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Retirement Income Covenant Position Paper: Stage Two of the Retirement Income Framework – December 2018

As a global leader in implementing next-generation retirement solutions built around a retirement income goal, Dimensional Fund Advisors is well placed to share our experience with the Australian Treasury as they design a new retirement income framework.

We believe that retirement income should be the primary goal in retirement focused investment solutions. These solutions should be based on a framework that aligns the management of participants' savings with their retirement income goals. This framework should have four components:

1. Providing a more complete risk management framework throughout all phases of participants' economic lifecycle;

2. Targeting higher expected returns within income growth assets;

3. Providing a lifecycle asset allocation focused on managing the uncertainty around future retirement income; and

4. Enabling more meaningful communication about retirement readiness for participants, plan sponsors, and advisors. Communication should be tightly coupled with investment solutions.

Generally, we see a successful framework as one that allows members to move from working life to retired life without large shocks to their consumption. The goal should be steady retirement income that provides them with sufficient flexibility to meet the costs of unexpected life events. Our experience outside Australia is that providing members with meaningful information about their projected retirement income well before they retire allows them to be more engaged and enables them to better plan for future retirement goals. Empowering members to change the outcome, for instance by saving more.

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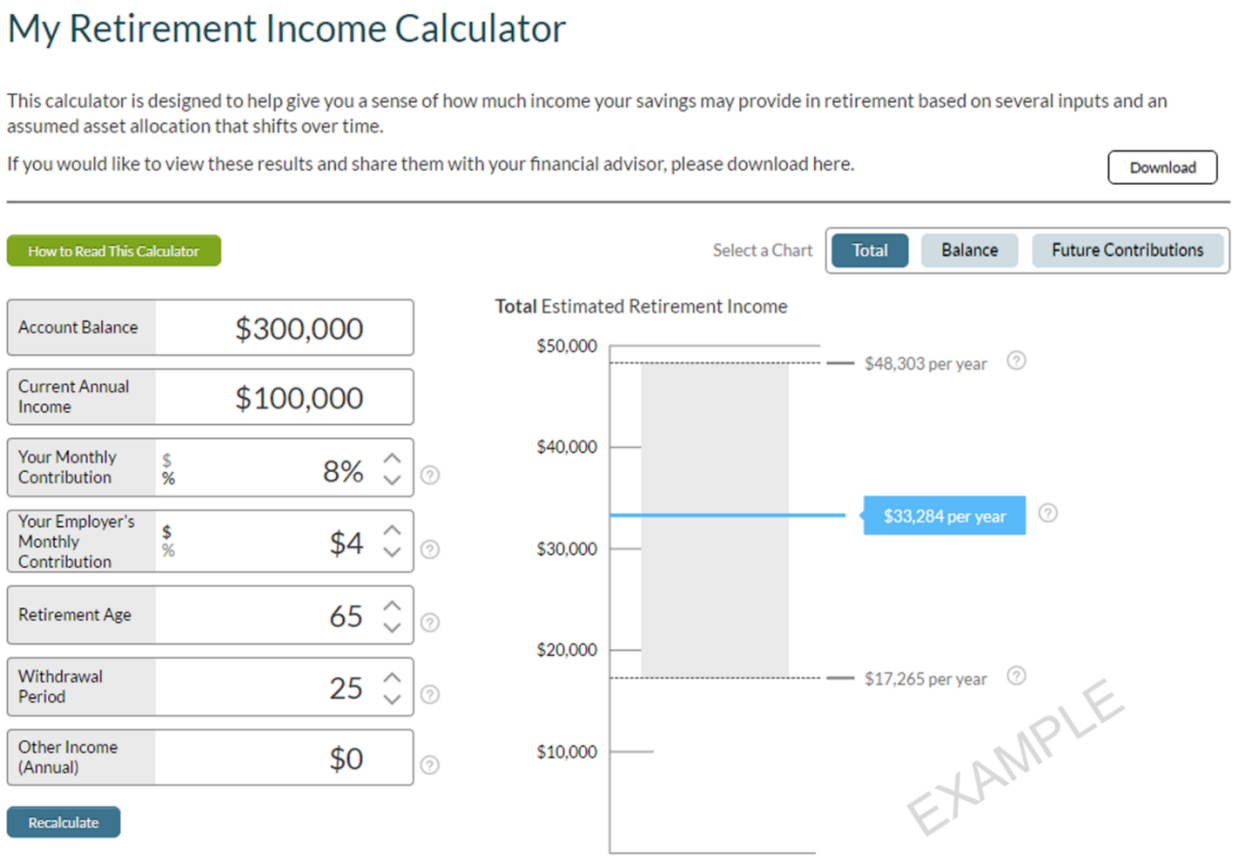
Against that background, we believe it is important that trustees be allowed to provide calculators and income estimates to members during the accumulation and decumulation phases. This will give investors the flexibility to manage retirement income needs at all phases in their lifecycle. We would encourage Treasury to extend its proposal to incorporate the provision of calculators and income estimates that provide meaningful information across the investment lifecycle that are linked to the investment approach. The below figure illustrates how a risk management framework can provide increasing clarity on expected income as investors approach retirement.



Further, to be meaningful, retirement income estimates must be presented in an intuitive way and tied to the investment solution. In the absence of meaningful information, member engagement tends to be infrequent. In contrast, our experience with retirement income calculators show these build engagement.

To facilitate engagement and planning, members need to clearly see the range of outcomes they can expect in retirement. It is not clear to us that an income stability rating scale will be effective in communicating this concept to members and will be open to subjective interpretation.

In our experience, retirement income estimates that present a range of outcomes are an effective mechanism for meaningful communication. An example of this approach is Dimensional's US My Retirement Income Calculator, can be found at https://us.dimensional.com/defined-contribution/retirement-calculator.

While we support standardised metrics that work across a range of products and asset allocations, the ideal metric needs to be able to accurately quantify to what extent the investment helped to reduce the uncertainty around future income. For example, Dimensional seeks to manage income uncertainty through a liability-driven investing (LDI) approach that matches the duration of assets with the duration of expected future income. Traditional risk-management assets (such as short-term fixed interest), focus instead on capital preservation. Relative to the LDI approach, these would generally appear far more volatile in income terms. It is important that end investors are aware of this.

Accompanying this letter, we have included some retirement analysis that Dimensional itself and academics affiliated with our firm have authored over the past decade.

Dimensional

Dimensional's Solutions for Effective Retirement Planning

Massi De Santis, PhD
Vice President
Research

June 2016

Two key elements of striving toward a successful retirement are for plan sponsors, advisors, consultants, and plan participants to have access to (1) low-cost investment solutions that manage the right risks and balance the tradeoff between growth and risk management, and (2) meaningful information to facilitate decision making. Relevant information about expected retirement spending ("consumption") allows plan sponsors to more effectively implement default savings rates, auto-escalation procedures, and communication initiatives to help improve the retirement readiness of plan participants. In addition, we believe plan sponsors, advisors, and consultants can use tools such as Dimensional's My Retirement Income Calculator to prepare plan reports that include individualized information concerning the retirement readiness of their participants.

Plan sponsors can also provide ongoing resources that help participants evaluate the effect of their decisions on expected outcomes. Participants need to determine when to retire and the level of consumption they may need in retirement. To make these decisions, participants need to know the estimated amount of consumption they can expect from their account balance and future contributions. They also need the degree of uncertainty around those expectations. Armed with this information, plan participants can decide how much to save, when to retire, and how much to consume in retirement. Research shows that providing information to plan participants about the effect of their own choices on expected outcomes helps them make better decisions (EBRI 2014,[1] Levi 2014,[2] Goda et al. 2014[3]). Research also shows that failing to plan properly can lead to costly mistakes in terms of early withdrawals or penalties (Argento et. al. 2013[4]).

