Asset Allocation and Asset Location Decisions Revisited

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In this article, we "go back to basics," but do so in the presence of taxes. There are but two assets: a stock fund and a bond fund. Each asset can be held in taxable accounts, deductible pension accounts, or both (deductible pension accounts include, e.g, 401(k), 403(b), Keogh, and SEP-IRA). An individual investor has some assets in taxable accounts and others in deductible pension accounts. He asks his financial professional to do three things. First, calculate the portfolio's current asset allocation. Second, recommend an optimal asset allocation. Third, recommend an optimal asset location. More specifically, he asks whether he should, to the degree possible, locate stocks or bonds in tax-sheltered pension accounts.

We argue that the traditional approach to calculating an individual's asset allocation is wrong. The traditional approach fails to distinguish between the before-tax funds in deductible pension accounts and the generally after-tax funds in taxable accounts. Goods and services must be purchased with after-tax funds. Yet, the traditional approach treats $1,000 in deductible pension accounts as equivalent to $1,000 of after-tax funds in taxable accounts. I believe that the profession must first convert before-tax funds to after-tax funds, and then calculate the asset allocation based on after-tax funds.[1]

We apply mean-variance optimization to determine an individual's optimal asset allocation and asset location. The individual has some assets in taxable accounts and others in deductible pension accounts. Each asset's risk and return depend upon whether it is held in a taxable account or a deductible pension. As we shall show, if assets are held in deductible pension accounts, the individual investor bears all the asset's risk and receives all its returns. In the taxable account, the government shares in the asset's risk and returns.

The research into asset location issues, including my own, considers the impact of the asset allocation decision on return, but ignores its impact on risk. The general conclusion is that active stock investors should have a strong preference to hold stocks in deductible pension accounts (and other retirement accounts) and bonds in taxable accounts, while passive investors should probably have a slight preference to hold stocks in taxable accounts. The optimization discussed here considers the asset allocation decision's impact on both return and risk. It implies that active and passive investors should locate bonds in pension accounts and stocks in taxable accounts. Moreover, it suggests active investors should be relatively indifferent to the asset location decision, while passive investors should have a much stronger asset location preference.

We recognize that certain investors make the asset location decision first and the asset allocation decision second. Our optimizations reveal that their optimal asset allocation varies predictably and strongly with their asset location decision. The optimal asset allocation

EXHIBIT 1
Asset Allocation for Three Portfolios

Asset	Market Value	Savings Vehicle	Stock Allocation: Traditional Approach	Stock Allocation: After-Tax Approach
Portfolio A				
Stock Fund	$100,000	Taxable Account	50%	50%
Bond Fund	$100,000	Taxable Account		
Portfolio B				
Stock Fund	$100,000	Roth IRA	50%	50%
Bond Fund	$100,000	Taxable Account		
Portfolio C				
Stock Fund	$153,800	Deductible Pension	61%	50%
Bond Fund	$100,000	Taxable Account		

calls for a much larger exposure to the asset held in taxable accounts.

MEASURING AN INDIVIDUAL'S ASSET ALLOCATION

Mark just retired at age 65. His assets are to be used to meet his retirement income needs. Suppose his portfolio is the one presented in Portfolio A of Exhibit 1. He has $100,000 in a stock fund held in a taxable account and $100,000 in a bond fund held in a taxable account. The book and market values are $100,000 for both the stock fund and the bond fund. What is his current asset allocation?

On this question, we all agree. His portfolio is 50% stocks and 50% bonds.

Suppose Mark's portfolio is Portfolio B of Exhibit 1. It has $100,000 in a stock fund held in a Roth IRA and $100,000 in a bond fund held in a taxable account. The book and market values of the bond fund are both $100,000. What is his current asset allocation?

Again, we all agree. The portfolio is 50% stocks and 50% bonds.

Portfolio C presents a third portfolio. It has $153,800 in a stock fund held in a deductible pension account and $100,000 in a bond fund held in a taxable account. The market and book values of the bond fund are both $100,000. Mark is in the combined federal-plus-state ordinary income tax bracket of 35%, and will remain there. What is his asset mix? According to the traditional approach to calculating the asset mix, his portfolio is 61% stocks ($153,800/$253,800) and 39% bonds.

I contend his portfolio is 50% stocks and 50% bonds, the same as for Portfolios A and B. In Portfolios A and B, he could withdraw, say, $1,000 from the stock fund and buy $1,000 of goods and services. In Portfolio C, he must withdraw $1,538 from the stock fund held in a deductible pension account to buy $1,000 of goods and services; taxes consume the other $538.

The deductible pension account includes before-tax funds, and before-tax funds buy fewer goods and services than the same amount of after-tax funds. Since Mark intends to use the funds to meet his retirement income needs, we can convert the $153,800 of before-tax funds to after-tax funds by multiplying by $(1 - t)$, where t is his expected tax rate during retirement. The deductible pension account represents $153,800 $(1 - 0.35)$ or $100,000 of after-tax funds.

