Optimal Asset Allocation, Asset Location and Drawdown in Retirement

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Assessing the impact of tax deferral and municipal bonds on retirement income generation.

Executive Summary

- This paper investigates how differences in tax treatment across asset classes and investment accounts affect retiree behavior, including desired asset allocations and the location and timing of withdrawals.
- We find that the distribution of wealth across accounts does not materially affect the aggregate asset allocation.
- However, asset location – the allocation within each account – is highly dependent on the tax treatment of each account.
- Despite lower tax rates on equities, retirees should consider holding more stocks in tax-deferred accounts to maximize their tax benefits.
- Retirees may be able to optimize after-tax income with allocations to muni bonds in their taxable accounts.

> "In this world nothing can be said to be certain, except death and taxes."
> – Benjamin Franklin (1789)

Retirement planning is immensely complex. Once individuals retire, they generally move from a phase in life where spending is evaluated relative to a reasonably predictable, dependable salary to a world where assets built up over a working lifetime are depleted over an uncertain number of future years. While one's ultimate mortality is not in question, there is great uncertainty as to when it will occur. Calibrating spending to an unknowable horizon adds significant complexity to the retirement problem, as spending decisions in any year may have a significant impact on future wealth and hence future consumption. Spend too much and risk poverty in one's golden years; spend too little and those golden years lack the luster they otherwise might have.

We would like to thank Jim Moore and Ying Gao for their important contributions to this paper.

In Sapra and Gao (2018), we looked at the canonical model for two distinct representative households to evaluate several key decisions: 1) whether to begin receiving Social Security benefits at retirement or defer them in exchange for higher benefit payments, 2) whether to purchase a deferred annuity to hedge against longevity risk and 3) how to allocate between stocks and bonds during retirement. The key findings from this research:

Social Security: If an individual had sufficient wealth to comfortably finance early-retirement consumption via the investment portfolio, it was optimal to defer Social Security to maximize the annual benefit paid and thereby increase longevity and inflation protection. Conversely, lower-wealth individuals, individual circumstances notwithstanding, generally were better off taking benefits immediately.[1]

Annuitization: The risks of outliving one's assets are significant, and the welfare benefits of the income certainty and longevity protection that annuities may provide are substantial. Dependent on their unique circumstances, retirees should consider holding a deferred annuity for additional longevity protection. In the research, this was the case even allowing for a sizable, 20% reduction in benefits from their actuarially fair value to reflect real-world annuity pricing.

Stock/bond mix: In general, dependent on their unique circumstances, wealthier retirees should consider holding more fixed income, while those who are less fortunate should consider allocating a greater fraction of their portfolio to equities. This result is driven by Social Security benefits, which can be thought of as a lifelong real bond. Because for wealthier retirees a relatively small fraction of income is replaced by Social Security, the absence of this "bond" exposure must be compensated for in the investment portfolio via an increased allocation to fixed income.

This work, in addition to earlier research by Pedersen and Klein (2014) and Klein et al. (2015), highlighted the ways that mortality and longevity risk have significant impacts on retirement decisions.

In this extension, we explore Franklin's other certainty: taxes. In the U.S., individuals often hold several different investment accounts facing potentially different tax rates, and within those accounts they allocate across investment options with their own varying tax treatments. We set forth to solve a retirement income optimization problem in which the hypothetical retiree must determine 1) their overall in-retirement asset allocation, 2) how to allocate assets between a taxable account and a tax-deferred account and 3) where to draw their income throughout retirement. Importantly, our work takes into account the current U.S. income tax code, including different tax treatment of equities and fixed income, differences in treatment across different investment accounts, and different treatment across taxable and tax-advantaged investments.

The tax code is notoriously complex. We model a stylized version of the U.S. tax code with two key features: Ordinary income and capital gains face different tax rates, and investments in tax-advantaged accounts can compound without taxation until their withdrawal. While this obviously does not capture the full complexity of the tax code, it provides insights into several key questions:

1. How do differences in tax treatment across asset classes and account types affect the level and timing of after-tax expected income throughout retirement?
2. How does taxation affect the optimal decumulation of wealth over time and across accounts?
3. How do the differences in tax treatment influence the optimal asset allocation across a taxable and a tax-deferred account?
4. By how much can retirees, theoretically, lower their tax burden?

1. MODEL

In our model, the hypothetical investor maximizes their expected utility of consumption over their retirement years by determining the amount to consume from a taxable account and a tax-deferred account, and the asset allocation to hold in each account in each year. Both the asset allocation and the asset location between the taxable and tax-deferred accounts affect the after-tax risk and income of the portfolio and the retiree's ultimate effective tax rate.

Formally, the investor solves a lifetime utility maximization problem:

$$max_{s_{j,t},\varphi_{t,j}} \sum_{t=0}^{T} E_t[\pi_t \beta^t U(C_t^R)] \ ,j = 1,2 \qquad (1)$$

1 This is without assuming any difference in mortality rates across income/wealth levels. As low income households face higher disability and mortality risks, they have further incentive not to defer the receipt of benefits.

where $j \in \{\text{Taxable,Tax Deferred}\}$ indicates the account type, $S_{j,t}$ is the savings rate in account j and $\varphi_{t,j}$ is the equity allocation in account j (with $1\text{-}\varphi_{t,j}$ representing the bond allocation in account j). C_t^R represents real consumption in period t and is equal to the sum of the inflation-adjusted after-tax income generated from the taxable account, the tax-deferred account and the retiree's (inflation-indexed) after-tax Social Security benefit.[2] Utility at each time t is weighted by the probability of survival, π_t, using life expectancy data from the Social Security Administration.[3] β is the subjective discount rate and is set equal to 0.975.[4]

In the taxable account, bond returns are taxed at the ordinary income tax rate, while equity dividends and equity capital gains are taxed at the qualified dividend and long-term capital gains rates, respectively. In the tax-deferred account, nothing is taxed unless funds are taken from the account, at which point the full withdrawal is taxed at the ordinary income rate. Thus, nominal wealth in each account, $W_{j,t}$, and real consumption from each account, $C_{j,t}^R$, in each period are determined by the following intertemporal budget constraints:

