocks in TDAs and bonds in taxable accounts because most individuals have a heavier stock allocation in their retirement accounts than in their taxable accounts (see Bergstresser and Poterba, 2004).

Table 4 presents the investor's after-tax mean-variance optimization. She first converts all account values to after-tax funds. Her portfolio contains $450,000 of after-tax funds in TDAs and $550,000 of after-tax funds in taxable accounts for a total portfolio of $1,000,000. She allocates the after-tax funds among four "assets": Stocks in retirement accounts, bonds in retirement accounts, stocks in taxable accounts, and bonds in taxable accounts. The usual portfolio constraints apply. In addition, the sum of stocks in retirement accounts and bonds in retirement accounts is 45%, $450,000 after taxes of the $1,000,000 after-tax portfolio. The risk tolerance is set at 49.9 (the same as for the traditional optimization) so we can compare the traditional optimization to the after-tax optimization.

Notice that the same asset (stocks or bonds) is effectively a different asset when held in retirement accounts or taxable accounts. For example, the after-tax returns and risk for bonds held in retirement accounts are 4% and 6%, while the after-tax returns and risk for bonds held in taxable accounts are 3% and 4.5%.

Table 4 After-tax mean variance optimization

	After-tax values	Optimal weights	Expected returns	Standard deviations
1. Stocks in retirement accounts	$45,000	4.5%	8.0%	15%
2. Bonds in retirement accounts	$405,000	40.5%	4.0%	6%
3. Stocks in taxable account	$550,000	55.0%	6.8%	12.75%
4. Bonds in taxable account	$0	0.0%	3.0%	4.5%
	$1,000,000			

Maximize Utility = ER − SD^2/RT, where ER is portfolio expected returns, SD is portfolio standard deviation, and RT, the investor's risk tolerance, is set at 49.9.

Constraints: Sr, Br, St, Bt ≥ 0; Sr + Br = 0.45; and Sr + Br + St + Bt = 1.0, where Sr denotes the weight of stocks in retirement accounts. Br, St, and Bt denote the weights of bonds in retirement accounts, stocks in taxable accounts, and bonds in taxable accounts. Retirement accounts include Roth IRAs and tax-deferred accounts such as 401(k).

The correlation coefficient between stock and bond returns is 0.1.

The values reflect an active investor in the 25% ordinary income tax bracket and 15% capital gain tax brackets. Stocks earn 8%, all long-term capital gains that are realized each year or, technically, in one year and one day.

Optimizations were performed in Excel.

Table 5 Optimal combination of asset location and stock management style for an active investor

Asset location	Active stock manager
1. Stocks in taxable accounts	15% tax rate
Bonds in retirement accounts	0% tax rate
2. Bonds in taxable accounts	25% tax rate
Stocks in retirement accounts	0% tax rate

Retirement accounts include Roth IRAs and tax-deferred accounts such as 401(k).

In Table 4, we assume the investor actively manages stocks in her taxable account such that she realizes capital gains in a year and a day and pays taxes at 15%. Reichenstein (2001) and Dammon et al. (2004) examine the implications of other stock management styles, whereas Brunel (2001; 2004) expands asset-location issues to include assets held in trusts and other savings vehicles. Her optimal portfolio contains $595,000 of after-tax funds in stocks and $405,000 of after-tax funds in bonds for a 59.5% to 40.5% stocks-bonds after-tax asset allocation. Of the $450,000 of after-tax funds in TDAs, $405,000 is invested in bonds and $45,000 in stocks. This translates into $540,000 of TDAs pretax funds in bonds and $60,000 in stocks. The optimal asset-location decision is to locate bonds in retirement accounts and stocks in taxable accounts.

A comparison of Tables 3 and 4 illustrates the errors in the traditional optimization. First, it fails to distinguish pretax funds from after-tax funds. It incorrectly implies that the investor has more money in TDAs than in taxable accounts when, after adjusting for taxes, she has less in TDAs. The optimizations should use $450,000 for the after-tax value of TDAs.