Any acceptable method of calculating an individual's asset mix must distinguish between before-tax and after-tax funds, because goods and services are purchased with after-tax funds. Before calculating the asset allocation, we should first convert all account values to after-tax values. In so doing, we compare after-tax funds to after-tax funds.

The same principle applies to investments in other savings vehicles—e.g., a non-deductible IRA, a non-qualified tax-deferred annuity, and a taxable account. The asset allocation should reflect those accounts' after-tax values.[2]

RISK AND RETURNS ACROSS SAVINGS VEHICLES

Properly measured, Portfolios A, B, and C are 50% stocks and 50% bonds; the current asset allocation should reflect current after-tax values. But these three portfolios are not equally desirable. Mark should prefer Portfolios B and C to Portfolio A, because assets held in a Roth IRA and a deductible pension account receive more favorable tax treatment than assets held in taxable accounts. In Reichenstein [1999, 2000a, 2000b, 2000c, and 2000d], I thoroughly discuss the implications of investing in alternative savings vehicles—taxable accounts, deductible pension accounts, Roth IRA, non-deductible IRA, and non-qualified tax-deferred annuities.

Let us first compare Portfolio B, which has $100,000 of stocks in a Roth IRA, and Portfolio C, which has $153,800 of stocks in a deductible pension. They are equally desirable.[3] Mark could withdraw $1,000 from the Roth IRA today and buy $1,000 of goods and services. Or, he could withdraw these funds n years hence. If the stock fund earns i% a year, today's $1,000 would buy $\$1{,}000(1 + i)^n$ of goods and services in n years. In a Roth IRA, returns are tax-exempt.

In the deductible pension account, Mark could withdraw $1,538 of before-tax funds today and buy $1,000 of goods and services. Or, he could withdraw these funds n years hence. If the stock fund earns i% a year, the $1,538 before taxes would buy $\$1{,}538(1 + i)^n \times (1 - 0.35)$ or $\$1{,}000(1 + i)^n$ of goods and services. The $1,538 in the deductible pension buys $1,000 today or $\$1{,}000 \times (1 + i)^n$ of goods and services in n years. This is precisely the same as the $1,000 in the Roth IRA.

In a deductible pension account, the individual bears all investment risk and receives all investment returns. In both a Roth IRA and a deductible pension, the effective tax rate is zero.

These examples illustrate that any acceptable method of calculating an individual's asset allocation must treat $1,000 in a Roth IRA as equivalent to $\$1{,}000/(1 - t)$ or, in this case, $1,538 in a deductible pension. The traditional approach violates this requirement.

In Portfolio A, the stock fund is held in a taxable account, so the government shares—like it or not—in its *return and its risk*. Mark does not bear all of the asset's risk or receive all of its returns.

Most professional investors would consider Portfolios A and B to be (virtually) the same and Portfolio C to be different from the other two. In reality, Portfolios B and C are the same, and Portfolio A is different. All three portfolios have the same current asset allocation, but because the stock portion of the portfolios is held in different savings vehicles, the individual bears different portions of its risk and returns. In Portfolios B and C, the individual bears all asset risk and receives all asset returns, while in Portfolio A, the government shares the asset's risk and returns.

EXHIBIT 2
Expected Returns and Risk in Pensions and Taxable Accounts*

	Expected Returns	Standard Deviation
Trader		
1. Stocks in pensions	11.00%	15.00%
2. Bonds in pensions	6.00%	10.00%
3. Stocks in taxable accounts	7.15%	9.75%
4. Bonds in taxable accounts	3.90%	6.50%
Active Investor		
1. Stocks in pensions	11.00%	15.00%
2. Bonds in pensions	6.00%	10.00%
3. Stocks in taxable accounts	7.87%	10.95%
4. Bonds in taxable accounts	3.90%	6.50%
Passive Investor		
1. Stocks in pensions	11.00%	15.00%
2. Bonds in pensions	6.00%	10.00%
3. Stocks in taxable accounts	10.30%	15.00%
4. Bonds in taxable accounts	3.90%	6.50%

**Pensions include Roth IRA and deductible pensions such as 401(k), 403(b), Keogh, deductible IRA, SEP-IRA.*

Exhibit 2 presents the risk and returns on bonds and stocks when held in pension accounts and taxable accounts, where pension accounts include deductible pension accounts and Roth IRAs. Assume bonds offer 6% pre-tax expected return and 10% pre-tax standard deviation. Stocks offer 11% pre-tax expected return and 15% pre-tax standard deviation. Stock returns consist of 2% dividend yield plus 9% expected capital gain. Mark, the individual investor, is in a combined federal-plus-state ordinary tax bracket of 35% and combined capital gains tax bracket of 27%.

As shown previously, in pension accounts, Mark bears all the risk and receives all the returns. When assets are held in a taxable account, Mark bears 65% of bonds' risk and receives 65% of returns; the after-tax risk (standard deviation) and returns are 6.5% and 3.9%, respectively.

