

CONTRIBUTORS

Smita Chirputkar
Director
Global Research & Design
smita.chirputkar@spglobal.com

Massi De Santis, PhD
Vice President
Dimensional Fund Advisors
massi.desantis@dimensional.com

Christine Lubieniecki
Senior Associate
Dimensional Fund Advisors
christine.lubieniecki@dimensional.com

Philip Murphy, CFA
Vice President
North American Equity Indices
philip.murphy@spglobal.com

Making STRIDEs in Evaluating the Performance of Retirement Solutions

EXECUTIVE SUMMARY

The S&P Shift to Retirement Income and Decumulation (STRIDE) Index Series incorporates an innovative risk management framework focused on providing increasing levels of clarity and stability around sustainable annual consumption in retirement. This paper tests S&P STRIDE's approach to consumption risk management and asset allocation over the period 2003 to 2016 for a hypothetical cohort of 2010 retirees by comparing the S&P STRIDE Glide Path 2010 Index Total Return to the average 2010 target date fund (TDF). Our main findings are as follows.

- The risk management approach employed by S&P STRIDE would have helped reduce uncertainty about retirement income through a period of variable interest rates, inflation, and market returns. In particular, we show how the risk management component of the S&P STRIDE Index can provide clarity and stability around affordable future consumption prior to and into retirement. The approach aims to help retirement plan participants seamlessly transition from accumulation to retirement.
- The risk management strategy can be used to reduce the impact of market, inflation, interest rate, and sequencing risks on retirement consumption.
- In contrast, we find that an industry average of traditional 2010 TDFs exhibited high variability in terms of retirement consumption over the period. Estimates of affordable consumption from such a strategy were highly sensitive to market risk, interest rates, and inflation. As a result, these strategies demonstrated large fluctuations in the level of expected retirement consumption over the period.

INTRODUCTION

Retirement can mean different things to different people. For some, retirement means a complete stop from working. For others, it means ending a professional career in pursuit of something new. Regardless of the definition, retirement normally marks the point when the primary source of income ends and savers begin to rely on their accumulated balances to

maintain their standard of living. Therefore, in the context of retirement, a primary goal is often to be able to sustain an inflation-adjusted stream of income, or a level of consumption associated with a standard of living, throughout retirement and to have relevant and meaningful information about what that level of sustainable consumption stream is before and throughout retirement.

The S&P STRIDE Indices use an asset allocation framework designed to balance the opportunity to grow assets with the need to reduce the uncertainty of how much in-retirement income a saver's balance can afford.

The S&P STRIDE Indices use an asset allocation framework designed to balance the opportunity to grow assets with the need to reduce the uncertainty of how much in-retirement income a saver's balance can afford. The indices use a glide path that transitions from growth-seeking assets to assets that can support a more stable level of inflation-adjusted, in-retirement income. The indices are designed to be a benchmark for market participants saving to fund consumption in retirement.

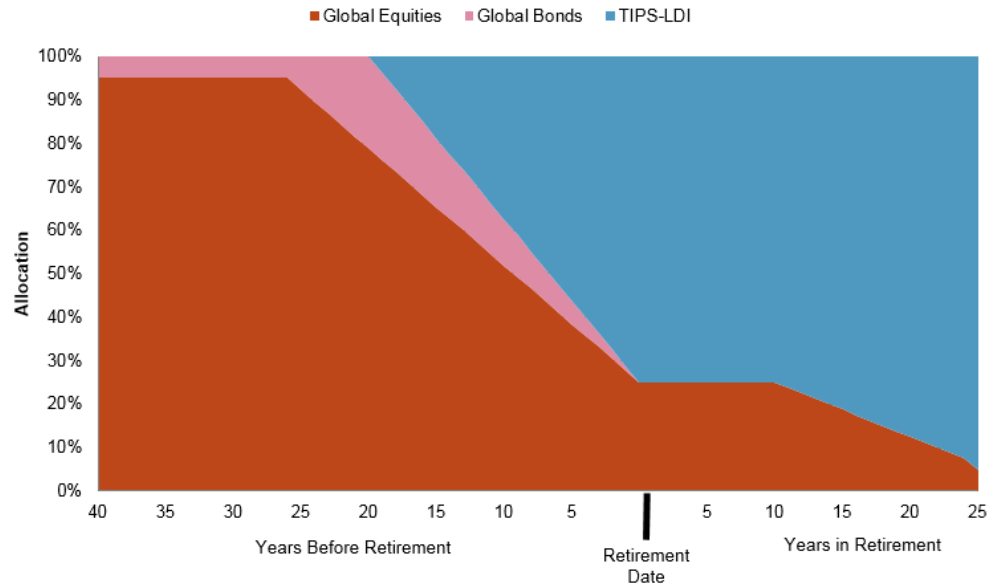
In this paper, we use the S&P STRIDE Indices to benchmark traditional TDFs, which are investment vehicles used predominantly by people saving for retirement. In particular, we focus on target date strategies that have moved from accumulation to retirement in the past 10-15 years, so we can evaluate their performance in terms of retirement income. To do that, we show how STRIDE data can be used to translate account balance performance into information about how much in-retirement income or consumption the account balance can be expected to afford over time. Our analysis illustrates how a retirement solution that manages uncertainty about how much in-retirement income a saver's balance can afford might provide more robust risk management and greater clarity on progress toward retirement goals.