Second, the traditional optimization only uses pretax returns and risk. It fails to recognize that stocks and bonds' after-tax returns and risks vary with the savings vehicle. The optimizations should consider four "assets": Stocks in retirement accounts, bonds in retirement accounts, stocks in taxable accounts, and bonds in taxable accounts.

Third, the traditional approach tends to exaggerate the allocation to the dominant asset held in tax-deferred accounts. For example, in Table 3 the investor thinks she has $600,000 in stocks but, if we convert the TDA funds to after-tax funds, she only has $450,000 in stocks. When calculated using after-tax values, her asset allocation in Table 3 contains 45% stocks. Yet, because she uses the traditional approach, she thinks it contains 52.2% stocks.

Traditional and after-tax optimizations produce different asset allocations. Based on the after-tax approach, her portfolio in Table 3 contains 45% stocks. Based on the after-tax approach, the portfolio in Table 4 contains 59.5% stocks. This 14.5% difference is substantial. The asset locations are also different in Tables 3 and 4. As noted earlier, most individuals hold a larger portion of stocks in their retirement accounts than in their taxable accounts. In contrast, the after-tax approach recommends the opposite asset location by holding bonds in retirement accounts and stocks in taxable accounts.

Table 5 presents an intuitive explanation of the optimal asset-location decision in an after-tax optimization. The left column shows the two asset-location strategies. The first strategy is to hold stocks in taxable accounts and bonds in retirement accounts, whereas the second strategy is the opposite. Recall that the effective tax rate is zero on assets held in retirement accounts. In contrast, the effective tax rate for the active investor is 25% on bonds and 15% on stocks held in taxable accounts. Because the effective tax rate is zero on assets held in retirement accounts, the key question is whether it is better to let the government have 15% of stocks' returns and risk or 25% of bonds' returns and risk when held in taxable accounts. The logical answer is that it is better to let the government have 15% of stocks' returns and risk.

The asset-location results can be generalized in two directions: We can consider other stock management styles and expand the assets beyond bonds and stocks. Table 4 considered an active stock manager. The asset-location advantage is because of the spread between the effective tax rates on bonds and stocks when held in taxable accounts, (25–15%) for the active investor. Generalizing, the wider this spread the larger is the advantage of locating bonds in retirement accounts and stocks in taxable accounts. This advantage is largest for high-income individuals who are in a high ordinary income tax bracket and follow an exempt stock management style. At the other extreme, there is no advantage for a day trader because he would pay taxes on stocks and bonds held in taxable accounts at the ordinary income tax bracket. Finally, as long as any portion of stock returns are taxed at preferential capital gain tax rates, the optimal location strategy is to hold stocks in taxable accounts. In short, except for the extreme case of a day trader who lived back in the days when dividends were taxed as ordinary income, there is an optimal asset location, and that is to hold stocks in taxable accounts.

The second generalization is to expand the assets beyond bonds and stocks. In general, taxable fixed-income assets, real estate investment trusts (REITs), and other assets whose returns are taxed at ordinary income tax rates should be located in retirement accounts; REITs generally pay nonqualified dividends that are subject to ordinary income tax rates. Stocks and other assets with substantial capital gain potential should be located in taxable accounts and passively managed. In addition to passively managed stocks, raw real estate and gold bullion would be good assets to locate in taxable accounts.

Finally, there is one exception to the rule-of-thumb that fixed-income assets should be held in retirement accounts and stocks in taxable accounts or vice versa, while attaining the target asset allocation. To serve their purpose, liquidity reserves must be held in taxable accounts.

4. Calculation of current after-tax asset allocation

Reichenstein (1998), Reichenstein and Jennings (2003), Horan (2002), and Sibley (2002) among others agree that the traditional approach to calculating an individual's asset allocation is wrong because it does not consider taxes. For example, the traditional approach considers $1 of *pretax* funds in a TDA and $1 of *after-tax* funds in a Roth IRA to be equally valuable. However, these authors disagree about how we should value $1 in a TDA and $1 in a Roth IRA when calculating an individual's asset allocation.