There is one important caveat: This type of information is only meaningful if the underlying investment solution manages the right risks and balances the tradeoff for the consumption goal. The risks to be managed are the risks that can affect the level of future retirement consumption that is sustainable with a given level of wealth. The right tradeoff is between the opportunity of asset growth and

1. How Would Defined Contribution Participants React to Lifetime Income Illustrations? Evidence from the 2014 Retirement Confidence Survey, *EBRI Notes*, March 2014. Survey funded in part and underwritten by Dimensional Fund Advisors.
2. Information Architecture and Intertemporal Choice: A Randomized Field Experiment in the United States.
3. What will my account really be worth? Experimental evidence on how retirement income projections affect saving. *Journal of Public Economics* 28, August 2014.
4. Early Withdrawals from Retirement Accounts During the Great Recession, Argento, Robert, Bryant, Victoria L., Sabelhaus, John. www.federalreserve.gov/pubs/feds/2013/201322/201322abs.html.

consumption risk management. Estimates of how much retirement consumption your account balance can sustain are not helpful without the right risk management, since you have no confidence in your ability to achieve that level of consumption when you retire. In our analysis, we assume a plan participant can invest in a solution that manages market, counterparty, inflation, and interest rate risks. By managing these risks, the uncertainty about retirement consumption can be reduced. This means the solution has to have a risk management investment matched to the participant's desired retirement date.

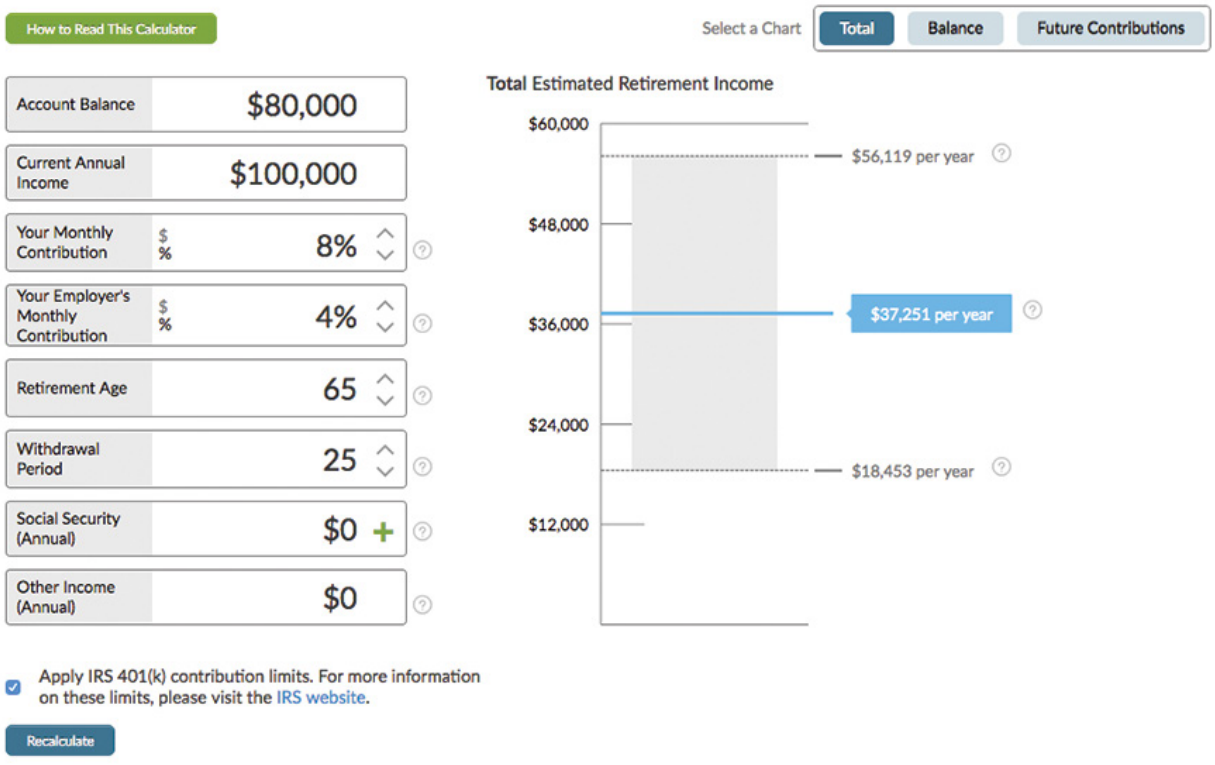
We believe that with the right goal and risk management framework, a retirement solution is more likely to seamlessly transition from accumulation to retirement, when assets will be used to provide real (inflation-adjusted) consumption.

DIMENSIONAL'S MY RETIREMENT INCOME CALCULATOR AND ITS BENEFITS

The Dimensional My Retirement Income Calculator provides perspective on an individual's expected retirement outcome by assessing an investor's ability to fund future retirement consumption goals with his/her savings. By using market data to estimate the future cost of a consumption stream, the calculator allows plan sponsors, advisors, consultants, and plan participants to estimate the ability of today's balance and contribution rate to support future retirement consumption.

It is important to consider current balance and contributions in terms of future consumption. The calculator provides participants the ability to see how present and future consumption are related. For financial planning purposes,

Exhibit 1 Dimensional's My Retirement Income Calculator: A Hypothetical 35-Year-Old



As of March 31, 2016. For illustrative purposes only.

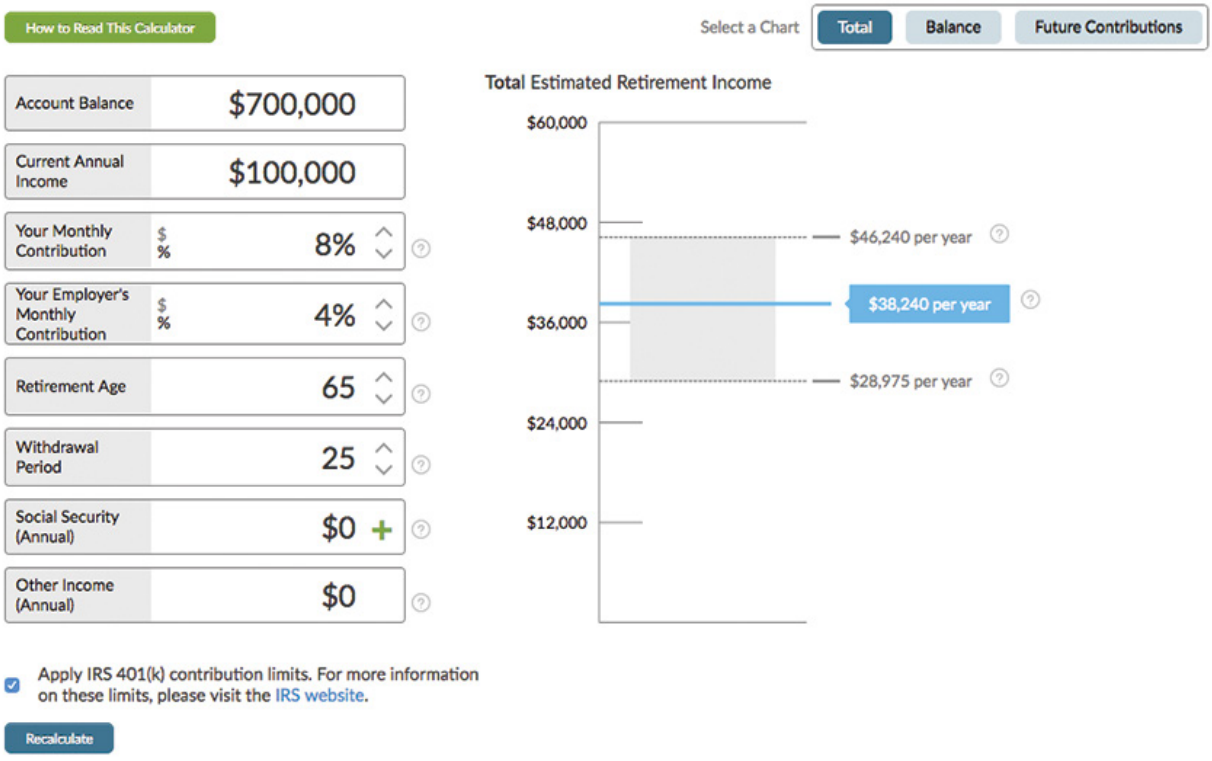
we believe this is a better comparison and can be more meaningful for a person's financial decisions.