When stocks are held in a taxable account, the individual's risk depends upon his or her approach to investment. We define three hypothetical individual investors. The *trader* realizes all gains as short-term gains each year, and pays taxes at the ordinary income tax rate. The *active investor* realizes all gains in one year and one day, and pays taxes at the capital gains tax rate. An active investor is someone who actively manages funds or invests in an active stock fund. The *passive investor* buys and holds stocks and never pays capital gains taxes. She may give appreciated assets to charity or await the step-up in cost basis at the owner's death (or death of the first spouse). She pays taxes annually on interest and dividends. This passive investor is someone who passively manages funds or buys and holds a passive stock fund.

The trader who holds stocks in a taxable account bears 65% of its risk and takes 65% of its returns; the government shares 35% of risk and returns. For this trader, stocks' after-tax expected returns and risk are 7.15% and 9.75%.

For the active investor who holds stocks in a taxable account, the after-tax expected returns are 7.87%, $2\% \times (1 - 0.35) + 9\%(1 - 0.27)$, and the after-tax standard deviation is 10.95%. The dividend yield provides a certain 1.3% after-tax return. The return uncertainty (and thus risk) involves the size of the capital gain or loss. Since the applicable tax rate for this portion of return is 27%, the government bears only 27% of stocks' risk. For this active investor, the government takes 28.5% of returns but bears only 27% of risk. Moreover, the spread between the return-sharing percentage and the risk-sharing percentage increases for investors in high ordinary income tax brackets. For someone in the 39.6% ordinary income tax bracket and 20% capital gains tax bracket, the government takes 23.6% of stock returns but bears only 20% of its risk.

For the passive investor who holds stocks in taxable accounts, the after-tax expected returns and standard deviation are 10.3% and 15%, respectively. The return is 11% less the 0.7% annual tax on dividends. The standard deviation is 15%, the same as for stocks held in pension accounts. As before, the uncertainty involves only the size of the capital gain, so this has the same risk as for a tax-exempt investor. The passive investor receives about 94% of stocks' returns and bears all their risk.

In summary, from an individual investor's perspective, an asset's risk and returns depend upon whether it is held in a pension or a taxable account. When the asset is held in a pension, the individual bears all risk and receives all returns. When the asset is held in a taxable account, the individual bears $(1 - t)$ percent of bonds' risk and returns, where t is the marginal tax rate. When the asset is held in a taxable account, the individual's share of stocks' risk and returns depends upon his or her management practices. The trader bears $(1 - t)$ percent of stocks' risk and returns. The active investor and the passive investor bear a greater fraction of stocks' risk than returns.

OPTIMIZATION WITH TAXABLE AND RETIREMENT ACCOUNTS

Each individual investor, perhaps with the help of his or her financial advisor, must choose an asset allocation and asset location. Asset allocation refers to the allocation of after-tax funds across asset classes—stocks and bonds in our two-asset world. Asset location refers to the decision to place, insofar as the asset allocation allows, stocks in pension accounts and bonds in taxable accounts or vice versa.

Mean-variance optimization traditionally ignores taxes and relies on before-tax risk and expected returns. When applied to individuals, it requires recognition that a portion of the individual's after-tax funds are held in taxable accounts and the remainder in pension accounts. There are two assets—stocks and bonds—and two savings vehicles, taxable accounts and pension accounts. For optimization, there are thus effectively four "assets": stocks in pension accounts, bonds in pension accounts, stocks in taxable accounts, and bonds in taxable accounts.[4]

Each of the three investors—trader, active investor, and passive investor—must make both an asset allocation decision and an asset location decision. Exhibit 3 summarizes one optimization for the active investor. He allocates funds among the four "assets" so that he maximizes utility. The study examines two utility functions: $U = ER - SD/RT$ and $U = ER - SD^2/RT$. U denotes utility; also, it is the portfolio's certainty-equivalent return, meaning it is the risk-free return that would provide the same utility as the portfolio. ER is the portfolio's after-tax expected returns. SD is after-tax standard deviation. RT denotes the investor's risk tolerance.

The usual portfolio constraints apply. There is no short-selling. In addition, we assume half of the after-tax funds in Mark's portfolio are in pension accounts and half in taxable accounts. The correlation coefficient between bond and stock returns is 0.2. The risk tolerance for the first utility function is set at 2.[5] It is set at 40 for the second utility function.[6] Exhibit 4 summarizes the results of these optimizations.

EXHIBIT 3

Expected Returns and Risk in Pensions and Taxable Accounts

	Expected Returns	Standard Deviation	$r_{1,j}$	$r_{2,j}$	$r_{3,j}$	$r_{4,j}$
1. Stocks in pensions	11.00%	15.00%	1.0			
2. Bonds in pensions	6.00%	10.00%	0.2	1.0		
3. Stocks in taxable account	7.87%	10.95%	1.0	0.2	1.0	
4. Bonds in taxable account	3.90%	6.50%	0.2	1.0	0.2	1.0

Maximize Utility = ER – SD/RT or Utility = ER – SD^2/RT

ER = Wsp (11%) + Wbp (6%) + Wst (7.87%) + Wbt (3.9%)

Constraints:
Wsp = 0 or >
Wbp = 0 or >
Wst = 0 or >
Wbt = 0 or >
Wsp + Wbp = 0.5
Wsp + Wbp + Wst + Wbt = 1.0