Reichenstein (1998) and Reichenstein and Jennings (2003) advocate calculating an individual's after-tax asset allocation, where they first convert assets' market values to after-tax funds and then calculate the asset allocation using these after-tax values. They conclude that each dollar in a Roth IRA has an after-tax value of $1, whereas each dollar in TDAs has an after-tax value of $(1 - t_n)$ dollar.

Sibley (2002) and Horan (2002) calculate the number of after-tax dollars in a taxable account that will provide the same expected after-tax future value as $1 in, respectively, a TDA and Roth IRA. Let us call these the taxable equivalent values. They then advocate using these taxable equivalent values when calculating the current asset allocation.

These studies agree that the traditional approach is wrong because it equates pretax funds and after-tax funds, and thus makes an apples-to-oranges comparison. However, these studies disagree with whether the proper apples-to-apples comparison should be based on assets' after-tax values or their taxable equivalent values. Let us review Sibley and Horan's studies.

We begin with a discussion of Sibley's models because they are simpler. He defines the taxable equivalent value of $1 in a TDA as the "number of ordinary after-tax dollars (invested to earn ordinary taxable income) that would be necessary to provide the same level of future consumption." He defines the taxable equivalent value of $1 in a Roth IRA in a parallel manner.

The projected after-tax future value of $1 of pretax funds in a TDA is:

$$(1 + r)^n (1 - t_n) \tag{1}$$

Actually, Sibley assumes a constant tax rate, t, for all years including the tax rate in the withdrawal year, t_n. I inserted the tax rate in the withdrawal year, t_n, into his model.

Assuming returns on assets held in taxable accounts are fully taxable each year at ordinary income tax rates, the after-tax future value of $1 of after-tax funds in a taxable account is:

$$(1 + r(1 - t))^n \tag{2}$$

Sibley then sets the current taxable equivalent dollars in a TDA at the ratio of Eq. (1) to Eq. (2):

$$(1 + r)^n (1 - t_n)/ (1 + r(1 - t))^n \tag{3}$$

Similarly, the after-tax future value of $1 of after-tax funds in a Roth IRA is:

$$(1 + r)^n \tag{4}$$

He then sets the current taxable equivalent value of a Roth IRA at the ratio:

$$(1 + r)^n / (1 + r(1 - t))^n \tag{5}$$

Notice that the current after-tax value of $1 in a TDA or Roth IRA depends upon projected rate of return (r), length of investment horizon (n), and tax rates (t and/or t_n).

Horan produces models that are in the same spirit as Sibley in that he converts funds in retirement accounts into taxable equivalent values. The only difference between Sibley and Horan's models is that Horan uses a different model to project the future value of assets held in taxable accounts.

For the after-tax future value of an asset held in a taxable account, Horan assumes the underlying asset is a mutual fund. The model is:

$$(1 + r^*)^n (1 - T^*) + T^*, \text{ where} \tag{6}$$

$$r^* = r - rp_{oi}t - rp_c t_c \text{ and}$$

$$T^* = t_c(1 - p_{oi} - p_c)/(1 - p_{oi}t - p_c t_c),$$

and r is the projected pretax rate of return,
n is the length of investment horizon,
t is the marginal tax rate on ordinary income,
t_c is the marginal tax rate on capital gains,
p_{oi} is the percentage of annual return distributed to shareholders as ordinary income, and
p_c is the percentage of annual return distributed to shareholders as capital gains.
For simplicity, t, tc, poi, and pc are held constant.

The r* is the annual after-tax rate of return, that is, the pretax return less taxes on distributions of ordinary income and realized capital gains. The T* is the effective tax rate on capital gains taking into account the changing basis from realizing capital gains before the end of the investment horizon.