One reason participants may have low savings rates is that while they understand the opportunity cost of a dollar saved today, they cannot easily quantify the benefit of that dollar for retirement (see Bernheim et al. 2011,[5] Choi et al. 2012,[6] and Levi 2014).

Exhibit 1 shows a simple example of a 35-year-old plan participant with an income of $100,000, an 8% savings rate, and an employer contribution of 4%, bringing her total savings per year to $12,000. She has a current balance of $80,000. These saving behaviors are estimated to yield, starting at age 65, $37,251 per year (expected median income at retirement) for a withdrawal period of 25 years.[7]

To estimate the effect of uncertain market returns, the calculator shows an uncertainty around the estimated median income. The upper level is an estimate of the 75th percentile of projected income (if market returns are greater than expected), while the lower level is an estimate of the 10th percentile of projected income (to give participants an estimate of the tail risk they may face in case of poor market performance). Participants further from retirement may see much larger uncertainty in those projections because they are likely to have a greater allocation to growth assets. Such assets increase their exposure to equity markets and do not seek to hedge the potential impact of future interest rate movements or inflation on their projected income. The range between the upper and lower estimate helps reflect these sources of uncertainty. Exhibit 1 shows that the range of the uncertainty band is wide (approximately 100% of the median estimate),

Exhibit 2 An Example Participant at Age 60



As of March 31, 2016. For illustrative purposes only.

5. Bernheim, B. Douglas, Andrey Fradkin, and Igor Popov 2011. "The Welfare Economics of Default Options: A Theoretical and Empirical Analysis of 401(k) Plans." NBER Working Paper 17587. National Bureau of Economic Research.
6. Choi, James J., Emily Haisley, Jennifer Kurkoski, and Cade Massey. 2012. "Small Cues Change Savings Choices." NBER Working Paper 17843. National Bureau of Economic Research.
7. See Appendix for methodology detail and assumptions.

highlighting the fact that many potential market outcomes are possible over a 30-year period. The median can serve as an indicator of whether participants are on track with their goals, and, if properly monitored, the median estimate can help participants stay on track.

The participant in our example shows an estimated median replacement rate of 37% of the final salary of $100,000. Adding a Social Security estimate of approximately $27,000 (which the calculator can incorporate using the amount estimated from the Social Security Administration's calculator), the overall replacement rate is 64%.[8] Participants can use these calculations to see if they are on track for their own replacement rate. Adjustments to contribution amounts in the calculator (from the employee or employer) can help participants consider the impact of adjustments to their savings plan.[9]

Exhibit 2 shows a 60-year-old participant with an account balance of $700,000. Contributions are still 8% and 4% (employee and employer contribution, respectively). The median income estimate is $38,240, very similar to the median in Exhibit 1. We can think of this example as the participant in Exhibit 1 at age 60 with an additional 25 years of savings and an accumulated balance of $700,000. Since most of the invested assets are focused on investments that seek to manage the risks relevant to retirement income, the range of outcomes has substantially narrowed to within 45% of the median estimate.

If the example participant retires at 65 with an account balance of $860,000, this balance yields a median income of $37,286, on track with previous estimates. At this stage, the range of uncertainty is within 29% of the median.

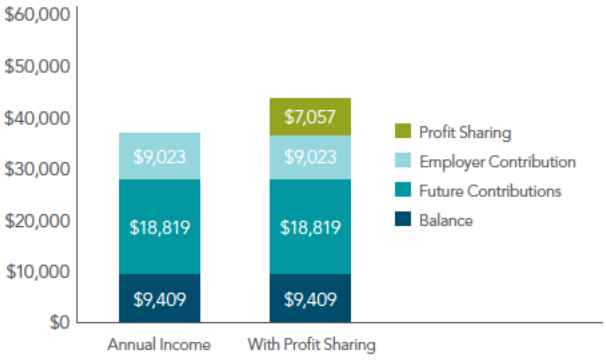
As retirement approaches, the participant is assumed to have an increasing allocation to inflation-protected bonds. This strategy is designed to manage the uncertainty around how much retirement consumption the participant can afford from his or her savings. Because of this, the range around the median retirement consumption estimate narrows. Why? The assumed asset allocation is less exposed to equity risk and seeks to hedge the effects that future interest rate changes or inflation can have on expected retirement consumption. This approach to risk management also implies the retirement consumption estimates can depend more on market data and less on assumptions about expected global equity and bond returns as retirement approaches.[10]

Having the right risk management is crucial to striving toward a successful outcome since retirees need confidence about the level of consumption they can afford in retirement. In some cases, these constraints are especially binding, such as workers with mandated retirement ages or health issues. The framework provided by the calculator gives participants the tools and information needed to calibrate their retirement expectations.

PLAN DESIGN CONSIDERATIONS

Dimensional's My Retirement Income Calculator is also useful for taking a bottom-up approach to retirement planning in that it can be used to break down the estimated retirement income by different sources of savings. In **Exhibit 3**, we can look at how the carried balance, employee contributions, and employer contributions work to create a combined retirement income for the participant.

Exhibit 3: Sources of Projected Retirement Income Estimates for an Example Participant



As of March 31, 2016. For illustrative purposes only.

8. The Social Security quick calculator can be accessed at www.ssa.gov/oact/quickcalc/.

9. As an additional help to plan for their goals, the calculator allows the breakdown of income estimates into its component pieces: estimated income from current account balance and estimated income from future contributions.

10. Assumptions about expected growth and expected volatility of the consumption growth assets are needed to make projections. With a longer time to retirement and a greater fraction devoted to growth assets, the estimates are relatively more sensitive to assumptions made. Closer to retirement, a greater fraction is devoted to risk management assets; income estimates from this allocation use market interest rates. See Appendix for methodological details.

These calculations show that the employer contribution accounts for over 25% of the estimated median income for our 35-year-old example participant.

Plan sponsors, advisors, and consultants can also use the calculator to evaluate the effect of plan changes on expected outcomes. As an example, Exhibit 3 shows the potential impact for the 35-year-old participant if the employer decided to provide additional support by implementing a profit-sharing program at around 3% of employee salary. Applying the 3% contribution to the calculator adds about $7,000 per year in retirement, bringing the replacement rate to around 44% before accounting for Social Security. These are tangible impacts that a plan sponsor, conscious of their employee retirement needs, can turn to for the purpose of designing or calibrating their plan to best fit their employee's needs.

CONCLUSIONS

Dimensional's My Retirement Income Calculator provides an innovative and intuitive approach for examining and planning for retirement. By integrating projected retirement income estimates with an appropriately relevant risk management framework, the calculator can provide investors with a retirement planning tool designed to help them monitor and track progress toward retirement readiness. By assuming investments in a combination of growth assets (equities and global bonds) and consumption risk-management assets (inflation-protected bonds matched to a target retirement date), the projections can give plan participants insight about the level of retirement consumption that their savings may support. We believe participants will find this information more useful than a simple account balance on their quarterly statement.

Plan sponsors, advisors, and consultants can use the calculator to design plans that help estimate the effect of changing the design of the employer contribution, auto-enrollment, and auto-escalation features and assessing the retirement readiness of their employees. This valuable information can help plan sponsors to improve participant outcomes and to communicate the entire value of the plan to their employees.

APPENDIX

Key Assumptions

Estimated retirement income projections are based on assumptions about returns using current and historical data, and income is generated through drawing down principal. The My Retirement Income Calculator ("the calculator") uses current interest rates on Treasury Inflation-Protected Securities (TIPS), expected to be updated quarterly. Global Equities are assumed to have a 5% expected real return with a 20% annual standard deviation, and Global Bonds are assumed to have a 1% expected real return with a 5% annual standard deviation. The covariance between Global Equities and Global Bonds is assumed to be zero. (Covariance measures how two asset classes move together.) These assumptions are net of expenses, which are assumed to be 0.30% annually. Annual expected returns are presented in excess of inflation and will be reviewed periodically.

The calculator uses the retirement year to select the appropriate corresponding asset allocation. The asset allocation shifts over time, with a larger portion of assets assumed to be invested in inflation-protected bonds as the retirement year approaches (see **Table 1** below for details).