ER is portfolio expected returns. SD is portfolio standard deviation. RT is the investor's risk tolerance. $r_{i,j}$ denotes the correlation coefficient between asset i and asset j. Wsp denotes the weight of stocks in pensions; Wbp, Wst, and Wbt denote the weights of bonds in pensions, stocks in taxable accounts, and bonds in taxable accounts. Wsp + Wbp = 0.5 restricts pension assets to 50% of total after-tax funds. Pensions include the Roth IRA and all deductible pensions—e.g., 401(k), 403(b), Keogh, deductible IRA. The values reflect an active investor in the combined federal-plus-state 35% ordinary income tax bracket and combined 27% capital gains tax bracket. Stocks earn 2% dividend yield plus short-term capital gains and 9% long-term capital gains. This active stock investor realizes all capital gains each year or, technically, in one year and one day.
Optimizations were performed in Excel.

Trader

For the trader, there are at least three optimal portfolios, and each of them produces identical portfolio risk, portfolio return, and utility. Portfolios 1 through 3 present the optimal portfolios for the first utility function. Portfolio 1 allocates 24.9% of after-tax funds to stocks in pension accounts, 25.1% to bonds in pension accounts, and 50% to stocks in taxable accounts. The utility or certainty-equivalent return is 3.10%. The overall stock allocation is 74.9%, and, to the degree possible, bonds are located in pension accounts. Portfolios 4 through 6 present the optimal portfolios for the second utility function.

Portfolios 1, 2, and 3 provide identical portfolios (in terms of portfolio risk, portfolio expected returns, and utility). Yet, they have different asset allocations and asset locations. The overall stock allocations in Portfolios 1 through 3 are 74.9%, 70.1%, and 61.4%, respectively. To the degree possible, Portfolio 1 locates bonds in pension accounts. Portfolio 3 locates stocks in pension accounts. And, Portfolio 2 locates both bonds and stocks in pension accounts. There is more than one optimal portfolio.

Similarly, Portfolios 4 through 6 provide identical portfolios, but they make different asset allocation and asset location decisions. Again, there is more than one optimal portfolio.

According to the specific input in this example and others not reported, there is not an optimal asset allocation for the trader. Traders always have more than one optimal portfolio, and each optimal portfolio reflects a different asset allocation and asset location. If the government shares equally in assets' risk and returns, identical portfolios (in terms of utility, portfolio risk, and portfolio returns) can be obtained with different asset allocation and asset location decisions.

Most researchers, though, appear to have approached the two decisions in a sequential fashion: Decide the asset allocation first, and make the asset location decision second.[7] For traders, the two-step procedure will not work; the asset allocation and asset location decisions must be solved jointly.

EXHIBIT 4

Asset Allocation, Asset Location, and Utility

Portfolio	Wsp	Wbp	Wst	Wbt	Stk	Portfolio Utility	Portfolio ER	Portfolio SD
Trader								
Utility = ER – SD/RT								
1	24.9%	25.1%	50.0%	0%	74.9%	3.10%	7.82%	9.44%
2	33.8%	16.2%	36.3%	13.7%	70.1%	3.10%	7.82%	9.44%
3	50.0%	0%	11.4%	38.6%	61.4%	3.10%	7.82%	9.44%
						Utility loss = 0%		
Utility = ER – SD^2/RT								
4	27.0%	23.0%	50.0%	0%	77.0%	5.60%	7.93%	9.65%
5	35.6%	14.4%	36.9%	13.1%	72.5%	5.60%	7.93%	9.65%
6	50.0%	0%	14.7%	35.3%	64.7%	5.60%	7.93%	9.65%
						Utility loss = 0%		

Portfolio	Wsp	Wbp	Wst	Wbt	Stk	Portfolio Utility	Portfolio ER	Portfolio SD
Active Investor								
Utility = ER – SD/RT								
7	23.7%	26.3%	50.0%	0%	73.7%	3.17%	8.12%	9.90%
8	50.0%	0%	23.7%	26.3%	73.7%	3.11%	8.39%	10.57%
9	50.0%	0%	15.0%	35.0%	65.0%	3.12%	8.05%	9.85%
						Utility loss = 0.05%		
Utility = ER – SD^2/RT								
10	24.1%	25.9%	50%	0%	74.1%	5.67%	8.14%	9.94%
11	50.0%	0%	24.1%	25.9%	74.1%	5.60%	8.41%	10.60%
12	50.0%	0%	16%	34%	66.0%	5.62%	8.09%	9.93%
						Utility loss = 0.05%		

Portfolio	Wsp	Wbp	Wst	Wbt	Stk	Portfolio Utility	Portfolio ER	Portfolio SD
Passive Investor								
Utility = ER – SD/RT								
13	19.6%	30.4%	50%	0%	69.6%	3.41%	9.13%	11.44%
14	50.0%	0%	19.6%	30.4%	69.6%	3.20%	8.70%	11.01%
15	50.0%	0%	27%	33%	77.0%	3.21%	9.18%	11.94%
						Utility loss = 0.20%		
Utility = ER – SD^2/RT								
16	14.2%	35.8%	50%	0%	64.2%	5.88%	8.86%	10.92%
17	50.0%	0%	14.2%	35.8%	64.2%	5.68%	8.36%	10.35%
18	50.0%	0%	16%	34%	66.0%	5.68%	8.41%	10.45%
						Utility loss = 0.20%		

Given an asset location decision, there is one optimal asset allocation. For example, given the decision to locate as many bonds as possible in pension accounts, Portfolio 1 is the optimal allocation, and it is 74.9% in stock. Given the decision to locate stocks in pension accounts, Portfolio 3 is the optimal asset allocation, 61.4% stocks.