The S&P STRIDE Index Series is published under agreements between S&P Dow Jones Indices and Dimensional Fund Advisors. In development of the S&P STRIDE Index Series, S&P Dow Jones Indices used ideas from life cycle finance and an innovative risk management approach to funding consumption in retirement. S&P Dow Jones Indices thanks Robert Merton for his pioneering work in these fields, as well as Dimensional Fund Advisors for their contributions in the development of the S&P STRIDE Index Series.

A PRIMER ON THE S&P STRIDE INDEX SERIES

The S&P STRIDE Index Series combines a target date glide path with a risk management framework designed to reduce uncertainty about future retirement consumption. It contains multi-asset-class indices composed of three broad asset classes: global equities, global fixed income, and a portfolio of inflation-protected securities intended to match to the investment and consumption horizon of cohorts retiring in five-year intervals, or vintages. Each vintage is designed to cover a full life cycle, including working years from ages 25 to 65 and in-retirement years from ages 65 to 90. The glide path allocation is illustrated in Exhibit 1.

Exhibit 1: S&P STRIDE Indices' Glide Path



Source: S&P Dow Jones Indices LLC and Dimensional Fund Advisors. Chart is provided for illustrative purposes. TIPS-LDI: Treasury Inflation-Protected Securities, liability-driven investing.

We can divide the glide path into three phases to examine how the allocation shifts over time.

We can divide the glide path into three phases to examine how the allocation shifts over time. The first phase goes from 40 to 20 years before retirement and focuses on diversified global stock and bond indices that are expected to grow over time. The second phase is a transition phase that goes from 20 years' pre-retirement to retirement. In this phase, the index weight is gradually shifted from growth assets to a risk management strategy designed to reduce uncertainty about the level of future retirement consumption the portfolio can afford. The final stage is the in-retirement or decumulation phase, where the main goal of the index is to mitigate uncertainty about the level of consumption that can theoretically be sustained from accumulated savings.

During the growth phase between 40 and 20 years before retirement, the S&P STRIDE glide path has a 95% allocation to equities. This is higher than the average allocation across TDFs weighted by assets. For example, as of December 2016, the average equity allocation ranged from 85% to 88% for TDFs dated 2040 to 2060.¹ At and throughout retirement, the equity exposure of the S&P STRIDE Indices is on the conservative end of the range of asset allocations across TDFs. While the S&P STRIDE Indices have a 25% equity allocation at retirement, the 2015 TDF average is 47% (ranging from 21% to 56% across funds) and the 2010 TDF average is 39% (ranging from 16% to 45%).²

The primary objective of the S&P STRIDE glide path near or in retirement is to manage uncertainty about the amount of retirement consumption that

¹ Asset weighted average, using available target date funds from the Morningstar database as of December 2016.

² As of December 2016.