Table 1: Assumed Asset Allocation by Years to Retirement

Years to Retirement	Global Equities	Global Bonds	Inflation-Protected Bonds
>25	95%	5%	0%
25	92%	8%	0%
20	79%	21%	0%
15	65%	16%	19%
10	52%	11%	38%
5	38%	5%	56%
Retirement year to 10 years post retirement	25%	0%	75%
>=15	20%	0%	80%

Percentages may not add to 100% due to rounding.

For example, if the computed retirement year is 2045, the calculator will select an asset allocation similar to the point in the table that corresponds with the number of years until 2045. The user's current age and retirement age (default of 65) are used to compute a retirement year. If the computed number of years until retirement falls between the five-year increments listed below, a blended allocation of the two nearest increments is used.

These assumptions are used to compute expected future wealth assuming a lognormal distribution of returns. The lognormal distribution is a standard statistical distribution used to represent outcomes from a random process and is commonly used to represent the distribution of returns. Estimated future wealth is divided by the estimated cost of $1 of inflation-adjusted income for the length of a user's withdrawal period. The cost of $1 of annual inflation-adjusted income during retirement is estimated using current interest rates on TIPS.

Using this methodology, we calculate two estimated distributions of income, one from a user's current account balance and the other from future contributions. The estimated retirement income projection from the current balance illustrates the expected income from a user's current account balance (meaning no additional future contributions are considered). The estimated retirement income projection from future contributions illustrates the expected income from future savings until retirement. It considers your total annual contribution and assumes the same amount (adjusted for inflation) is contributed each year until you retire.

The resulting estimated distributions of income, approximated by a lognormal distribution, are used to compute the median value of estimated retirement income, the 10th percentile of estimated retirement income, and the 75th percentile of estimated retirement income from the current balance and from future contributions. The median of a distribution represents the amount at which half of the expected outcomes are greater than the amount and half of the expected outcomes are lower than that amount. The 75th percentile of a distribution represents the amount at which 25% (or one out of every four) of the expected outcomes are larger than or equal to that amount. The 10th percentile of a distribution represents the amount at which 90% (or nine out of every 10) of the expected outcomes are larger than or equal to that amount.

The total value of the estimated retirement income projection is the sum of the estimated retirement income projections from the current balance and future contributions entered by the user. Taxes, penalties, and other fees or expenses that may be due upon withdrawal are not considered. The estimate is presented in today's dollars. For years past the retirement date, contributions are assumed to be zero, and the total projected retirement income shown represents the income that can be expected from a user's current account balance over the remaining withdrawal period.

Prior to the retirement year, the default withdrawal period is 25 years and can be adjusted by the user. After the retirement year, the default withdrawal period is 25 years minus the number of years since the retirement year and can be adjusted by the user. If the user adjusts the withdrawal period, the estimated retirement income projection is proportionally adjusted to account for the new number of withdrawals.

No representation or warranty is made as to the reasonableness of the assumptions or that all assumptions used in achieving the returns have been stated or fully considered. Changes in the assumptions may have a material impact on the estimated retirement income projections presented.

The assumptions are subject to change as subsequent conditions vary. Assumptions used for the estimated retirement income projections are subject to high levels of uncertainty regarding future economic and market factors that may affect actual future performance. There is no guarantee that these assumptions will be achieved, and actual returns or retirement income could be significantly higher or lower than those shown. These assumptions should not be relied upon as a forecast or prediction of future events, and they should not be construed as guarantees of returns that may be realized in the future from any asset class described herein.

Material Limitations

Because of the inherent limitations associated with the use of illustrative asset allocations based on the above assumptions, investors should not rely on the information shown in the My Retirement Income Calculator when making an investment decision. The illustrative retirement income projections cannot account for the impact that economic, market, and other factors may have on an actual investment portfolio. Unlike actual portfolios, the projections shown in the My Retirement Income Calculator do not reflect actual trading, liquidity constraints, fees, expenses, taxes, and other factors that could impact an investor's realized future returns and retirement income.

The estimated retirement income projections are hypothetical in nature and are not a guarantee of future results. Since past performance is not an accurate predictor of the future and reliance on historical and current data involves inherent limitations, you must understand that the estimates are only a tool to be used in evaluating your retirement portfolio. Actual results will vary.

Investments in stocks and bonds are subject to risk of economic, political, and issuer-specific events that cause the value of these securities to fluctuate. International investments are subject to additional risks such as currency fluctuation, political instability, and adverse economic conditions. The estimated retirement income projections are based on hypothetical investments in global equities, global bonds, and Treasury Inflation-Protected Securities. Other investments not considered may have characteristics similar or superior to those being analyzed.

IMPORTANT: The projections or other information generated by the My Retirement Income Calculator regarding the likelihood of various investment outcomes are hypothetical in nature, do not reflect actual investment results, and are not guarantees of future results. Results may vary with each use and over time. Actual retirement incomes may vary significantly. Past performance is no guarantee of future results.

This information is provided for registered investment advisors and institutional investors and is not intended for public use. Dimensional Fund Advisors LP is an investment advisor registered with the Securities and Exchange Commission.

Investing involves risk and possible loss of principal. There is no guarantee strategies will be successful.

Fixed income securities are subject to increased loss of principal during periods of rising interest rates. Fixed income investments are subject to various other risks, including changes in credit quality, liquidity, prepayments, call risk, and other factors. Inflation-protected securities may react differently from other debt securities to changes in interest rates. Please see "Material Limitations" for additional information regarding the risks associated with certain investments and the limitations of calculators.

Dimensional

RESEARCH MATTERS

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Income Growth Through an LDI Approach

February 2019

Successful investment strategies require well-defined goals. This allows investors to identify and control key risks relevant to the goals and provides a framework for how to think about the most effective way to achieve those goals. In the context of lifecycle investing, for many people the goal is to save enough to afford a desired level of steady income in retirement. Reducing the uncertainty around this income stream requires managing the risks relevant to this goal. We use a retirement income lens to evaluate three different fixed income assets used for risk management—two commonly used in traditional target date funds and a liability driven investing (LDI) strategy designed to manage interest rate risk for an investor saving for retirement. Controlling for the level of income volatility across strategies, in our simulations we find that having a risk management strategy that aligns with the investment goal may outperform approaches with misaligned risk management.

RETIREMENT INCOME FRAMEWORK

Research into lifecycle finance has shown that individuals should allocate financial capital to growth and risk management assets and that the mix of these should change over time. Commonly, equities are used as the growth asset within a portfolio because their returns, and thus growth potential, are typically higher than that of risk management assets. As an individual approaches retirement, allocations to the risk management assets are increased to offset the individual's depleting human capital. Some common risk management assets used within existing retirement products include short-term and intermediate-term bonds.

We believe the goal of most investors saving for retirement is to be able to achieve a desired level of steady income in retirement. To assess the effectiveness of different risk management assets at providing steady income in retirement we need to more specifically define the goal of retirement income. Many people aim to retire at age 65, at which point life expectancy is around 20 years.[1] For our analysis, we assume retirement at age 65 with a series of 25 annual constant cash flows to support consumption in retirement.[2]

This sequence of cash flows can be viewed as a liability that can be estimated by summing the present value of

each cash flow—we call this the retirement income liability. In the normalized case of a $1 per-year cash flow, we call this the cost of income

$$\text{Cost of income} = \frac{\$1}{(1+y_{t_1})^{t_1}} + \frac{\$1}{(1+y_{t_2})^{t_2}} + \cdots + \frac{\$1}{(1+y_{t_{25}})^{t_{25}}} = \sum_{i=1}^{25} \frac{\$1}{(1+y_{t_i})^{t_i}}$$

where y_{t_i} is the nominal US Treasury yield for t_i and t_i is the time until the i^{th} cash flow.[3] The value today of any desired retirement income level can then be calculated by multiplying the cost of income by that income level. Alternatively, we can estimate the level of retirement income that can be afforded from a given current wealth by dividing the current wealth by the cost of income.

$$\text{Annual retirement income} = \frac{\text{Current wealth}}{\text{Cost of income}}$$

THE THEORY BEHIND LDI

Exhibit 1 provides two examples of how the cost of income can be used to estimate the annual retirement income that can be drawn from a given balance. Both examples have the same account balance, but the cost of income is quite different. In Example A, the investor can afford more income in retirement than in Example B because the cost of income is lower.