For j =1 (taxable account),

$$W_{j,t+1} = W_{j,t}s_{j,t+1}[\varphi_{j,t}(1 + r_{t+1}^{Div}(1-\tau_D) + r_{t+1}^{CG}(1-\tau_{CG})) + (1-\varphi_{j,t})\left(1 + r_{t+1}^{Bond}(1-\tau_I)\right)] \quad \text{(2a)}$$

$$C_{j,t}^R = W_{j,t}(1 - s_{j,t+1})/\, p_t \quad \text{(2b)}$$

For j = 2 (tax-deferred account),

$$W_{j,t+1} = W_{j,t}s_{j,t+1}[\varphi_{j,t}(1 + r_{t+1}^{EQ}) + (1-\varphi_{j,t})(1 + r_{t+1}^{FI})] \quad \text{(2c)}$$

$$C_{j,t}^R = W_{j,t}(1-\tau_I)(1 - s_{j,t+1})/\, p_t \quad \text{(2d)}$$

where p_t is the inflation index in period t, $r_{t+1}^{EQ} = r_{t+1}^{Div} + r_{t+1}^{CG}$ is the sum of the dividend and the capital gains return, τ_D is the qualified dividend tax rate, τ_I is the ordinary income tax rate and τ_{CG} is the long-term capital gains tax rate.[5] Preferences are defined using the standard constant relative risk aversion (CRRA) utility function of the form:

$$U = \frac{C^{1-\rho}}{1-\rho} \quad (3)$$

where ρ is the coefficient of risk aversion, which is set to 4 throughout.[6]

Our hypothetical retiree is assumed to be a wealthy 65-year-old male[7] with $2 million in investable assets[8] who has earned an after-tax real Social Security retirement benefit of $22,491 per year.[9] Tax rates are assumed to be 20% on equity dividends, 20% on capital gains and 30% on ordinary income and IRA withdrawals. Our tax rate assumptions are listed in Exhibit 1. Withdrawals from the tax-deferred vehicle are subject to IRS-mandated required minimum distributions (RMDs), the details of which are provided in the Appendix. While academic studies often find annuities to be highly effective at hedging longevity risk, we do not include an annuity as part of the opportunity set, reflecting the fact that a very small fraction of retirees purchase longevity annuities in retirement (Brown et al. 2000).

Exhibit 1: Tax rate assumptions[10]

	Qualified dividend	Long-term dividend	Ordinary income	Municipal bond	Social Security
Marginal tax rate	20%	20%	30%	0%	25.5%

Source: PIMCO

2 We assume that the hypothetical investor takes the Social Security benefit at 66, reflecting the fact that very few retirees defer to age 70.

3 https://www.ssa.gov/oact/STATS/table4c6.html. See Appendix for details.

4 Intuitively, this means that the same level of income yields 2.5% lower utility in the next year relative to the current year. The combination of the subjective discount rate and mortality weighting means that the retiree will prefer current consumption to future consumption, all else equal.

5 We assume taxes are incurred only upon realized gains and treat taxes as zero on realized losses. In the current tax code, some losses in some circumstances may be carried forward to offset future gains. This complexity is not included in the model and will tend to slightly lower the effective capital gains rate and thus increase the appeal of capital gains.

6 There are many empirical estimates of risk aversion parameters. Four is selected based on the empirical work in Barksy et al. (1997), Halek and Eisenhauer (2001) and Kimball et al. (2008), and for consistency with existing PIMCO research.

7 The optimization is based on the life expectancy for a hypothetical 65-year-old male. As such, we often use the pronoun "he" throughout. Results computed using female life expectancy, which are slightly longer, are virtually identical.

8 The mean and median levels for the 90th–100th wealth percentile in the U.S. are $5.3 million and $2.4 million, respectively. The mean and median wealth levels for a 65- to 74-year-old are $1.06 million and $224,000, respectively. As such, our assumptions would be appropriate for a wealthy retiree. Source: 2016 Survey of Consumer Finances

9 Calculated by PIMCO, based on the Social Security Administration's 2017 benefit formula

10 Consistent with their real-world treatment, 85% of Social Security benefit payments are subject to ordinary income taxes, for an effective tax rate of 25.5% on Social Security income.

Finally, equity, inflation and yield curves (both nominal and real) are jointly simulated for a 40-year retirement horizon. Bonds are repriced at each point in time on each 40-year path, and thus return correlations are endogenously determined. Exhibit 2 shows the simulated annual rates of return. Additional information on the simulation can be found in the Appendix.

Exhibit 2: Risk and return assumptions[11]

	r	r-rf	Vol	Sharpe	r Tax Eq
Equity	5.56%	3.06%	16.5%	0.186	5.56%
Bond	3.04%	0.54%	7.5%	0.072	3.04%
Muni	2.90%	0.41%	6.5%	0.063	4.15%
rf	2.50%	N/A	N/A	N/A	2.50%

Hypothetical example for illustrative purposes only. Source: PIMCO. r is the average net return, and r-rf is the return in excess of the "risk-free rate." Vol is the annualized standard deviation of returns. Sharpe ratio is the excess return divided by Vol. r Tax Eq is the tax-equivalent yield for munis specifically.

In the next section, we optimize the retirement income problem under three distinct scenarios: 1) All wealth is held entirely in a taxable account, 2) wealth is split evenly between a taxable account and a tax-deferred account, and 3) wealth is again split evenly between a taxable account and a tax-deferred account, but the investable universe includes tax-advantaged municipal bonds.[12]

2A. RESULTS – HYPOTHETICAL CASE 1: TAXABLE ACCOUNT ONLY, NO TAX-ADVANTAGED ASSETS

We start with the simplest hypothetical case, in which all of the retiree's assets are held in a single brokerage-style taxable account. The at-retirement account balance is assumed to be $2 million, and the available investments are equities, represented by a broad-based, cap-weighted market portfolio, and fixed income, approximated by a 10-year constant-maturity nominal U.S. government bond. Although we focus on a specific type of bond to demonstrate the income-hedging nature of fixed income, both the equity and fixed income assets in our framework are intended to proxy for broad-based, diversified exposures to the underlying asset class.

As the assets are held in a taxable account, all returns are taxed upon their realization, irrespective of whether the retiree chooses to sell the assets to generate income or reinvests the proceeds. Importantly, the tax rates on the two assets are different. Bond returns are taxed at the investor's ordinary income tax rate of 30%,[13] while equity dividends and long-term capital gains are taxed at the qualified dividend rate and the long-term capital gains rate (both set to 20%), respectively. That is, the differences in statutory tax rates make bonds relatively less attractive than equities.