This 13.5 percentage point difference is not minor. A frequent rule of thumb says that an investor should maintain each asset class weight within 10% of the target weight. Suppose the target weight calls for 75% stocks. This rule of thumb would say Portfolio 3 deviates too far from the target portfolio, and its stock allocation should be increased. Yet, in reality, Portfolios 1 and 3 provide identical portfolio risk and portfolio expected returns. In short, the rule of thumb is inadequate.

Given an asset location decision, the optimal asset allocation varies predictably with the location decision. This statement remains valid for all investors—traders, active, passive. The optimal asset allocation calls for a relatively large exposure to the asset held in taxable accounts.

There is an easy explanation of this investment implication. For the trader, the government shares 35% of taxable assets' risk and returns. We can thus think of taxable assets as belonging 35% to the government and 65% to the individual investor.

After making this adjustment, for every $100 in Portfolio 1 the individual effectively has stocks in pension accounts of $24.90, bonds in pension accounts of $25.10, and stocks in taxable accounts of $32.50[(0.65)$50]. The effective overall asset allocation is $57.40 in stocks and $25.10 in bonds. The individual's effective overall allocations for Portfolios 2 and 3 are the same. It follows from this shared ownership that the optimal asset allocation calls for a relatively large exposure to the asset held in taxable accounts.

Active Investor

Most individuals are active investors. They either actively manage their stock portfolios or invest in active stock funds.[8] For the active investor, there is an optimal asset allocation and asset location. Portfolio 7 presents the optimal portfolio for the first utility function. The overall stock allocation is 73.7%. To the degree possible, bonds are located in pension accounts.

This asset location decision appears to be relatively insensitive to the particular assumptions. For example, this decision calls for bonds in pension accounts when each of the following values is changed, holding everything else constant. The correlation is set at 0.0 or 0.4. Stocks' pre-tax expected return is set at 9% or 13% (pre-tax standard deviation set at 12% or 20%). Bonds' pre-tax return is set at 4% or 8% (pre-tax standard deviation set at 8% or 12%). The level of risk tolerance is set at levels from 1.75 to 2.5.

Finally, the asset location decision remains the same whether we maximize $U = ER - SD/RT$ or $U = ER - SD^2/RT$. For the latter utility function, we allow RT to vary from 35 to 50. In addition, we allow the correlation coefficient, expected returns, and standard deviations to vary in the same range as before.

Shoven [1999], Shoven and Sialm [1998], and Reichenstein [2000d], among others, examine the asset location decision for active investors. We each approach portfolio optimization as a two-step procedure: First determine the optimal asset allocation, and then determine the optimal asset location. We all conclude that active stock investors should locate stocks in pension accounts and bonds in taxable accounts, because this decision provides greater expected ending wealth—that is, higher expected returns—than the decision to locate bonds in pension accounts.

In Reichenstein [2000d], I use logic as follows. Individuals expect to save more in taxes (that is, lose less in return) from holding stocks in pension accounts than from holding bonds in pension accounts. From Exhibit 2 for the active investor, stocks' after-tax expected return is 3.13 percentage points lower if held in taxable accounts instead of pension accounts, while bonds' return is 2.1 percentage points lower. I thus concluded that active investors should shelter stocks' return by holding them in pension accounts; this strategy would provide a higher expected return and, I presumed incorrectly, the same risk.

Comparing Portfolio 7 and 8 (or Portfolios 10 and 11) confirms that, for a given asset allocation, locating stocks in pension accounts provides a higher expected return. For example, Portfolio 8 (stocks in pension accounts) provides a 27 basis point higher expected return than Portfolio 7 (bonds in pension accounts), while both portfolios entail a 73.7% stock allocation. Notice that these studies consider the impact of the asset location decision on return but not risk.

In Reichenstein [2000d], I tried to hold portfolio risk constant by rebalancing the portfolio back to the target asset allocation at the end of each year. I assumed, incorrectly, that portfolio risk is the same as long as the overall asset allocation is the same. This assumption is incorrect. Portfolios 7 and 8 (or Portfolios 10 and 11) have the same asset allocation, but Portfolio 8 (or 11) has more

risk. I failed to recognize that the asset location decision affects portfolio risk. Because the investor bears all the risk from holding stocks in the pension, the portfolio risk is higher in Portfolio 8 than in Portfolio 7.