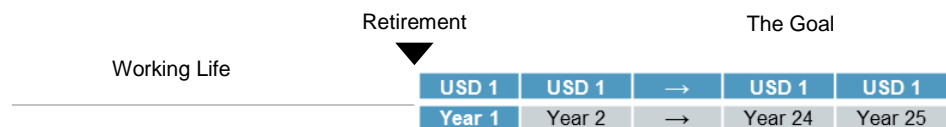
An allocation of 25% equities at retirement aims to constrain the potential losses in the event of poor stock market performance.

accumulated savings can afford. History has shown that during financial or other crises, both equity markets and the economy may suffer declines. An allocation of 25% to equities at retirement aims to constrain the potential losses in the event of poor stock market performance. This explains the more conservative equity exposure of the S&P STRIDE Indices at and throughout retirement and the high allocation to a risk management strategy designed to reduce uncertainty around the retirement consumption that the asset allocation can support. For the first 10 years after the target date, the target equity allocation remains at 25%. This remaining allocation to global stocks provides potential growth to possibly increase the consumption amount that can be afforded during the initial 25-year horizon. After 10 years in retirement, a portion of the consumption growth assets is “sold off” (removed from the Index portfolio) in an effort to provide additional retirement consumption. This is the rationale for a gradual decline in equity allocation 10 years after the target date.

S&P STRIDE’S RETIREMENT HORIZON AND RISK MANAGEMENT FRAMEWORK

S&P STRIDE’s risk management strategy begins with defining both a retirement goal and its expected horizon. The goal is defined as annual inflation-protected income or consumption over a horizon of 25 years, starting at retirement. The 25-year horizon includes life expectancy at age 65 plus a buffer to account for uncertainty about life expectancy. Assuming participants retire at age 65, this covers the period between age 65 and age 90. The goal is indexed to a USD 1 annual inflation-adjusted consumption stream over the 25 years, as illustrated in Exhibit 2.

Exhibit 2: USD 1 Annual Inflation-Adjusted Consumption Stream



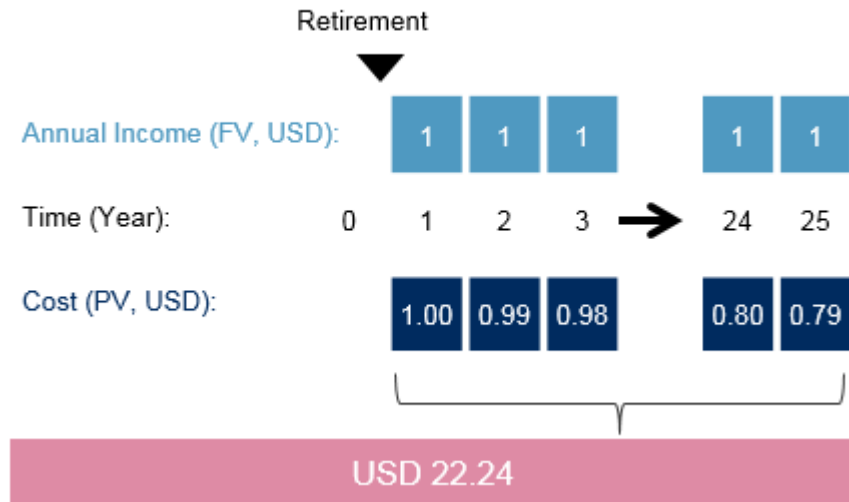
Source: S&P Dow Jones Indices LLC. Chart is provided for illustrative purposes.

The starting point for the consumption stream for each vintage is linked to the target date. For example, the 2025 index assumes that withdrawals will start in 2025 and end in 2049, the 2030 index assumes withdrawals will start in 2030 and end in 2054, and so on.

At any point in time, the consumption stream illustrated in Exhibit 2 can be viewed as a liability. This liability has a cost, which can be computed as the present value of the future expected cash flows. Because the liability is in inflation-adjusted terms, this cost can be estimated using real interest rates. For example, assuming a real interest rate of 1%, the cost of a 25-year USD 1 inflation-adjusted stream of income is USD 22.24, as illustrated in Exhibit 3.

**Exhibit 3: The Cost of a Generalized Retirement Income Liability, "GRIL"
Today's Cost of a 25-Year USD 1 Inflation-Adjusted Stream of Income**

If interest rates go up, the cost of GRIL goes down, and vice versa.