With this parametrization, as shown in Exhibit 3, the retiree allocates 42% of his portfolio to equities and 58% to taxable bonds.[14] Exhibit 4 shows that, at retirement, real after-tax income averages $99,194, including the investor's Social Security benefit and $76,703 from the portfolio alone. Portfolio income is $73,611 and $63,628 at ages 75 and 85, respectively. Beyond age 85, income falls rather dramatically: When the retiree is 95, the portfolio is yielding only $35,968 in real dollars. Because the retiree generates income from returns and principal, his account balance declines. Average nominal portfolio balances are $1.96 million, $1.54 million and $925,000 at ages 66, 75 and 85, respectively.[15]

11 See Appendix for technical details of return estimation.

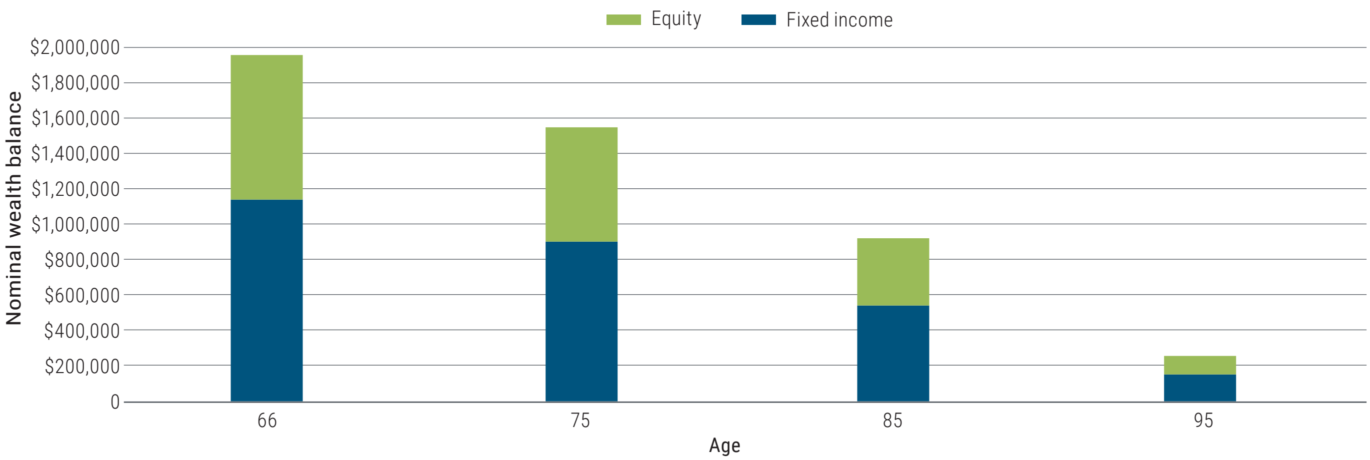
12 Because assets held in a traditional IRA are considered pretax dollars, assuming the same total wealth in the second case is effectively lowering the retiree's overall wealth by the amount invested in the IRA multiplied by 1 minus the tax rate. However, for simplicity and intuition we ignore this issue and simply assume assets are evenly split.

13 Technically, U.S. government bond returns are exempt from state taxation. We do not consider this effect here because the Treasury bond is intended to represent general bond market exposure, including sectors such as corporate bonds and mortgages, which are subject to state income taxes.

14 With these parameters, in the absence of any other complexities, CRRA preferences would imply an optimal equity allocation of 28% $\left(\frac{\mu-r}{\rho\sigma^2} = \frac{.03}{4\times0.027} \cong 0.28\right)$.

15 Throughout this paper, we show income in real (inflation-adjusted) terms and wealth in nominal terms. Income is shown in real terms to reflect purchasing power, while wealth balances are shown in nominal terms to reflect the fact that most people view account balances relative to the initial holdings and thus as a nominal quantity.

Exhibit 3: Nominal wealth and asset allocation, Case 1



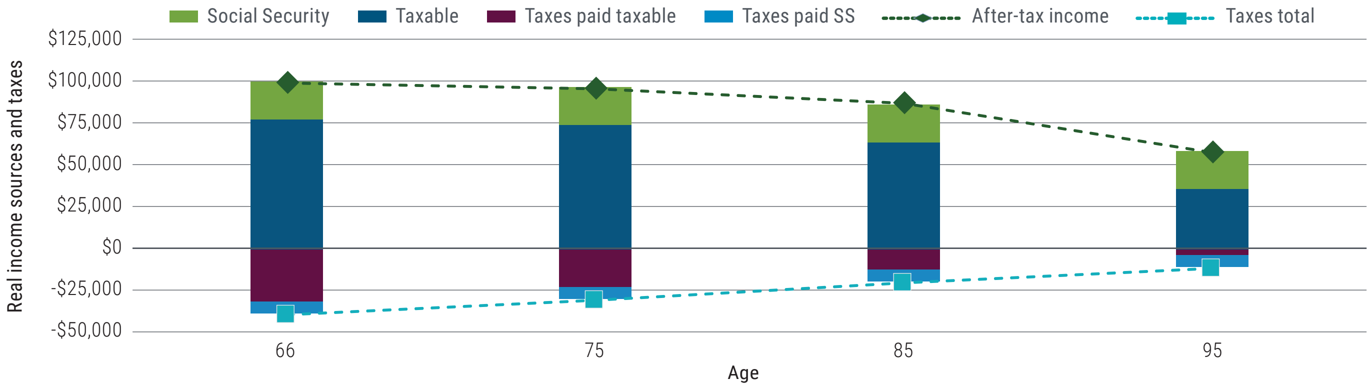
		Age			
		66	75	85	95
Wealth	Taxable	$1,958,990	$1,544,421	$925,093	$253,863
	IRA	$0	$0	$0	$0
	Total	**$1,958,990**	**$1,544,421**	**$925,093**	**$253,863**
Asset allocation	**Taxable**				
	FI	58.3%	58.3%	58.3%	58.3%
	MUNI	0.0%	0.0%	0.0%	0.0%
	EQ	41.7%	41.7%	41.7%	41.7%
	IRA				
	FI	0.0%	0.0%	0.0%	0.0%
	MUNI	0.0%	0.0%	0.0%	0.0%
	EQ	0.0%	0.0%	0.0%	0.0%
	Overall				
	FI	58.3%	58.3%	58.3%	58.3%
	MUNI	0.0%	0.0%	0.0%	0.0%
	EQ	41.7%	41.7%	41.7%	41.7%

Hypothetical example for illustrative purposes only. Source: PIMCO

Income is thus brought forward and tilted toward early retirement primarily because of the combined effects of increasing mortality rates with age and time discounting (β in Equation 1). Of course, the timing of income and consumption is intimately related to asset returns; as expected returns increase, individuals would be expected to want to consume less and save more, which would produce higher income in the future. Most agree that current valuations suggest relatively low expected returns today compared with history, which would imply that current consumption is more attractive than it has been in the past.

As time passes, the retiree will incur taxes as a function of the realized gains on bonds and equities. Exhibit 4 also shows the average taxes paid (adjusted for inflation), along with the effective investment tax rate, both inclusive and exclusive of Social Security. At retirement, the retiree pays an average effective tax rate of 28.4% on the investment portfolio and 27.8% when Social Security income is included. His effective portfolio tax rate declines significantly with age, from 28.4% down to 15.3% and 7.7% at ages 85 and 95, respectively. This reflects the fact that, over time, an increasing fraction of his income is generated from principal drawdown rather than from returns.