Exhibit 1: The Impact of Changes in The Cost of Income on Estimated Annual Retirement Income

	Example A	Example B
Account Balance	$1,000,000	$1,000,000
Cost of Income	$15	$20
Estimated Annual Retirement Income	**$66,667**	**$50,000**

Hypothetical example for illustrative purposes only.

For an investor with the goal of stable retirement income from their risk management assets, this finding is insightful. It shows that if we can identify an asset whose value moves relatively in-line with the cost of income, the estimated annual retirement income will stay stable. This concept is known as liability driven investing (LDI), an approach that has been implemented by defined benefit (DB) plans and insurance companies for many years.

As shown in the previous equation, the cost of income is driven by current yields. That is, if yields decrease, the current cost of income goes up and vice versa. To implement an LDI approach that aims to keep retirement income estimates stable, we would want an asset with the same sensitivity to yields as the retirement income liability. This can be achieved through a portfolio of fixed income securities with the same duration[4] as the retirement income liability. The value of this portfolio should move in-line with the cost of income, thus keeping retirement income estimates stable and reducing uncertainty about how much income in retirement investors will be able to afford.

In the following sections, we compare the income returns and volatility[5] of an LDI strategy to other risk management strategies commonly used near retirement to evaluate their effectiveness in reducing income uncertainty while providing the ability to grow income.

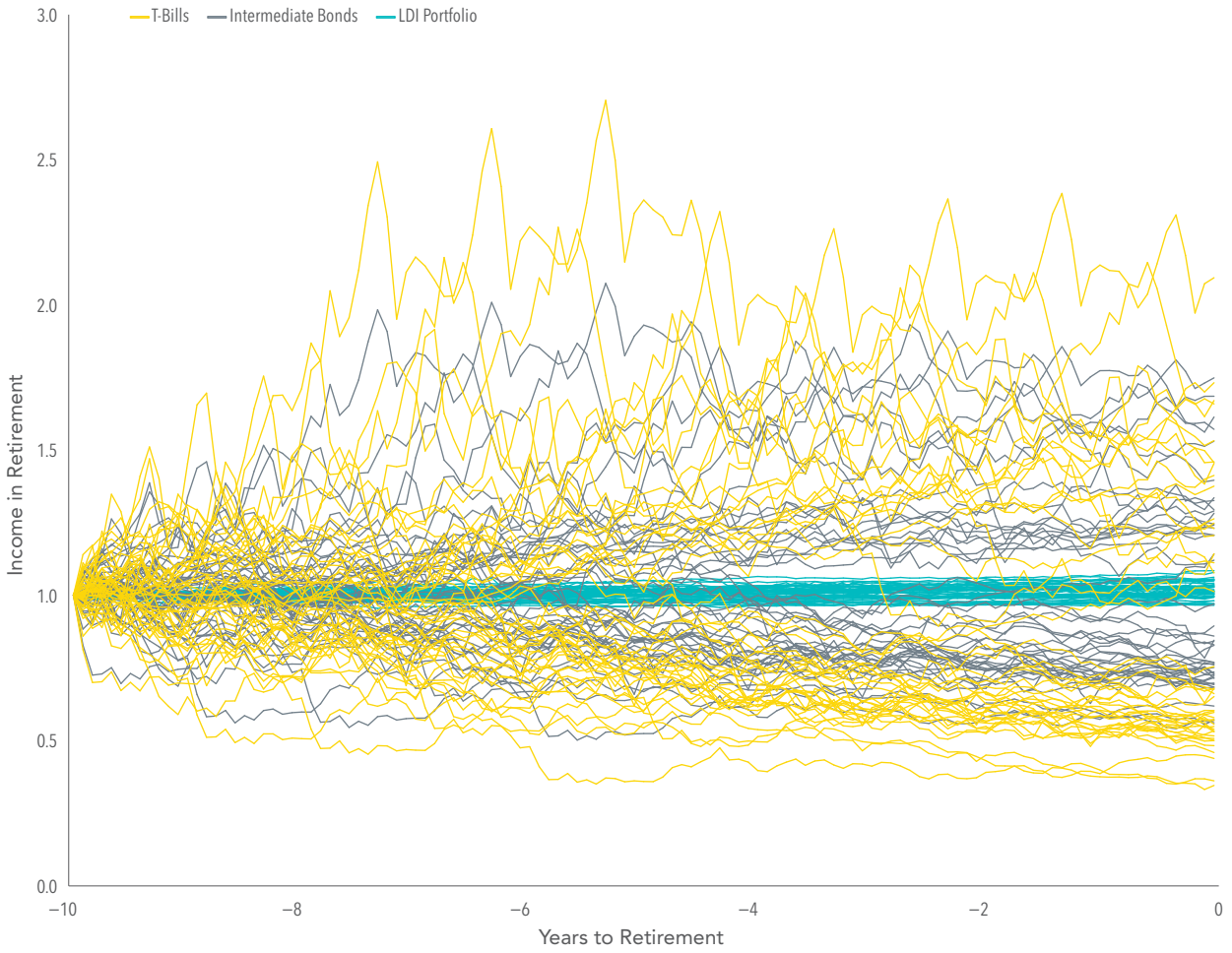
RETURNS VS. VOLATILITY TRADEOFFS FOR RISK MANAGEMENT ASSETS

Allocations nearing retirement typically consist of growth and risk management assets. In this section, we focus exclusively on three risk management assets—US One-Month Treasury Bills (T-bills), US intermediate-term bonds (intermediate bonds)[6], and a simulated LDI portfolio[7]—to highlight differences in retirement income.

Imagine an investor who is 10 years from retirement and with her current savings expects to afford $1 per year in retirement income based on the current cost of income. If she would like to keep this income estimate stable, how should she invest her portfolio? In **Exhibit 2**, we simulate the experience of 45 such investors using rolling 10-year periods beginning in 1962 through 2016. For each of these 10-year periods, we plot the income estimates throughout the period resulting from a hypothetical investment in T-bills, intermediate bonds, and the LDI portfolio designed to hedge against income uncertainty. We observe significantly more dispersion in the value of estimated retirement income for T-bills and intermediate bonds than for the LDI portfolio.

Let's take a closer look at why this may be the case. As **Exhibit 3** shows, interest rates varied quite a bit over the sample period. Investments that had a meaningful duration mismatch with the investor's retirement income liability would have been poor hedges for changes in interest rates resulting in dispersion between the asset and liability values.

Exhibit 2: Retirement Income Estimates Over the 10 Years Prior to Retirement



Simulations are hypothetical in nature, do not reflect actual investment results, and are not guarantees of future results. Results may vary with each use and over time. These hypothetical incomes are used for discussion purposes only and are not intended to represent, and should not be construed to represent, predictions of future incomes or returns. Actual incomes may vary significantly.