Source: S&P Dow Jones Indices LLC and Dimensional Fund Advisors. Chart is provided for illustrative purposes. Assuming first year of income begins immediately. Present value calculation assumes a discount rate of 1%.

In the [S&P STRIDE Index Series Methodology](#), this liability is referred to as the generalized retirement income liability (GRIL). S&P Dow Jones Indices computes a monthly present value, or cost, of GRIL for each retirement vintage using prevailing real interest rates. The liability decreases by USD 1 each year into retirement, so that after the first year, only 24 years of payments are expected, after the second year, only 23 payments are expected, and so on.

The cost of GRIL fluctuates with changes in inflation and interest rates. Much like the relationship between bond prices and interest rates, if interest rates go up, the cost of GRIL goes down, and vice versa. This implies that, for a given level of account balance, the amount that can be consumed is higher when interest rates are higher, and vice versa. Interest rates constitute a risk to the level of consumption that can be sustained from a level of savings. Inflation has a similar effect—the purchasing power of an account balance declines with inflation and increases with deflation.

The sensitivity of GRIL to real interest rates and inflation depends on the maturity of its cash flows. The longer the average maturity or, more technically, the duration of the cash flow, the higher the sensitivity.³ An investment that matches the sensitivity of GRIL to interest rates and inflation can reduce the uncertainty about how much consumption can be sustained with an investment. One can attempt to achieve this by computing the duration of the GRIL and constructing an inflation-protected

³ Duration is a measure of sensitivity of a cash flow stream (like a bond) to interest rates. It is a weighted average maturity across the cash flows, with weights given by the relative present value of each cash flow.

portfolio of government bonds with the same duration. This is an example of liability-driven investing (LDI). The S&P STRIDE Index Series constructs the LDI strategy for each target date by combining a set of Treasury Inflation-Protected Securities (TIPS) to match the duration of the appropriate GRIL.⁴

How does this investment strategy reduce uncertainty about future consumption? The sensitivity of the strategy to inflation and interest rate risks is the same as that of the GRIL. When interest rates go up, the value of the TIPS-LDI index allocation tends to decrease along with the value of GRIL. When interest rates go down, the converse is true, with the values of the TIPS-LDI index allocation and GRIL tending to increase. Similarly, the value of the TIPS-LDI index allocation tends to rise alongside GRIL when inflation is positive, and vice versa, thus protecting the future purchasing power represented by S&P STRIDE.

The sensitivity of the strategy to inflation and interest rate risks is the same as that of the GRIL.

USING THE S&P STRIDE TO EVALUATE THE PERFORMANCE OF TDFs

Given their design, the S&P STRIDE Indices can be used to analyze how an investment solution that balances the tradeoff between growth opportunities and income risk management has performed in various market, inflation, and interest rate environments. For the same reasons, and because providing income in retirement is one of the primary goals of participants in retirement accounts, the S&P STRIDE Indices can be used to evaluate the performance of traditional TDFs under the same scenarios.

As a proxy for traditional TDFs, we take the asset-weighted average returns of all Morningstar-categorized TDFs. Back-tested hypothetical returns for S&P STRIDE Indices are available from January 2003 to the present. The observed variability in market and interest rates over this period gives us a useful case study for the purpose of our analysis. We focus the analysis on the S&P STRIDE Glide Path 2010 Index. For this index, the 2003-2016 period covers the seven years leading up to retirement and the first seven years into retirement, a key transitional period from accumulation to early retirement.

The GRIL measure allows us to translate traditional performance (normally viewed in units of returns or account balance) into retirement income or consumption units, which is important because the performance that matters to retirees is in terms of affordable consumption in retirement. We will look at performance in consumption units after a review of performance in traditional, account balance terms.