Horan's model is sufficiently flexible to accommodate bond funds (i.e., $p_{oi} = 1$) and stock funds for the day trader, active investor, passive investor, and exempt investor. The tables in his study, however, provide taxable equivalent values for TDA and Roth IRA balances assuming the underlying investment is an "average" stock fund with p_{oi} of 0.0699 and p_c of 0.4423, where these values come from Crain and Austin (1997). These taxable equivalent values would change whenever the parameters change (i.e., $p_{oi,}$ p_c, t, or t_c).

Like Sibley, Horan defines the taxable equivalent value of TDA and Roth IRA balances as the amount of current after-tax funds in taxable accounts that will produce the same expected future after-tax value. For a lump-sum withdrawal, he defines the current after-tax value of $1 of pretax funds in a TDA as:

$$(1 + r)^n (1 - t_n) / [(1 + r^*)^n (1 - T^*) + T^*] \tag{7}$$

He defines the current after-tax value of a $1 withdrawal of after-tax funds in a Roth IRA as:

$$(1 + r)^n / [(1 + r^*)^n (- T^*) + T^*] \tag{8}$$

In his models, the current value of $1 in a TDA or Roth IRA depends upon the projected rate of return, length of investment horizon, mutual fund's investment style (i.e., p_{oi}) and management style (i.e., p_c), and tax rates.

In a similar study to those of Sibley and Horan, Poterba (2004) compares the after-tax future value of $1 in a TDA to the after-tax future value of $1 in a taxable account. For the taxable account he assumed stocks pay dividends but capital gains are deferred until the end of the investment horizon, that is, he set $p_{oi} > 0$ and $p_c = 0$ in Eq. (6). His analysis states that this comparison should be viewed "from the standpoint of providing future retirement income." However, he does not claim that his models or analysis is appropriate for measuring an individual's current asset allocation.

To understand the criticism of Sibley and Horan's taxable equivalent models, it is important to understand that their taxable equivalent values are the present values of projected future values, where the discount rate reflects the risk of an asset held in a taxable account. For example, Sibley says $1 in a Roth IRA has a taxable equivalent value of: $(1 + r)^n/(1 + r(1 - t))^n$. The projected future after-tax value of the Roth IRA, $(1 + r)^n$, is discounted at the after-tax rate of return on assets held in a taxable account. However, the individual bears all risk of assets held in a Roth IRA but only $(1 - t)$ of the risk on assets held in a taxable account. Thus, it is inappropriate to discount the Roth's future value by the risk borne by an investor holding the asset in a taxable account. The appropriate discount rate for the Roth IRA is r, so the present value of the projected future value is $(1 + r)^n/(1 + r)^n$ or \$1. That is, the current value of \$1 in the Roth IRA is \$1.

The same argument applies to funds in a TDA. According to Horan, \$1 in a TDA has a taxable equivalent value of: $(1 + r)^n (1 - t_n)/ [(1 + r^*)^n (1 - T^*) + T^*]$. The projected future after-tax value of the TDA, $(1 + r)^n (1 - t_n)$, is discounted at the after-tax rate of return on assets held in taxable accounts. However, the individual bears all risk of assets held in a TDA. Therefore, the appropriate discount rate for the TDA is r, and the present value of the projected future value is $(1 + r)^n (1 + t_n)/ (1 + r)^n$ or $\$1(1 - t_n)$. That is, the current after-tax value of \$1 of pretax funds in a TDA is $\$1 (1 - t_n)$. The investor effectively owns $(1 - t_n)$ of the principal.