Optimization requires us to consider the consequences of asset location decisions for portfolio *returns and risk*. My prior analysis neglected the asset location decision's impact on portfolio risk.

Portfolios 7 though 9 (or Portfolios 10 through 12) demonstrate that the asset allocation and asset location decisions must be solved jointly. From Portfolio 7, the optimal portfolio entails 73.7% stock exposure, and bonds are located in pension accounts. Portfolio 8 has this same asset allocation but locates, to the degree possible, stocks in pension accounts. Portfolio 9 presents the optimal asset allocation *if someone insists on locating stocks in pension accounts*.[9] As before, if someone insists on locating stocks in pension accounts, the optimal stock allocation is lower than when bonds are located in pension accounts.

The levels of utility are also levels of certainty-equivalent return. A comparison of the utility of Portfolios 7 and 9 suggests that the asset location decision is of relatively little importance to active investors. Portfolio 7, the optimal portfolio, provides a certainty-equivalent return of 3.17%. If someone insists on locating stocks in pension accounts, she could select Portfolio 9, which provides a 0.05 percentage point lower certainty-equivalent return; the utility loss is 0.05 percentage point. Portfolios 8 and 10 demonstrate that the utility loss is also the same when the utility function is $U = ER - SD^2/RT$.

In short, for the active investor, the optimal asset allocation calls for bonds in pension accounts, but the opposite strategy appears to be only slightly less desirable.

Passive Investor

For the passive investor, there is an optimal asset allocation and asset location. Portfolio 13, the optimal portfolio, has 19.6% stocks in pension accounts, 30.4% bonds in pension accounts, and 50% stocks in taxable accounts. The optimal portfolio is 69.4% in stocks, and it locates bonds in pension accounts and stocks in taxable accounts. The asset allocation and asset location decisions must be solved jointly. Moreover, this asset location decision appears to be relatively insensitive to particular assumptions.

Portfolios 13 and 14 (and 16 and 17) have the same asset allocations, but opposite asset locations. Stocks are equally risky whether held in taxable accounts or pension accounts, and their after-tax return is similar in both savings vehicles. Therefore, locating stocks in pension accounts is a poor use of these tax-favored accounts. In contrast, bonds are much more desirable when held in pension accounts, and it is thus the pension asset of choice.

A comparison of levels of utility reveals the importance of the asset location decision. It is most important to the passive investor. Portfolio 13, the optimal portfolio, provides a certainty-equivalent return of 3.41%. If someone insists on locating stocks in pension accounts, he could select Portfolio 15, which provides a 0.20 percentage point lower certainty-equivalent return; the utility loss is 0.20 percentage point. Portfolios 16 and 18 demonstrate that the utility loss is the same when the utility function is $U = ER - SD^2/RT$.

In short, for this passive investor, the optimal asset allocation calls for bonds in pension accounts and stocks in taxable accounts, and the opposite asset location strategy appears to be much less desirable.

CALCULATING MARK'S OPTIMAL ASSET MIX: TRADITIONAL VERSUS AFTER-TAX APPROACH

It is instructive to compare the optimal asset mix based on the traditional and the after-tax approach. Let us assume an active investor, because most investors are active. Mark's portfolio is $153,800 in deductible pension accounts and $100,000 in taxable accounts. (The market and book values of the taxable accounts are both $100,000.) Cheryl, his financial advisor, determines that Mark's risk tolerance is 2, and the first utility function applies.

The traditional approach says he has $253,800 of assets—that is, it ignores the difference between before-tax and after-tax funds—and bases the optimization on assets' before-tax risk and returns. The optimal asset mix is 69.6% stocks. Following recent professional advice, Cheryl recommends that stocks should be located in pension accounts to the degree possible.

The first two columns of Exhibit 5 present Mark's optimal portfolio by the traditional approach, which is $176,600 in stocks (69.6% of $253,800) including $153,800 in pension accounts and $22,800 in taxable accounts. The remaining $77,200 of taxable accounts should be bonds.

The next two columns indicate Mark's optimal asset mix according to the after-tax approach. From Exhibit 4, the true optimal mix is 73.7% stocks including 23.7% in pension accounts and 50% in taxable accounts. In dollars, it is $72,900 in stocks in pension accounts, $80,900 in

EXHIBIT 5

Optimal Asset Allocations Based on Traditional and After-Tax Approaches

	Traditional Approach		After-Tax Approach		Dollar
	Dollars	Percent	Dollars	Percent	Reallocation
Stocks in pensions	$153,800	60.6%	$72,900	23.7%	-$80,900
Bonds in pensions	$0	0%	$80,900	26.3%	+$80,900
Stocks in taxable accounts	$22,800	9.0%	$100,000	50.0%	+$77,200
Bonds in taxable accounts	$77,200	30.4%	$0	0%	-$77,200

bonds in pension accounts, and $100,000 in stocks in taxable accounts.[10]

The last column indicates the portfolio adjustments necessary to move from the asset allocation recommended by the traditional approach to the allocation recommended by the after-tax approach. In pension accounts, $80,900 of stocks must be moved to bonds. In taxable accounts, $77,200 of bonds must be moved to stocks. The traditional approach and the after-tax approach recommend substantially different portfolios.