Exhibit 4: Real income and taxes, Case 1



	Age			
	66	**75**	**85**	**95**
Taxable	$76,703	$73,611	$63,628	$35,968
IRA	$0	$0	$0	$0
Social Security	$22,491	$22,491	$22,491	$22,491
After-tax total	**$99,194**	**$96,101**	**$86,119**	**$58,459**
Taxes paid taxable	$30,442	$21,799	$11,461	$2,987
Taxes paid IRA	$0	$0	$0	$0
Taxes paid SS	$7,698	$7,698	$7,698	$7,698
Taxes total	**$38,140**	**$29,497**	**$19,160**	**$10,685**
Eff. inv. tax rate	28.4%	22.8%	15.3%	7.7%
Eff. total tax rate	27.8%	23.5%	18.2%	15.5%

Hypothetical example for illustrative purposes only. Source: PIMCO

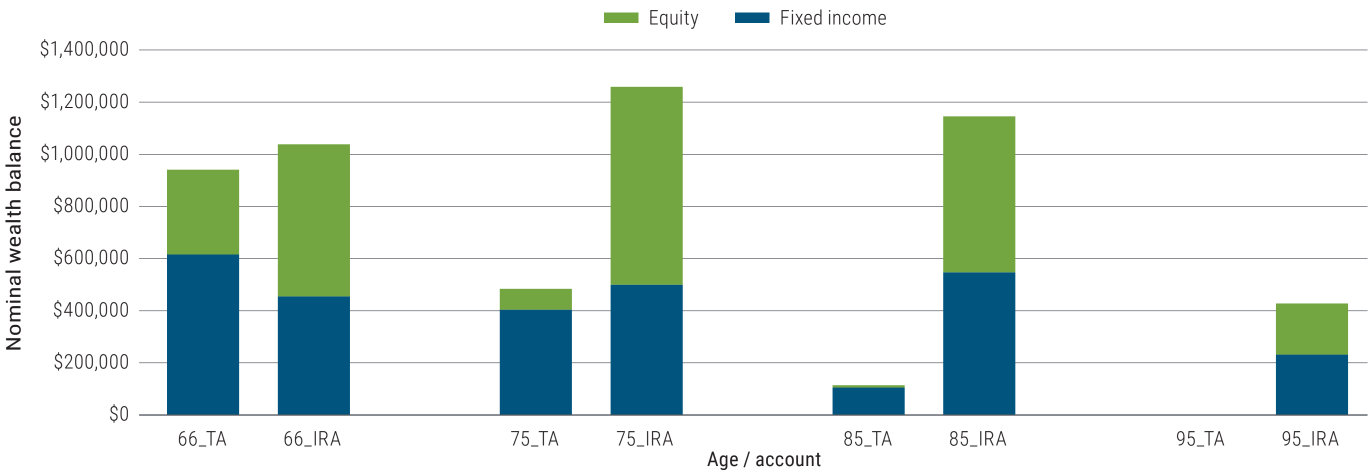
2B. RESULTS – HYPOTHETICAL CASE 2: TAXABLE ACCOUNT AND TAX-DEFERRED ACCOUNT

In our second hypothetical case, we introduce a tax-deferred savings vehicle, which we will generically refer to as an IRA, although it can be considered to be any vehicle in which taxes are deferred until the account is accessed, such as a 401(k). In the taxable-account-only example, taxes were assumed to have been collected when the returns were realized, regardless of whether the income was spent in the period. In an IRA, gains are allowed to compound tax-free until the retiree draws from the account, at which point the full withdrawal is subject to taxation at the retiree's income tax rate.

As before, we assume the retiree has $2 million in investable assets, but now it is equally distributed between two accounts, with $1 million each in the taxable account and the IRA. Adding the IRA to the problem doubles the number of choices the retiree must make, as he now needs to plan an asset allocation and drawdown strategy for both accounts. Other than the addition of the IRA account, all assumptions are the same as in Case 1.

As shown in Exhibit 5, the introduction of the IRA yields a stock/bond mix similar to Case 1, at 46% and 54%, or about a 4 percentage point increase in equities. Although the aggregate mix is similar, the asset allocation within each of the two accounts – the so-called asset location – is very different. At retirement, the investor holds 65.5% fixed income in the taxable account, compared with 39.3% in the IRA. When he is 75, the allocations are 83.4% and 39.7% to fixed income in the taxable account and the IRA, respectively. Interestingly, this result is the opposite of conventional wisdom, which holds that less tax-efficient assets should be held in the IRA, which in this case would favor fixed income (Dammon et al. 2004). The larger equity allocation in the IRA stems from the conveyance of the tax-deferral benefit, which incentivizes the retiree to delay consuming from this account for as long as reasonably possible (Poterba 2004). As a result, income is generated primarily from the taxable account in the earlier retirement years. Thus, to prevent undue variation in his retirement income, the retiree holds a relatively large allocation to fixed income in the taxable account. This, in turn, is offset by a larger equity weight in the IRA.

Exhibit 5: Nominal wealth and asset allocation, Case 2

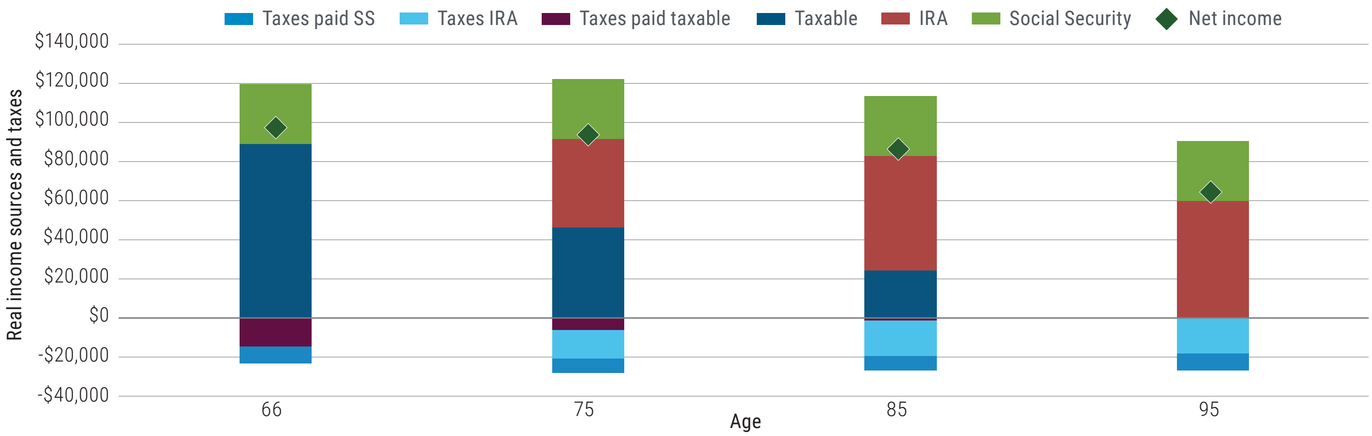


		Age			
		66	**75**	**85**	**95**
Wealth	Taxable	$940,572	$484,015	$114,330	$69
	IRA	$1,038,164	**$1,259,184**	**$1,145,726**	**$428,245**
	Total	**$1,978,736**	**$1,743,199**	**$1,260,056**	**$428,314**
Asset allocation	**Taxable**				
	FI	65.5%	83.4%	92.4%	50.1%
	MUNI	0.0%	0.0%	0.0%	0.0%
	EQ	34.5%	16.6%	7.6%	49.9%
	IRA				
	FI	43.9%	39.7%	47.7%	54.3%
	MUNI	0.0%	0.0%	0.0%	0.0%
	EQ	56.1%	60.3%	52.3%	45.7%
	Overall				
	FI	54.3%	54.3%	54.3%	54.3%
	MUNI	0.0%	0.0%	0.0%	0.0%
	EQ	45.7%	45.7%	45.7%	45.7%