To further clarify the criticism of Sibley and Horan's approaches, let us consider the current value of \$1 of after-tax funds held in a taxable account. They correctly view the current value at \$1 regardless of rate of return, length of investment horizon, and so on. Based on Sibley's method, the present value of the projected future value is:

$$\$1(1 + r((1 - t))^n/(1 + r((1 - t))^n \text{ or } \$1.$$

Based on Horan's method, the present value of the projected future value is:

$$\$1[(1 + r^*)^n (1 - T^*) + T^*]/[(1 + r^*)^n (1 - T^*) + T^*] \text{ or } \$1.$$

There are two reasons why financial planners should celebrate this study's conclusion that the after-tax approach is the best approach to estimating an individual's asset allocation. First, (when cost bases equal market values on assets held in taxable accounts) to calculate an individual's asset allocation, we only need an estimate of t_n, his or his beneficiary's applicable marginal tax rate when funds are withdrawn. In contrast, to calculate an individual's current asset allocation using the taxable equivalent approach, we must estimate rates of return, length of investment horizon, mutual fund distribution patterns, and tax rates. Therefore, the after-tax approach is much easier to apply. Second, with the after-tax approach there is no need to distinguish an individual's *current* asset allocation from his *future* asset allocation. He has only one asset allocation, implicitly understood to mean current. He should select his optimal asset allocation. As time passes, his asset allocation will change but, at any point in time, he only has only one asset allocation.

5. Implications for financial planning and topics for future research

This article has implications for the practice of financial planning. In addition, it suggests topics for future research.

Implications for financial planning include the following:

- Individual investors effectively own $(1 - t_n)$ of the principal of TDAs. However, they effectively receive all of the asset's returns and bear all of its risk. A dollar in a TDA is like $(1 - t_n)$ dollar in a Roth IRA.

- The choice of savings vehicles affects the portion of an asset's risk borne by and returns received by an individual investor. Thus, in an after-tax mean-variance framework, a bond held in a TDA or Roth IRA is effectively a different asset than the same bond if held in a taxable account.
- A client's optimal portfolio consists of an optimal asset allocation and optimal asset location, and these two decisions are jointly determined. Furthermore, the asset location decision should be most important to individuals in high tax brackets who passively manage stocks held in taxable accounts.
- Jeffery and Arnott (1993) conclude that the *tax savings alone* from tax-efficiently managing stocks in taxable accounts almost certainly exceeds the value added from security selection. This article suggests that another benefit of tax-efficiently managing stocks in taxable accounts is that it increases the asset-location benefit. It follows that active stock management in taxable accounts must overcome three burdens: (1) additional taxes, (2) reduced asset-location benefits, and (3) higher costs (i.e., that is, expense ratios and transaction costs) associated with active management. Altogether, they would appear to be a formidable hurdle for active management to overcome.
- Financial planners should calculate clients' after-tax asset allocation. Planners who use the traditional approach are miscalculating their clients' asset allocations and thus mismanaging their portfolios.

Topics for future research may include the following:

- Previous financial research has often assessed the desirability of two portfolios or strategies by looking at their expected ending wealth values, while ignoring differences in the standard deviations of their ending wealth distributions. For example, in earlier asset-location studies, Shoven and Sialm (1998), Shoven (1999), Reichenstein (2000), and Daryanani (2004) assumed constant rates of return on stocks and bonds and asked whether the ending after-tax wealth was larger when stocks were held in TDAs and bonds in taxable accounts or vice versa. These constant return analyses indicated differences in median ending wealth values (i.e., that is, one point in each distribution) but they ignore differences in risk. Similarly, for long horizons, the expected after-tax future values from a dollar in a TDA may equal the expected after-tax future value from a dollar in a taxable account, but the standard deviations of their ending distributions are not equal. To properly assess the merits of competing portfolios or strategies we must consider differences in the *risks and expected returns* of the ending distributions.
- How does the progressive tax system affect the conclusions and implications of this study? The after-tax approach converts pretax funds in TDAs to after-tax funds by multiplying by $(1 - t_n)$, which implicitly assumes all withdrawals will be subject to a constant marginal tax rate. How should we estimate t_n for someone in a progressive tax system? Horan (2006) examines implications of a progressive tax system for investors in their withdrawal stage. I suspect much work remains to be done in other areas. For example, consider someone with \$1 million in a TDA who, anticipating a normal life span, expects to work another decade or more and to withdraw funds in retirement when in the 33% tax bracket. He considers the TDA to be worth \$670,000 after taxes

today. If he dies today, his spouse may be able to withdraw the funds at a tax rate of 25%, in which case the after-tax value of the TDA is worth $750,000. Thus, the TDA has a life-insurance-type feature.