RELATIVE IMPORTANCE OF MANAGEMENT STRATEGY AND ASSET LOCATION

Jeffrey and Arnott [1993] and Ghee and Reichenstein [1996] conclude that, when stocks are held in taxable accounts, it is difficult for a stock manager to add enough value through active trading to pay for the additional taxes associated with that trading. The utility levels in Exhibit 4 allow us to compare the utility loss that taxable investors bear from being in the "wrong" management strategy—that is, not being a passive manager—and from a "wrong" asset location decision. Exhibit 6 presents the results.

According to the first utility function, the trader loses 0.31 in utility from being a trader instead of a passive investor. He loses 0.28 according to the second utility function. Since the trader does not have an optimal asset location, he suffers no additional loss in utility from making the wrong asset location decision.

The location decision is, nonetheless, important in that the optimal asset allocation is different when bonds are located in the pension instead of stocks. In short, the loss from choosing the wrong management strategy is substantial, while the loss from choosing the wrong asset location is nil.

According to the utility functions, the active investor loses, respectively, 0.24 and 0.21 in utility from being an active investor instead of a passive investor. This is about three-fourths the extent of the utility loss for the trader. The active investor loses an additional 0.05 if she locates stocks instead of bonds in pension accounts. The loss of utility from choosing the wrong management strategy is four to five times greater than the loss from choosing the wrong asset to locate in pension accounts. Moreover, the active investor's loss from choosing the wrong management strategy is only about one-fourth less than the loss for the trader.

EXHIBIT 6

Loss in Utility from "Wrong" Management Strategy and "Wrong" Asset Location

	Loss in Utility	
	U1	U2
Trader:		
Wrong management strategy	0.31	0.28
Wrong asset location	0.00	0.00
Active Investor: Stocks in taxable accounts		
Wrong management strategy	0.24	0.21
Wrong asset location	0.05	0.05
Passive Investor: Stocks in taxable accounts		
Wrong management strategy	n.a.	n.a.
Wrong asset location	0.20	0.20

U1 is the utility function: $U = ER - RT/SD$, where ER is expected portfolio return, RT is risk tolerance, and SD is standard deviation. U2 is the utility function: $U = ER - RT/SD^2$. n.a. denotes not applicable, since the passive manager uses the "correct" management strategy.

By definition, the passive investor chooses the "right" management strategy. He loses 0.20 if he makes the wrong asset location decision. The loss from making the wrong location decision is greater for the passive investor than for the trader or active investor.

Admittedly, I suspect few passive investors will make the mistake of locating stocks in pension accounts. Nevertheless, the evidence suggests that this decision would be costly.

In summary, the optimizations suggest that traders and active stock investors can benefit more from changing to a passive management strategy than they can by changing their asset location strategy.

CONCLUSIONS AND INVESTMENT IMPLICATIONS

First and foremost, I conclude that the profession has been miscalculating an individual's asset allocation, and the measurement error can be substantial. Asset allocation should reflect after-tax funds because goods and services are purchased with after-tax money.

Second, for an individual investor, an asset's risk and expected returns depend upon the savings vehicle it is held in. In deductible pension accounts or Roth IRAs, the individual bears all asset risk and receives all returns. For bonds held in taxable accounts, an individual bears a portion $(1 - t)$ of the risk and return, where t is the expected marginal tax rate during retirement. When stocks are held in taxable accounts, the individual and the government share its risk and return. Moreover, the risk-and-return sharing varies according to the investor's stock management practices.

Traders who realize all gains as short-term gains each year bear a portion $(1 - t)$ of stocks' risk and returns. Active investors, who realize all gains as long-term gains each year, bear a larger portion of dividend-paying stocks' risk than returns. Passive investors, who never pay capital gains taxes, bear all of stocks' risk and receive all returns, except the drag due to taxes on dividends.

Our mean-variance optimization is applied to the holding of some assets in taxable accounts and others in pension accounts—that is, deductible pension accounts such as 401(k) or Roth IRA. Each investor—trader, active investor, or passive investor—must decide the optimal asset allocation and the optimal asset location.

For traders, there is not an optimal asset allocation or optimal asset location. Identical portfolios (in terms of utility, portfolio expected returns, and portfolio risk) can be obtained with more than one asset allocation. Moreover, one optimal portfolio locates stocks in pension accounts, and another locates bonds in pension accounts. If the investor decides to locate stocks in taxable accounts, the optimal asset allocation calls for a relatively large stock exposure. And, if bonds are located in taxable accounts, the optimal asset allocation calls for a relatively large bond exposure. Intuitively, since the government shares the risk and returns of the taxable account's asset, the government effectively owns part of these assets. It follows that an individual's optimal asset mix calls for a relatively large exposure to the asset held in taxable accounts.

For active investors, there is an optimal asset allocation and asset location. To the degree possible without violating the asset allocation, bonds should be located in pension accounts and stocks in taxable accounts, although the opposite strategy appears to produce only a small loss in utility. In short, either asset location decision can produce portfolios that are almost equally desirable. When individuals locate stocks in taxable accounts, the optimal asset mix calls for a relatively large overall stock allocation. Similarly, when individuals locate bonds in taxable accounts, the optimal asset mix calls for a relatively large overall bond allocation.