Hypothetical example for illustrative purposes only. Source: PIMCO

The addition of an IRA produces interesting income timing effects. The return benefits of tax-free compounding and tax deferral conveyed by the IRA make early-retirement consumption relatively expensive compared with Case 1. As a consequence, the retiree "flattens" his income profile by consuming less in the initial years in order to generate greater after-tax income in the later years. As shown in Exhibit 6, portfolio income at ages 66 and 75 is $74,925 and $72,009 (combining the taxable account and IRA), respectively. This represents a decline in real income versus Case 1 of roughly 2.2%. However, while income in the first 10 years is lower than in Case 1, income at age 85 is about 1% higher. And while income beyond age 85 remains less valuable than income in the earlier years due to discounting and mortality risk, the compounding tax incentives of the IRA produce a 17% increase in portfolio income over Case 1 at age 95. Unsurprisingly, the deferral of consumption results in higher average account balances; nominal balances are 1%, 13% and 36% higher at ages 66, 75 and 85, respectively, compared with Case 1.

Exhibit 6: Real income and taxes, Case 2



	Age			
	66	**75**	**85**	**95**
Taxable	$74,867	$39,857	$23,217	$43
IRA	$58	**$32,152**	**$40,835**	**$42,175**
Social Security	$22,491	$22,491	$22,491	$22,491
After-tax total	**$97,415**	**$94,499**	**$86,543**	**$64,709**
Taxes paid taxable	$14,650	$6,176	$1,403	$1
Taxes paid IRA	$25	$13,779	$17,501	$18,075
Taxes paid SS	$7,698	$7,698	$7,698	$7,698
Taxes total	**$22,373**	**$27,654**	**$26,602**	**$25,775**
Eff. inv. tax rate	16.4%	21.7%	22.8%	30.0%
Eff. total tax rate	18.7%	22.6%	23.5%	28.5%

Hypothetical example for illustrative purposes only. Source: PIMCO

As shown in Exhibit 6, taxes paid in the early periods are lower in Case 2, but they are significantly higher later in life, with taxes about 50% lower at retirement but 65% higher at age 85. There are three reasons for the shift in tax timing: Early in retirement, effectively only half the retiree's assets generate tax payments, as half are sheltered in the IRA. Second, as time passes, in part due to RMD requirements, he will draw an increasingly large fraction of the IRA to generate income, incurring a marginal income tax rate of 30% on each dollar. This exceeds even the highest effective tax rate in Case 1. Finally, recall that the optimal income profile for an IRA is tilted toward consumption later in retirement. This means that the retiree is withdrawing more – and paying a higher tax bill – later in life. Combined, these effects produce a tax rate that increases with age.

2C. RESULTS – HYPOTHETICAL CASE 3: TAXABLE ACCOUNT AND TAX-DEFERRED ACCOUNT, WITH MUNI BONDS

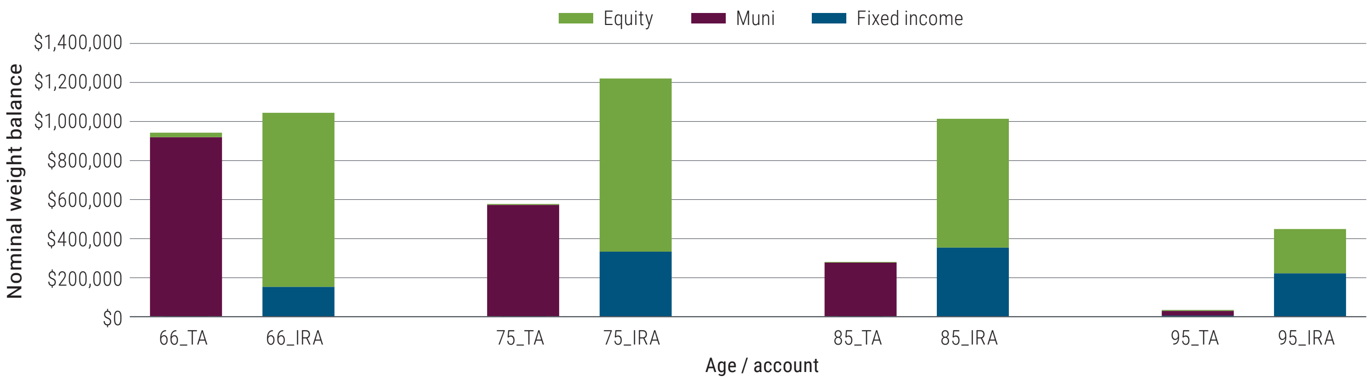
In the real world, investors have access to tax-advantaged investments as well as tax-advantaged accounts. In our third hypothetical case, we introduce a tax-advantaged investment represented by a municipal bond, or muni. Like the taxable bond investments in Cases 1 and 2, tax-advantaged bonds are modeled as a constant-maturity 10-year security.[16] While, as shown in Exhibit 2, pretax expected returns for municipal bonds are assumed to be below those of the equivalent-maturity taxable bond, munis tend to produce a higher tax-equivalent return. In our parametrization, pretax returns for municipals (2.90%) average 14 basis points (bps) below taxable bonds (3.04%), but a marginal income tax rate of 30% would imply that the tax-equivalent return for munis is 111 bps higher.

16 The muni option-adjusted spread (OAS) over Treasuries is modeled as a 50-50 blend of AA and AAA municipal bonds, with an assumed zero default rate. Both the taxable and municipal bonds have approximately 8.5 years of duration in our simulations.

The addition of a tax-advantaged bond has significant impacts. While the retiree holds a very similar overall stock/bond allocation as in Cases 1 and 2, and he continues to hold the majority of his fixed income in the taxable account, the asset location consequences are even more pronounced. With tax-advantaged bonds as part of the investment opportunity set, the taxable account contains essentially 100% fixed income, held almost entirely in federally tax-free municipals.[17] Thus, as shown in Exhibit 7, the retiree effectively swaps out all traditional bond exposure for munis and increases the allocation to fixed income in the taxable account relative to Case 2. Because the overall asset allocation is similar to Case 2, the higher allocation to fixed income in the taxable account necessitates an even higher allocation to equities in the IRA. Over time, the asset allocation migrates from munis to taxable bonds. This occurs because the retiree first depletes his taxable account, effectively lowering his dollar allocation to munis.