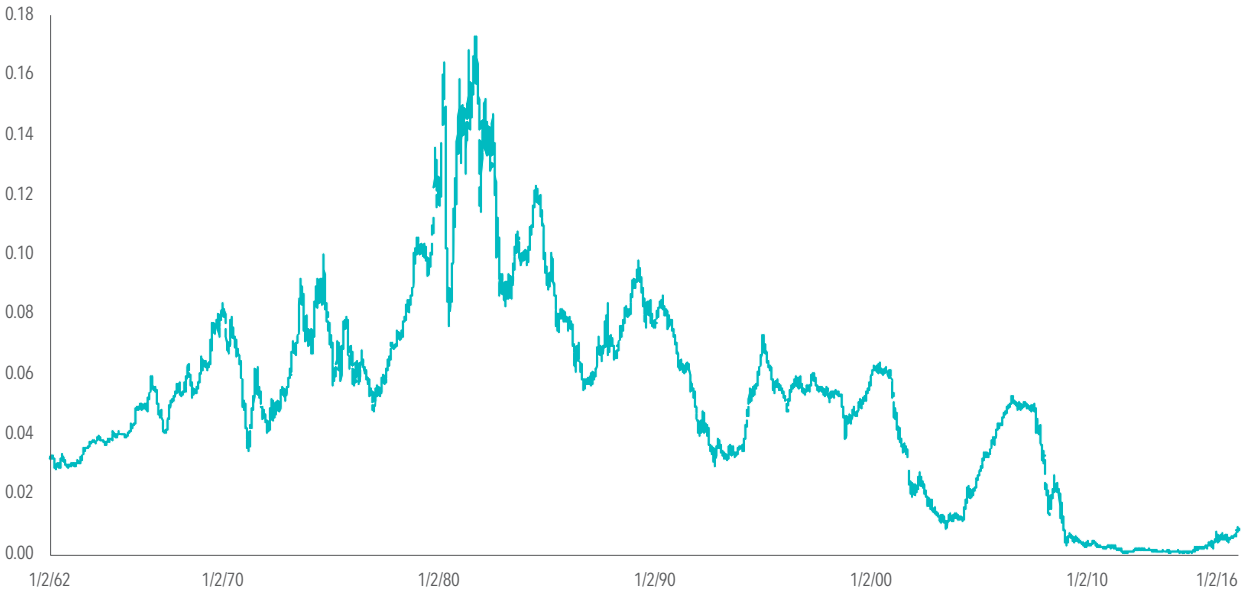
Each line represents estimated annual income in retirement over a 10-year assumed investment window starting 10-years from retirement for T-bills, intermediate bonds, and a simulated LDI portfolio starting with a $1 initial estimate. Annual income in retirement is assumed to be a level income for 25 years (e.g. with a $1 income estimate 10-years from retirement, it would be $1 each year for 25 years starting in 10 years), and the cost of this income is calculated from monthly Treasury yield curves. The first period is January 1962–January 1972, the second period is January 1963–January 1973, and so on. See the Disclosures for details.

On average, over the 45 periods we examined, the retirement income liability had a duration of 19 years at the start of the simulations and nine years at retirement. The average duration of the T-bill portfolio was almost zero. This entails significant duration mismatches for T-bills. Since the ratio of the present value of the retirement income liability to T-bills ($P_{TBill} / P_{Liability}$) will be proportional to the duration mismatch ($D_{TBill} - D_{Liability}$)

$$(P_{TBill} / P_{Liability}) \sim (D_{TBill} - D_{Liability})\, \Delta yield$$

interest rate changes (Δyield) remain largely unhedged, which significantly increases income volatility. While the duration mismatch with intermediate bonds is lower due to its higher average duration of around 3.5 years,[8] the mismatch still causes significant variation in income outcomes. The estimated retirement income after 10 years of investing in intermediate bonds ranges from $0.50 to $1.75 with 60% of the simulations resulting in less than the initial estimate of $1. In stark contrast, dispersion in outcomes was very small with the LDI approach because of the duration matching—the value of the LDI portfolio moved similarly to the value of the retirement income liability.

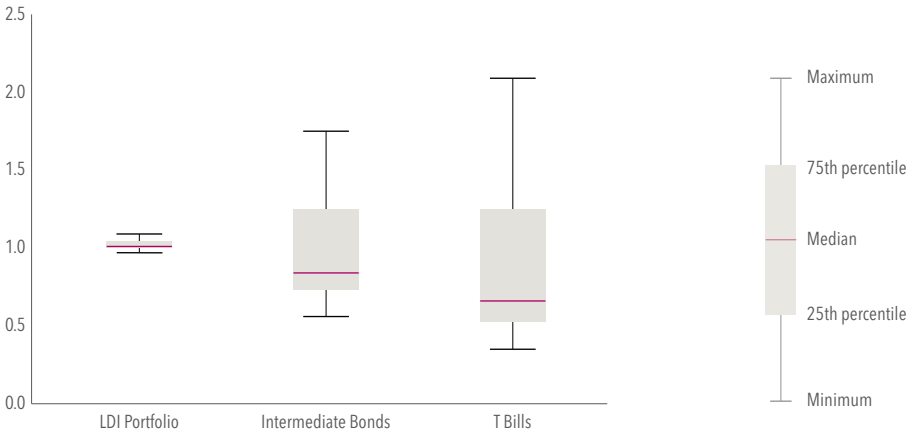
Exhibit 3: Historical US One-Year Nominal Interest Rates



Source: One-Year Treasury Constant Maturity Rate (DGS1) from FRED website 11/1/2018. Past results are no guarantee of future results.

To summarize the dispersion in retirement income that each investment option generated, we compute the 75th, 50th (median) and 25th percentile income levels at retirement across all 45 simulations for each risk management asset (T-bills, intermediate bonds, and LDI portfolio) and report these statistics in **Exhibit 4**. The size of the boxes is the interquartile range[9] and is a measurement of income volatility. The whiskers denote

Exhibit 4: Range of Retirement Income Estimates at Retirement Date After 10-Year Investment Horizon



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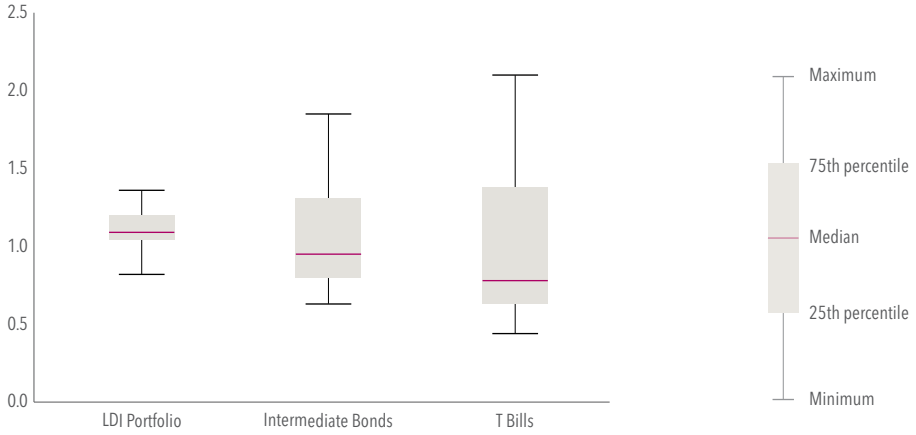
Estimated annual income at retirement date following a 10-year assumed investment window where the initial income estimate was $1, for T-bills, intermediate bonds, and a simulated LDI portfolio. Annual income in retirement is assumed to be a level income for 25 years (e.g. with a $1 income estimate 10-years from retirement, it would be $1 each year for 25 years starting in 10 years), and the cost of this income is calculated from monthly Treasury yield curves. This summarizes the results in Exhibit 2 at retirement date. Simulations are hypothetical in nature, do not reflect actual investment results, and are not guarantees of future results. Results may vary with each use and over time. These hypothetical incomes are used for discussion purposes only and are not intended to represent, and should not be construed to represent, predictions of future incomes or returns. Actual incomes may vary significantly. See the Disclosures for details.

Exhibit 5: 25% Equity, 75% Risk Management Asset Blends: Range of Retirement Income Estimates at Retirement Date After 10-Year Investment Horizon



Simulations are hypothetical in nature, do not reflect actual investment results, and are not guarantees of future results. Results may vary with each use and over time. These hypothetical incomes are used for discussion purposes only and are not intended to represent, and should not be construed to represent, predictions of future incomes or returns. Actual incomes may vary significantly.

Estimated annual income at retirement date following a 10-year assumed investment window where the initial income estimate was $1, for a blend of 25% equity and 75% risk management asset (the simulated LDI portfolio, intermediate bonds, or T-bills). Annual income in retirement is assumed to be a level income for 25 years (e.g. with a $1 income estimate 10-years from retirement, it would be $1 each year for 25 years starting in 10 years), and the cost of this income is calculated from monthly Treasury yield curves. Simulations are hypothetical in nature, do not reflect actual investment results, and are not guarantees of future results. Results may vary with each use and over time. These hypothetical incomes are used for discussion purposes only and are not intended to represent, and should not be construed to represent, predictions of future incomes or returns. Actual incomes may vary significantly. See the Disclosures for details.

the smallest and largest values in the sample. The LDI portfolio has the lowest income volatility and highest median income. As discussed earlier, we would expect the LDI portfolio to have the lowest volatility given this is the stated goal of the strategy. However, it is less clear that we should expect a higher median income. For this simulation period (10-year rolling periods starting in 1962), in aggregate, longer-duration bonds outperformed shorter-duration bonds. Since the LDI portfolio has a much higher average duration than T-bills and intermediate bonds, it is no surprise that the LDI portfolio outperformed the others.