- How sensitive is the optimal portfolio to changes in expected returns, standard deviations, tax rates, portion of after-tax funds in taxable and retirement accounts, and stock management style?
- This study assumed market values and cost bases were the same for assets held in taxable accounts. When taxable accounts contain assets with substantial unrealized capital gains or losses, how should this affect the measurement of an individual's current asset allocation? How do unrealized gains affect the portions of an asset's risks borne by the investor and returns received by the investor? In addition, should a "large" gain essentially lock an asset in a portfolio?
- What are the implications of risk- and returns-sharing across savings vehicles for the optimal strategy of withdrawing funds in retirement from taxable accounts, TDAs, and Roth IRAs? Horan (2006) and Reichenstein (2006) have begun this work.
- What is the role of nonqualified tax-deferred annuities within an after-tax optimization, and how does it affect the asset-location decision? Because returns are tax-deferred in these annuities, the portions of returns received by and risk shared by an individual will vary with, among other things, the length of the investment horizon. In an annuity, returns (whether interest, dividends, or capital gains) are eventually taxed as ordinary income. This suggests holding bonds in an annuity. However, the annuity's death benefit is more valuable when the underlying asset is stocks. How should this tradeoff play out?
- How does the asset-location decision and risk- and return-sharing across savings vehicles affect risk budgeting for individual investors?

6. Summary

This article illustrates important insights and implications associated with the tax treatments of assets held in Roth IRAs, TDAs, and taxable accounts. For assets held in Roth IRAs, the individual investor effectively owns all principal, receives all returns, and bears all risk. For assets held in TDAs, the individual effectively owns $(1 - t_n)$ of principal, receives all returns, and bears all risk. For bonds held in taxable accounts (with cost bases equal to market values), the individual effectively owns all principal, receives $(1 - t)$ of returns and bears $(1 - t)$ of risk. For stocks held in taxable accounts (with cost bases equal to market values), the individual effectively owns all principal, but the portion or returns received and risk borne by the investor varies with the management style. Therefore, an individual's share of an asset's after-tax risk varies by savings vehicles. Thus, a bond held in a Roth IRA or TDA is riskier to the individual than a bond held in a taxable account. Stated differently, in a mean-variance optimization a bond held in a Roth IRA or TDA is effectively a different asset than a bond held in a taxable account.

In addition, this study compares and contrasts a tax-oblivious, traditional mean-variance optimization with an after-tax mean-variance optimization. It highlights problems with the traditional approach, and the potentially substantial differences in optimal portfolios. In addition, the after-tax optimization helps explain the optimal asset-location decision. As long as part of stocks' returns are subject to preferential capital gains tax rates, the optimal asset location is to hold bonds in retirement accounts and stocks in taxable accounts. The importance of the asset-location decision increases with the spread between the ordinary income tax rate and effective tax rate on stocks held in taxable accounts. Thus, asset location should be most important to high income individuals who passively manage stocks in taxable accounts.

Sibley (2002), Horan (2002), and Poterba (2004) develop models that compare the number of dollars currently invested in a taxable account that will produce the same after-tax future value as a dollar invested in, respectively, a Roth IRA or TDAs like the traditional IRA. We explain why we believe these models should not be used to calculate an individual's *current* asset allocation. To measure an individual's current asset allocation, we recommend the after-tax approach advocated by Reichenstein and Jennings (2003). The current after-tax value of \$1 of pretax funds in a TDA is $(1 - t_n)$, where t_n is the expected tax rate during retirement, whereas the current value of \$1 of after-tax funds in a Roth IRA or taxable account is \$1.

Finally, we discuss some of the implications for financial planning of principal, risk, and returns sharing across savings vehicles and suggest topics for future research. My hunch is the list merely scratches the surface.

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