Hence, over time the asset allocation becomes increasingly weighted toward the taxable bonds (held in the IRA).

Exhibit 7: Nominal wealth and asset allocation, Case 3



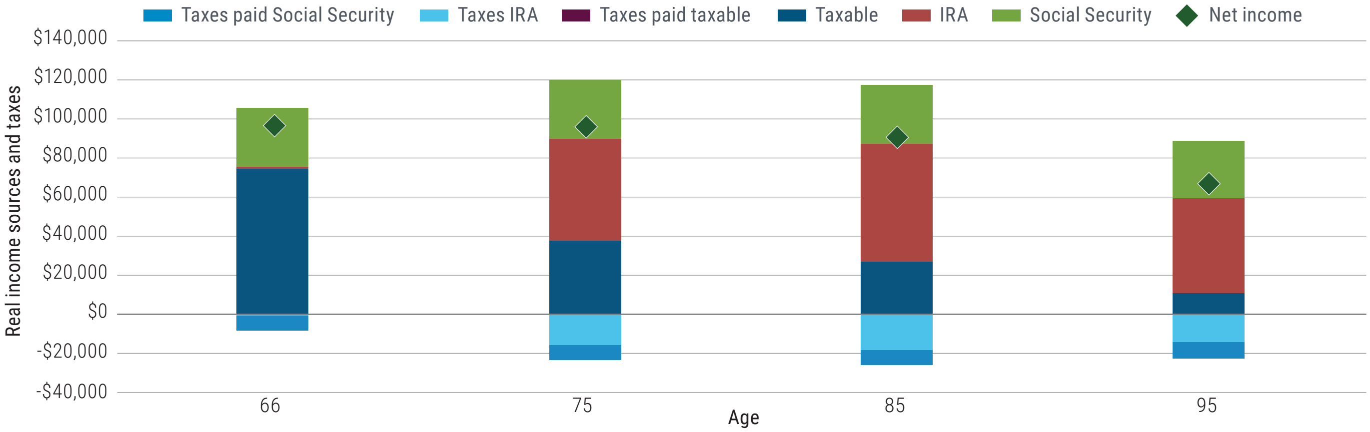
		Age 66	Age 75	Age 85	Age 95
Wealth	Taxable	$943,222	$577,069	$280,207	$34,617
	IRA	$1,045,019	**$1,220,916**	**$1,013,783**	**$449,482**
	Total	**$1,988,241**	**$1,797,985**	**$1,293,990**	**$484,099**
Asset allocation	**Taxable**				
	FI	0.3%	0.6%	1.0%	16.9%
	MUNI	97.3%	98.8%	98.0%	70.7%
	EQ	2.4%	0.7%	1.1%	12.4%
	IRA				
	FI	14.7%	27.3%	34.9%	49.5%
	MUNI	0.0%	0.0%	0.0%	0.0%
	EQ	85.3%	72.7%	65.1%	50.5%
	Overall				
	FI	7.8%	17.2%	24.6%	45.3%
	MUNI	46.7%	37.3%	29.9%	9.2%
	EQ	45.5%	45.5%	45.5%	45.5%

Hypothetical example for illustrative purposes only. Source: PIMCO

The addition of municipal bonds to the investment universe has a significant impact on the level of retirement income. Portfolio income in the first year is $74,892, which is nearly identical to Case 2. However, the compounding of federal tax-free interest in the taxable account yields higher income in the later years. When the retiree is 75, real portfolio income is $74,104, an increase of 3% over Case 2. Real portfolio income is 8% higher at age 85. This naturally translates into higher levels of nominal wealth, as well: Case 3 wealth levels are $2 million, $1.8 million and $1.3 million at ages 66, 75 and 85, respectively, representing increases of 0.5%, 3.1% and 2.7% over Case 2.

17 The inconsequential 0.3% weight in taxable bonds in the taxable account is largely a function of the small diversification benefit of Treasuries vis-à-vis municipals, as they are not perfectly correlated. Given the already favorable tax treatment of municipals, we preclude them from being held in the IRA.

Exhibit 8: Real income and taxes, Case 3



Age	66	75	85	95
Taxable	$74,682	$37,697	$26,458	$10,395
IRA	$210	**$36,407**	**$42,851**	**$34,193**
Social Security	$22,491	$22,491	$22,491	$22,491
After-tax total	**$97,383**	**$96,595**	**$91,799**	**$67,079**
Taxes paid taxable	$519	$107	$75	$148
Taxes paid IRA	$90	$15,603	$18,365	$14,654
Taxes paid SS	$7,698	$7,698	$7,698	$7,698
Taxes total	**$8,307**	**$23,408**	**$26,138**	**$22,500**
Eff. inv. tax rate	0.8%	17.5%	21.0%	24.9%
Eff. total tax rate	7.9%	19.5%	22.2%	25.1%

Hypothetical example for illustrative purposes only. Source: PIMCO

As shown in Exhibit 8, municipal bonds in the taxable portfolio results in a material reduction in taxes. Taxes incurred in the taxable account are minimal as a result of the large allocation to municipal bonds. At retirement, the investor's portfolio tax rate is low but grows with time as the taxable account is depleted and he begins to generate income from the IRA. When he is 75, his effective portfolio tax rate is 17.5%, which represents a 4.2 percentage point reduction in tax rates versus Case 2. At age 85, he is paying a tax rate 1.8 percentage points lower than in Case 2. Over time, his tax rate approaches that of Case 2 as a result of consuming from the IRA. Nonetheless, as he ages from 66 to 85, his overall tax bill on the investment portfolio declines by 35% in Case 3 relative to Case 2.

3. DISCUSSION

In the previous section, we showed the impact on asset allocation, asset location and retirement income across several hypothetical cases when 1) all of a retiree's assets are held in a single taxable account, 2) when the assets are equally split between a taxable account and an IRA, and 3) when the retiree is able to invest in municipal bonds. As shown in Exhibit 9, we found that the optimal asset allocation for a 66-year-old with $2 million in assets is roughly 45% equities and 55% fixed income; this finding is relatively constant across cases. However, we found that while the asset *allocation* is generally stable, the choice of asset *location* is significantly affected by the types of accounts and investments available. The introduction of an IRA shows that in our example the retiree should hold a disproportionate allocation to fixed income in his taxable account compared with the IRA; in Case 2, the retiree holds 65% of his taxable account in taxable bonds versus only 44% in the IRA. This effect is even more pronounced in Case 3. When munis are included in the opportunity set, the retiree allocates nearly 100% of his taxable account to munis and 85% of his IRA to equities.