RETURNS VS. VOLATILITY TRADEOFFS IN INCOME TERMS FOR BLENDED ASSETS

Now, instead of considering the risk management asset in isolation, let's consider how the three different risk management assets perform in income terms when combined with equities. We run the same simulations as the previous section but add a 25% allocation of US equities[10] to each risk management asset. **Exhibit 5** summarizes these results. The additional equity allocation causes the LDI portfolio's income volatility to significantly increase. However, for the other two risk management assets we do not observe the same increase. This suggests that both the pure T-bills and intermediate bonds have equity-like volatilities in income terms, making it difficult to use these assets for retirement income risk management purposes.

VOLATILITY-ADJUSTED PERFORMANCE

Effective risk management assets reduce income volatility, allowing additional allocations toward growth assets, which can improve income returns. To compare the returns of the three risk management assets in income terms, we form hypothetical portfolios that blend the risk management assets with equities for a targeted level of income volatility.[11] This gives us the ability to compare the returns of the portfolios per unit of volatility in income terms. The weights for the blends required to achieve similar income volatilities are shown in **Exhibit 6**.

The results show that to target the same level of income volatility, the T-bills/equities portfolio is only able to allocate 20% to equities, while the LDI/equities portfolio is able to allocate more than four times that—85% allocated to equities. This difference exemplifies the LDI portfolio's ability to manage interest rate risk and therefore reduce income volatility. We also observe that the intermediate bonds/equities portfolio has a lower

Exhibit 6: Portfolio Weights Resulting in Equalized Volatility

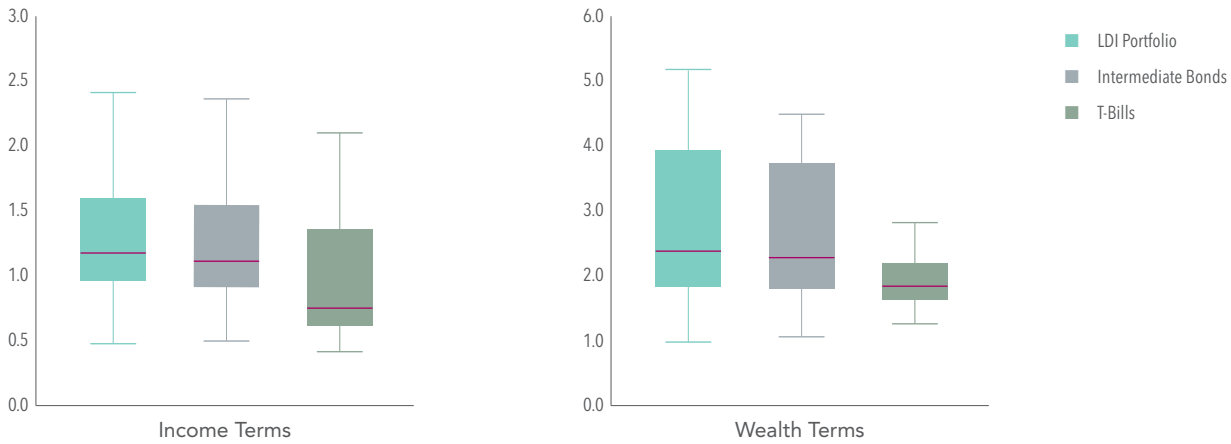
	Equity Allocation	Income Risk Management Asset Allocation
T-Bills/equities portfolio	20%	80%
Intermediate bonds/equities portfolio	70%	30%
LDI/equities portfolio	85%	15%

This exhibit shows hypothetical portfolio weights leading to the same average volatility in income estimates at retirement date after a 10-year investment horizon. The volatility level targeted is a standard deviation of 0.45. Refer to Exhibit 7 for further details about methodology.

Exhibit 7: Simulated Performance in Income and Wealth Terms of Blended Equity/Income Risk Management Portfolios with Equalized Volatility[12]

		Income Units			Wealth Units		
		LDI/equities portfolio (15%/85%)	Intermediate Bonds/equities portfolio (30%/70%)	T-Bills/equities portfolio (80%/20%)	LDI/equities portfolio (15%/85%)	Intermediate Bonds/equities portfolio (30%/70%)	T-Bills/equities portfolio (80%/20%)
Return	Average Cumulative 10-Year Growth[13]	$1.29	$1.23	$0.97	$2.87	$2.67	$1.94
	Average Annualized	2.61%	2.13%	−0.28%	11.11%	10.32%	6.84%
	Annualized vs. LDI	—	−0.48%	−2.89%	—	−0.78%	−4.27%
Volatility	Standard Deviation 10-Year Outcomes[14]	0.45	0.45	0.45	1.23	1.02	0.47

Range of Retirement Income Estimates at Retirement Date After 10-Year Investment Horizon



Simulations are hypothetical in nature, are constructed with the benefit of hindsight, do not reflect actual investment results, and are not guarantees of future results. Results may vary with each use and over time. These hypothetical incomes are used for discussion purposes only and are not intended to represent, and should not be construed to represent, predictions of future incomes or returns. Actual incomes may vary significantly.

This exhibit shows the simulated performance, in income and wealth units, of the different blends of risk management assets (LDI portfolio, intermediate bonds, and T-bills) and equity, all producing the same income volatility at retirement date, starting from a unit of income 10 years prior. Income return measures the change in retirement income estimate leading up to retirement (i.e. if 10 years from retirement, the retirement income estimate was $1, and at retirement the retirement income estimate was $1.10, this would be a 10-year income return of 10%). Income volatility measures the dispersion of income returns (i.e. the variation in ending retirement income estimates from the same starting estimate throughout simulations). Income estimates are based on an assumed level income for 25 years starting at retirement date (e.g. with a $1 income estimate 10 years from retirement it would be $1 each year for 25 years starting in 10 years), and the cost of this income is calculated from monthly Treasury yield curves. Statistics are computed from 45 10-year simulations starting each year from 1962 to 2006. See the Disclosures for details.

allocation to equities, at 70%, than the LDI/equities portfolio. When compared to T-bills, intermediate bonds have a longer duration which is closer to that of the liability, thereby reducing some of the volatility from interest rates and allowing a higher equity allocation.

Exhibit 7 reports the results of the three portfolios formed in Exhibit 6. We verify that the average income volatility is now the same across all portfolios—$0.45 standard deviation in income that can be afforded at retirement. The LDI/equities portfolio results in the highest income growth with a 2.6% annualized return, outperforming the intermediate bonds/equities portfolio by 48 basis points (bps) per year. In addition, the LDI/equities portfolio also has the largest returns in wealth units—78 bps per year more than the intermediate bonds/equities portfolio and 4.27% per year more than the T-bills/equities portfolio. This is largely attributable to the higher equity allocation. The standard deviation of the wealth level at retirement was higher for the LDI/equities portfolio than for the intermediate bonds/equities and T-bills/equities portfolios. However, for an income goal this may not be a primary concern.

CONCLUSION

If one of the primary goals of retirement savings is to provide for consumption in retirement, the investment approach should be aligned with the investment goals. This means that it is important to manage the risks that are relevant to the goal. In the case of retirement income, two primary risks are inflation and interest rate risk, both of which can be addressed with an LDI approach to risk management. Not having the right risk management in place leads to unnecessary uncertainty about how much income one can afford. Additionally, investors may sacrifice returns unnecessarily. As investors shift away from growth assets, they tradeoff some expected return to gain risk reduction. So, it's imperative that the investments reduce the risks that matter to make this a good tradeoff. We show that a blended LDI and equity solution may be able to achieve a better balance of growth vs. risk reduction—that is, a higher income return per unit of income volatility.