For passive investors, there is an optimal asset allocation and asset location. Bonds should be located in pension accounts and stocks in taxable accounts. Since capital gains are eventually tax-exempt in a taxable account, it is a virtual waste of the tax shelter to locate stocks in pension accounts. Moreover, the asset location decision is much more important to this passive investor than to an active investor. As before, if someone insists on locating bonds in taxable accounts, then the optimal asset allocation calls for a relatively large exposure to bonds.

This study rejects the two-step procedure of, first, setting the optimal asset allocation and, second, choosing the asset location. The two decisions must be made jointly. Moreover, if the investor makes the asset location decision first, his or her optimal asset allocation depends upon that location decision; the optimal asset allocation calls for a relatively large exposure to the asset located in taxable accounts.

Finally, optimizations suggest that traders and active stock investors can benefit more from changing to a passive management strategy than they can by changing their asset location strategy.

ENDNOTES

[1]Deductible pension accounts include all savings vehicles for which the investment contribution is tax-deductible in the contribution year, returns accumulate tax-deferred, and all withdrawals are taxed at the ordinary income tax rate.

[2]In Reichenstein [1998 and 2000c], I argue that, in general, an individual's portfolio should be broadened to include, at a minimum, the value of retirement income streams—i.e., Social Security, company pension accounts, and military retirement. These income streams are essentially bonds, and including them substantially changes the individual's asset allocation. The decision about what to include in an individual's portfolio is a separate question and is not addressed in this study.

[3]The analysis assumes the funds are intended for retirement income needs. I thus ignore differences such as the lack of minimum withdrawal requirements on the Roth IRA.

[4]We apply mean-variance optimization to individual portfolios. The analysis adjusts portfolio weights to reflect after-tax values—e.g., $1,000 of after-tax funds in a taxable account counts the same as $1,000/(1 – t) in a deductible pension—and it uses the risk and returns that the individual bears in taxable accounts and pension accounts. Brunel [1998] discusses two shortcomings of mean-variance analysis as applied to individuals. It ignores the tax costs of, first, shifting to a new target asset allocation and, second, rebalancing to an existing one. These shortcomings apply as well to my study, except to the degree that the portfolio adjustments involve the movement of retirement funds or the allocation of new funds.

[5]I take as a given that the investor would prefer to save in a Roth IRA or deductible pension rather than in a taxable account. This implies that the risk tolerance must exceed 1.67. That is, 6% – 10%/RT > 3.9% – 6.5%/RT.

[6]Assuming the investor would prefer to save in a Roth IRA or deductible pension instead of a taxable account, the risk tolerance must exceed 33.6. That is, $11\% - (15\%)^2/RT > 7.87\% - (10.95\%)^2/RT$.

[7]This two-step procedure certainly reflects my prior thought. Also, I believe it reflects the thought in Shoven [1999] and Sialm and Shoven [1998]. They compare the ending after-tax wealth of two strategies. In Strategy 1, each year $5,000 is invested in stocks held in taxable accounts and $5,000 in bonds held in deductible pension accounts. Strategy 2 is the opposite. With equal annual investments in stocks and bonds and annual rebalancing, Shoven and Sialm believe both strategies represent the same asset allocation. By comparing the strategies' ending after-tax wealth, they then decide the asset location.

Although they believe their two strategies represent the same asset allocation, they do not if we adjust for taxes. A $5,000 pension contribution is not equivalent to a $5,000 investment in taxable accounts. For someone in the 35% tax bracket, the $5,000 pension contribution would reduce current-year consumption by only $3,250 or $5,000 (1 – 0.35), while the $5,000 after-tax investment in the taxable account reduces current-year consumption by $5,000. The pension contribution is a $3,250 investment of after-tax funds, while the investment in the taxable account requires $5,000 after taxes.

Moreover, when Shoven and Sialm rebalance, they do not distinguish between before-tax and after-tax funds. In addition, Shoven [1999] states, "Particularly with rebalancing … any wealth improvement from one asset location strategy over another is very close to a pure efficiency gain." This suggests that he does not recognize that a given asset's risk to an individual depends upon whether it is held in a taxable account or a pension.

[8]Reichenstein [2000a] shows that there is little benefit to deferring taxes for a few years. Many active investors typically realize capital gains within a few years. So, even though the active investor model assumes all capital gains are realized each year, it adequately represents most active investors.

[9]This is the optimal portfolio based on 1 percentage point increments. Thus Portfolio 9 has a slightly higher utility than portfolios with 14% or 16% stocks in taxable accounts. The 1 percentage point increment is used in similar optimizations.

[10]Stocks in pension accounts are about $72,900, which is 23.7% of $200,000 after-tax funds divided by 0.65 or (1 – t) with t denoting the marginal tax rate. Similarly, bonds in pension accounts are $80,900 or 26.3% ($200,000)/0.65.

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