Exhibit 9: Asset allocation summary for Cases 1-3

		Age			
		66	75	85	95
Case 1					
		Taxable			
	Bonds	58%	58%	58%	58%
	Equities	42%	42%	42%	42%
Case 2					
		Taxable			
	Bonds	65%	83%	92%	50%
	Equities	35%	17%	8%	50%
		IRA			
	Bonds	44%	40%	48%	54%
	Equities	56%	60%	52%	46%
Case 3					
		Taxable			
	Bonds	0%	1%	1%	17%
	Munis	97%	99%	98%	71%
	Equities	2%	1%	1%	12%
		IRA			
	Bonds	15%	27%	35%	50%
	Munis	0%	0%	0%	0%
	Equities	85%	73%	65%	50%

Hypothetical example for illustrative purposes only. Source: PIMCO

The fact that more tax-efficient equities are held in the IRA and less tax-efficient fixed income in the taxable account may be counterintuitive. After all, at first glance it may make sense that investors should hold tax-inefficient assets in an IRA to maximize the after-tax return compounding benefit of tax deferral. This logic generally would favor holding bonds in the tax-deferred vehicle and equities in the taxable account. Indeed, if the choice of asset location was between two assets with the same return and volatilities but with different tax rates, this would be the case. However, equities and fixed income have very different risk/return properties, with bonds normally characterized by lower returns and materially lower volatility. The tax-deferred nature of an IRA incentivizes the retiree to postpone consumption from the account for as long as is practically feasible. This, in turn, means that consumption in the earlier years of retirement will come largely from the taxable account. Because income will be primarily generated from the taxable account early on, more conservative positioning, to minimize income volatility, may be prudent – hence, the high allocation to bonds. This result highlights the fact that tax rates are only one consideration in the asset location problem and, at least currently, the difference between ordinary income and capital gains tax rates is simply not large enough to push the fixed income allocation toward an IRA.

The general impact of an IRA is to push consumption and income further out into the future. As shown in Exhibit 10, income in Case 2 declines by just over 2% at ages 66 and 75 but subsequently moves higher than in Case 1. Unsurprisingly, because the retiree is deferring consumption in Case 2 relative to Case 1, wealth levels are systematically higher. At age 75, the retiree's wealth is 12.9% higher than in Case 1, and at age 85 it is 36.2% higher. In Case 2, this is primarily a function of the tax-deferred compounding accorded the IRA, which incentivizes the retiree to postpone consumption. Interestingly, the impact of munis is similar to the IRA in that because returns compound federally tax-free – effectively increasing the asset's return – the retiree prefers to delay consumption. However, because munis have higher after-tax returns than taxable bonds, the retiree's overall quality of life is materially higher than in either Case 1 or Case 2. Almost immediately after retirement, his overall after-tax income is higher when he is able to allocate to federal tax-free munis.[18]

18 In results not shown in this paper, we found the hypothetical retiree's expected lifetime utility to be nearly 9% higher in Case 3 relative to Case 2. This highlights the improvement in quality of life that the higher after-tax returns of munis produce.

Exhibit 10: Income and wealth summary for Case 1-3

	Age			
	66	75	85	95
		Real income		
Case 1	$76,703	$73,611	$63,628	$35,968
Case 2	$74,925	$72,009	$64,052	$42,219
Case 3	$74,893	$74,105	$69,308	$44,588
% Change 1-2	-2.3%	-2.2%	0.7%	17.4%
% Change 2-3	0.0%	2.9%	8.2%	5.6%
		Nominal wealth		
Case 1	$1,958,990	$1,544,421	$925,093	$253,863
Case 2	$1,978,736	$1,743,199	$1,260,056	$428,314
Case 3	$1,988,241	$1,797,985	$1,293,990	$484,099
% Change 1-2	1.0%	12.9%	36.2%	68.7%
% Change 2-3	0.5%	3.1%	2.7%	13.0%

Hypothetical example for illustrative purposes only. Source: PIMCO

Finally, all of the results in this paper are naturally a function of the assumptions that we have made regarding the main inputs, such as expected returns, volatilities, correlations, tax rates and savings levels. However, some of these assumptions are more subjective than others. Long-run asset volatilities, for example, tend to be fairly stable. Tax rates are based directly on the current U.S. tax code and are therefore fairly objective in nature. Expected returns, however, are highly uncertain. As shown in Exhibit 2, we have estimated the long-run pretax return of taxable bonds to be 2.9% and the return of equities to be 5.6%. Many of the results in this paper, including the optimal asset allocation, are directly linked to this 2.7 percentage point return premium for equities over fixed income. If we assumed a smaller risk premium, the optimal asset allocation would lean more toward fixed income, and vice versa. In fact, given today's stretched valuation levels, it would not be unreasonable to intuit that equities could earn lower returns than we have put forth here, at least for the next several years. Sapra and Gao (2018), for example, assume a lower equity premium than we have assumed in this paper, a result of considering current rich valuations. Although that paper did not consider the impact of taxes, the authors found the optimal equity allocation to be 29%, compared with about 45% in this paper. This difference highlights the importance of expected returns in the formulation of the retirement income problem. When deciding on the "right" asset allocation in retirement, retirees and their advisors should be cognizant of the sensitivity of results to inputs of expected returns. Forecasting returns is inherently difficult. Deciding the in-retirement asset allocation should be approached with a level of humility, reflecting the high degree of uncertainty in trying to predict long-term asset returns.

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APPENDIX: CAPITAL MARKETS SIMULATION

Real interest rates are modeled using an Ornstein–Uhlenbeck (OU) process, while nominal interest rates are modeled using a variation of the Cox–Ingersoll–Ross (CIR) model. The choice of an OU process for real rates allows for the realization of negative rate levels, whereas a CIR structure ensures positive levels for nominal interest rates and spreads. The dynamics for yields and spreads are governed by the following differential equation:

$$dx_i = \theta_i(\mu_i - x)dt + \sigma_i x^i dz_i \quad \text{(A1)}$$

where dz is a multivariate Wiener process with covariance matrix Σ, μ is the long-term equilibrium factor level, σ is the shock volatility and θ is a mean-reversion parameter for each tenor. For real rates, i =0, and for nominal rates and spreads, i =0.5. All simulation paths are conditioned on the current level, x_0.

Municipal bond yields are modeled as a proportion of the matched-tenor nominal yields:

$$dm = \theta_m(\mu_m - m)dt - \frac{\sigma_m^2}{2} + \sigma_m dz_m \quad \text{(A2)}$$

where σ_m is the volatility of the yield ratio and θ, μ and dz are defined as above. The drift is adjusted for the volatility to remove the induced drift from geometric compounding. Municipal parameters are calibrated to AA and AAA levels, and are modeled as default free. Between 1970 and 2017, the 10-year cumulative default rate was 0.00% and 0.02% for AAA and AA rated municipal bonds, respectively.[19] Although increasing pension pressure on municipalities may change this relationship going forward, we assume that any needed credit adjustment to municipal yields is small relative to their after-tax returns.