1. In the US as of the most recent Actuarial Life Table made available by the Social Security Administration.
2. 25 years of cash flows assumes an additional five-year buffer to address longevity risk.
3. We assume nominal cash flows throughout the analysis and hence apply nominal US Treasury yields. This allows us to extend the analysis back to the 1960s. Real US Treasury yields are only available from the 2000s on. The implications of the analysis, however, would apply to a real cash flow framework as well.
4. Duration measures the sensitivity of an asset or liability to changes in yields. Duration-matching is a common approach for managing an LDI strategy.
5. Income return measures the change in retirement income estimate leading up to retirement (i.e. if 10 years from retirement, the retirement income estimate was $1 and at retirement the retirement income estimate was $1.10, this would be a 10-year income return of 10%). Income volatility measures the dispersion of income returns (i.e. the variation in ending retirement income estimates from the same starting estimate throughout simulations). Refer to the next section with more detail about income returns and volatility.
6. US intermediate bonds are represented using the returns of the Bloomberg Barclays US Aggregate Intermediate Bond Index for 1976–2016 and the average return of long-term US government bonds (33.3%), long-term US corporate bonds (33.3%), and US one-month T-bills (33.3%), rebalanced monthly prior to 1976 due to the inception date of the Bloomberg index. US one-month T-bills, long-term US government bonds, and long-term US corporate bonds returns are sourced from Morningstar with underlying data provided by Ibbotson Associates via Morningstar Direct. Long-Term US government and corporate bonds include bonds with an average maturity of 20 years.
7. The simulated LDI portfolio is designed to mitigate against interest rate risk. It is constructed using 1-, 7-, and 25-year constant maturity rates from the US nominal yield curve to match the duration of the retirement income liability of $1 per year over an assumed 25 years in retirement. The simulated LDI portfolio will re-weight assumed allocations to the 1-, 7-, and 25-year constant maturity bond yields based on changes in duration between the three yield curves and the retirement income liability each month. Simulated returns are calculated monthly based on changes in the yield curve. Yield curve data sourced from Federal Reserve Bank of St. Louis. The simulated portfolio is hypothetical and cannot be invested into directly. Performance does not reflect fees and expenses associated with an actual portfolio.

   **Please see additional important disclosures at the end regarding the data for T-bills, intermediate bonds, and the simulated LDI portfolio.*
8. Average of the monthly duration of the Bloomberg Barclays U.S. Aggregate Intermediate Bond Index from January 1989–December 2016.
9. The interquartile range is the difference between the 75th and 25th percentile outcomes at retirement across the 45 simulations.
10. The equity allocation used in the simulations is the Fama/French US Marketwide Index.
11. This analysis is completed using the same methodology as the previous trials, looking at 45 individual 10-year investment periods from 1971–2016. We target a 0.45 standard deviation in income terms (income volatility) and solve for how much equity allocation we have to add to each risk management asset in order to reach this point.
12. Income units show the impact of portfolio performance on income estimates. Wealth units show the impact on the account balance. See below for further descriptions.
13. Growth in income units represents the growth in the retirement income estimate for each strategy from $1, 10 years prior to retirement, to a final estimate at retirement date. Growth in wealth units represents the growth of wealth of $1 invested in each strategy over the 10-year period.
14. Standard deviation 10-year outcomes in income units measures the standard deviation between the income estimates at retirement for the 45 simulations.

DISCLOSURES

This information is provided for registered investment advisors and institutional investors and is not intended for public use.

For each **Exhibit 1–7** (except **Exhibit 3**), we assume cost and duration of $1 nominal income stream for 25 years in retirement is estimated using monthly nominal yield curves. Where certain points on the yield curve are unavailable, the curve is extrapolated from available points. The wealth level at the beginning of the 10-year window (time zero) equals the cost of income 10 years before retirement such that the estimated retirement income equals $1. At any time "t" after time zero, the estimated retirement income equals the simulated wealth level divided by the cost of retirement income at time "t". The wealth level is simulated for the LDI portfolio, intermediate bonds and T-bills using returns over each 10-year period: January 1, 1962–December 31, 1971, January 1, 1963–December 31, 1972, … , January 1, 2007–December 31, 2016. There is a total of 45 periods.

T-bills are represented by one-month Treasury bills, data from Morningstar. Not intended to represent an actual portfolio and does not reflect fees and expenses associated with an actual portfolio.

US intermediate bonds are represented using the returns of the Bloomberg Barclays US Aggregate Intermediate Bond Index for 1976–2016, and the average return of long-Term US government bonds (33.3%), long-term US corporate bonds (33.3%), and US one-month T-bills (33.3%), rebalanced monthly prior to 1976 due to the inception date of the Bloomberg index. US one-month T-bills, long-term US government and long-term US corporate bonds returns are sourced from Morningstar. The blended returns of the asset classes using the above proxies to represent US intermediate bonds prior to 1976 are backtested and hypothetical, are not representative of actual returns, and are for illustrative purposes only. Not intended to represent an intermediate bond portfolio or actual investment. Dos not reflect fees and expenses associated with an actual portfolio.

Bloomberg Barclays data provided by Bloomberg.

Indices are unmanaged and cannot be invested into directly. Their performance does not reflect fees and expenses associated with an actual portfolio.

The simulated LDI portfolio is designed to mitigate against interest rate risk. It is constructed using 1-, 7-, and 25-year constant maturity rates from the US nominal yield curve to match the duration of the retirement income liability of $1 per year over an assumed 25 years in retirement. The simulated LDI portfolio will re-weight assumed allocations to the 1,7, and 25 year constant maturity bond yields based on changes in duration between the three yield curves and the retirement income liability each month. Simulated returns are calculated monthly based on changes in the yield curve. Yield curve data sourced from Federal Reserve Bank of St. Louis. The simulated portfolio is hypothetical and cannot be invested into directly. Performance does not reflect fees and expenses associated with an actual portfolio.

These portfolios are unmanaged and cannot be invested into directly. Their performance does not reflect fees and expenses associated with an actual portfolio.

Exhibit 5: Simulated results are calculated using a fixed hypothetical allocation of 25% equities and 75% bonds (T-bills, intermediate bonds, and LDI portfolio) for three total simulations. The performance information for the allocations is based on performance of model/backtested asset allocations using indices and simulations and assumes all allocations have been rebalanced monthly.

Exhibit 7: Simulated results are calculated using a fixed hypothetical allocation of equities and bonds as provided in Exhibit 6. The performance information for the allocations is based on performance of model/backtested asset allocations using indices and simulations and assumes all allocations have been rebalanced monthly.

SIMULATED PORTFOLIO RESULTS: The performance was achieved with the retroactive application of a model designed with the benefit of hindsight; it does not represent actual investment performance. Backtested model performance is hypothetical (it does not reflect trading in actual accounts) and is provided for informational purposes only. The securities in the model may differ significantly from those in client accounts. There are limitations inherent in model allocations. In particular, model performance may not reflect the impact that economic and market factors may have had on the advisor's decision making if the advisor were actually managing client money. Simulated portfolio results do not reflect performance of an investment or strategy. Results for other time periods may differ. Actual results may vary significantly.

The simulated performance is "gross performance," which includes the reinvestment of dividends and other earnings but does not reflect the deduction of investment advisory fees and other expenses. A client's investment returns will be reduced by the advisory fees and other expenses that may be incurred in the management of the advisory account. For example, if a 1% annual advisory fee were deducted quarterly and a client's annual return were 10% (based on quarterly returns of approximately 2.41% each) before deduction of advisory fees, the deduction of advisory fees would result in an annual return of approximately 8.91% due, in part, to the compound effect of such fees. Past performance, including simulated performance, is no guarantee of future results, and there is always the risk that a client may lose money.

The equity allocation used in the simulations shown for exhibit 5 and 6 is the Fama/French Total US Market Index. This value-weighted index is constructed every month using all issues listed on the NYSE, AMEX, or Nasdaq with available outstanding shares and valid prices for that month and the month before. Exclusions: American Depositary Receipts. Source: CRSP. Dividends reinvested in the paying company until the portfolio is rebalanced. **Results shown during periods prior to each index's index inception date do not represent actual returns of the respective index. Other periods selected may have different results, including losses. Backtested index performance is hypothetical and is provided for informational purposes only to indicate historical performance had the index been calculated over the relevant time periods. Backtested performance results assume the reinvestment of dividends and capital gains.**

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