Equations A1 and A2 are estimated for two-year, 10-year and 30-year tenors for municipals, nominal rates and real rates. Future yield curves are fitted from these simulated tenors using a Nelson–Siegel model. Simulated inflation is endogenous to the realized path for nominal and real interest rates, and is modeled based on breakeven inflation, or the difference between nominal and real rates. Formally, realized inflation, i_t, is determined by the following dynamics:

$$i_t = BE_t + \sigma_{in} dz_{in} \quad \text{(A3)}$$

$$BE_t = y^n_{1,t} - y^r_{1,t} + \mu_\pi \quad \text{(A4)}$$

where σ_i is inflation volatility; $y^n_{1,t}$ and $y^r_{1,t}$ are the one-year nominal and real rates at time t, respectively; and μ_π is a shift parameter containing both the inflation risk premium and a liquidity premium. Finally, equities are modeled as returns in excess of the risk-free rate and realized inflation, based on the following equation:

$$r_t = r_t^f + i_t + \mu_{ERP} + e^{(-0.5\sigma_r^2 \Delta t + \sigma_r \sqrt{\Delta t}\varepsilon_t)} - 1 \quad \text{(A5)}$$

where r_t^f is the risk-free rate (three-month Treasury yield) at time t, μ_{ERP} is the equity risk premium, σ_r is the equity volatility and ε_t is a standard normal shock. Hence, the system is fully described by the risk factor returns $[x, i, r]$, where x represents the full set of nominal rates, real rates and municipal rates. We explicitly account for nonzero correlations across all of the dz.

The parameters in the simulation are intended to represent reasonable values over a very long (40-year) horizon and are disclosed in Exhibit A1.

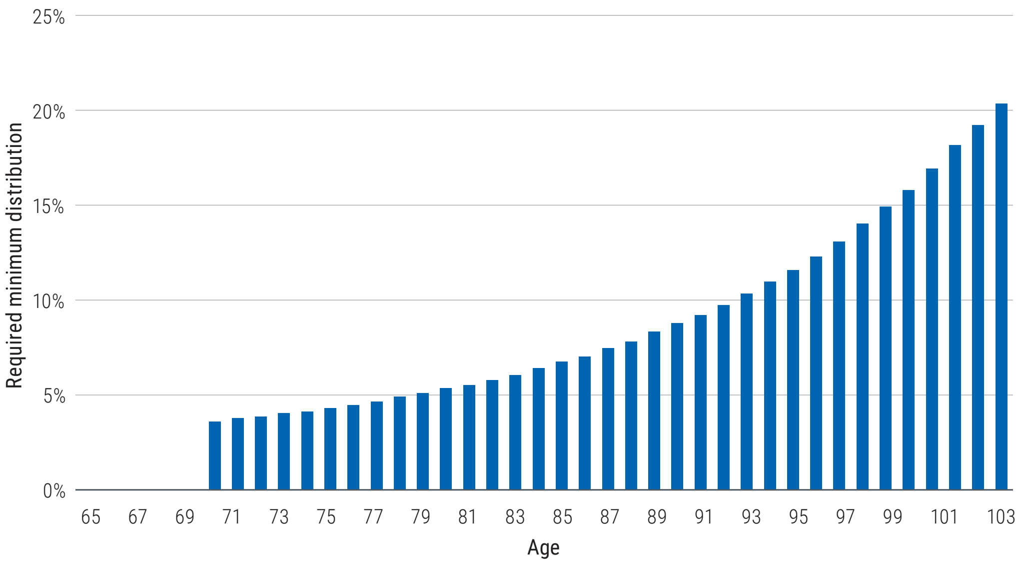
Exhibit A1: Simulation parameters

Variable	Tenor	θ	μ	σ
Nominal rates	2	0.1	2.7%	1.00%
	10	0.1	3.0%	0.90%
	30	0.1	3.1%	0.80%
Real rates	2	0.1	0.7%	1.00%
	10	0.1	1.0%	0.75%
	30	0.1	1.1%	0.60%
Municipal ratio	2	0.3	0.75	0.23%
	10	0.2	0.95	0.20%
	30	0.1	1.05	0.22%
Inflation	-	-	0.0%	0.50%
Equity	-	-	3.0%	16.00%

Hypothetical example for illustrative purposes only. Source: PIMCO

19 Source: US Municipal Bond Defaults and Recoveries, 1970–2017 and Moody's Investors Service, July 31, 2018

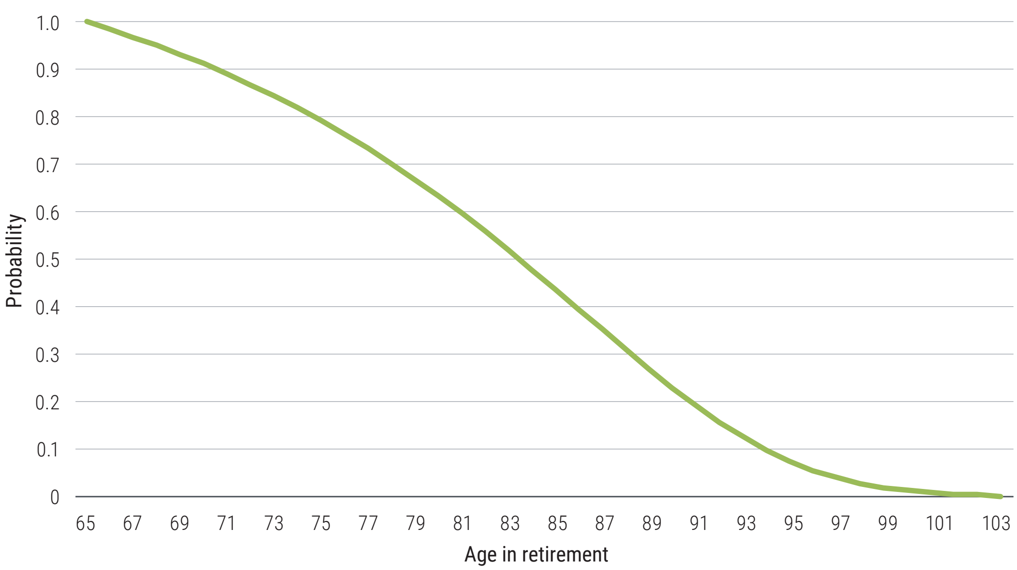
Exhibit A2: IRS required minimum distribution



Source: Internal Revenue Service and the Social Security Administration as of 2018

Exhibit A3: Survival probability

The probability of surviving up to a particular year, conditional on survival to age 65



Source: Social Security Administration as of 2018

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The **"risk-free rate"** can be considered the return on an investment that, in theory, carries no risk. Therefore, it is implied that any additional risk should be rewarded with additional return. All investments contain risk and may lose value.

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