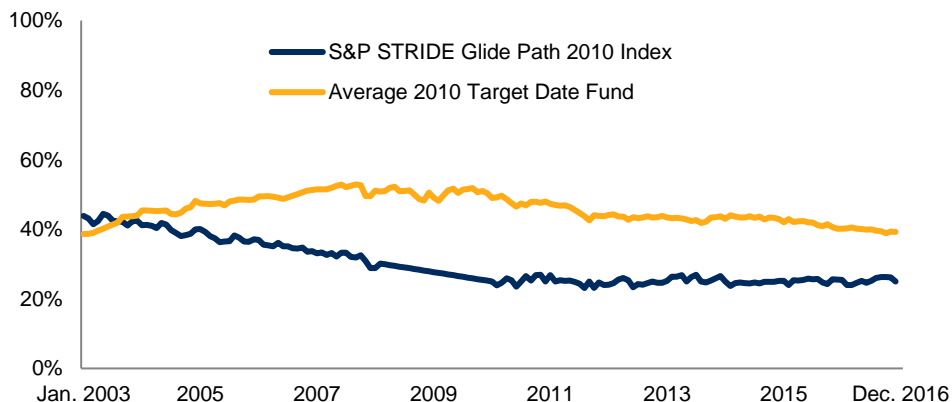
⁴ For more details about STRIDE design and methodology, see Gerard O'Reilly, Massi De Santis, Philip Brzenk, Aye Soe, Peter Tsui, "[Introducing the S&P STRIDE Index Series](#)," S&P Dow Jones Indices, 2016, and the [S&P STRIDE Index Methodology](#), S&P Dow Jones Indices, 2016.

2010 Target Date Asset Allocation Comparison and Implications for Risk Management

The S&P STRIDE allocation to equities follows the glide path referenced in Exhibit 1. As seen in Exhibit 4, the 2010 equity allocation was 43% in January 2003 and reached 25% by December 2009. It then stayed close to that level throughout the remaining sample period. In January 2003, the equity allocation across the 2010 TDFs ranged from 17% to 63%. The asset-weighted average allocation was approximately 40%, similar to the S&P STRIDE Glide Path 2010 Index.⁵ Over the period studied, the sample of funds included in the asset-weighted average changed as additional fund families released 2010 TDFs. Not only did some of the new fund families have equity allocations above 50%, but some existing fund families increased their equity allocation during the period.⁶ This explains why the asset-weighted average for TDFs was 50% by December 2009, with allocations across fund families ranging from 15% to 64%.

The asset-weighted average allocation was approximately 40%, similar to the S&P STRIDE Glide Path 2010 Index.

Exhibit 4: Allocation to Equities – Back-tested S&P STRIDE Glide Path 2010 Index Versus Average 2010 TDF



Source: S&P STRIDE Glide Path 2010 Index data from S&P Dow Jones Indices LLC. Average 2010 TDF is the asset-weighted average across the TDF families included in the Morningstar universe. As of December 2016, the data included 57 TDF families. Past performance does not guarantee future results. Chart is provided for illustrative purposes. Data from January 2003 to December 2016 is back-tested. Back-tested performance is not actual performance but is hypothetical. Indices are not available for direct investment. Index performance does not reflect the expenses associated with the management of an actual portfolio. Please see the Performance Disclosures at the end of this document for more information regarding the inherent limitations associated with back-tested performance. For more information, see “S&P STRIDE Index Series Description and Disclosures” in the Appendix.

The S&P STRIDE Indices lower weight to equities reflects their focus on attempting to reduce uncertainty about retirement consumption. As discussed earlier, three main investment risks drive uncertainty around future consumption: market risk, interest rates, and inflation. For savers

⁵ Values for the TDF industry computed using data from Morningstar as of December 2016. If for a given month the equity allocation of a fund is not available, we use the closest previous and subsequent months with observed allocation for that fund and interpolate between the two.

⁶ Some TDF families did increase allocation prior to retirement. For an analysis, see “Bait and Switch: Glide Path Instability,” Ibbotson Morningstar, Sept. 12, 2011.

For savers that are close to retirement, the sequence in which they experience returns may also affect their ability to sustain a consistent level of consumption.

that are close to or are already drawing down from their portfolios, the sequence in which they experience returns may also affect their ability to sustain a consistent level of consumption. For example, a sequence of poor market performance early in retirement can increase the likelihood of running out of money early. Market risk is not the only cause of sequencing risk. Interest rates and inflation risks also matter. For example, an unexpected rise in inflation early in retirement increases the likelihood of running out of money early. A traditional allocation to stocks and bonds introduces sequencing risk because of market, interest rate, and inflation risks.

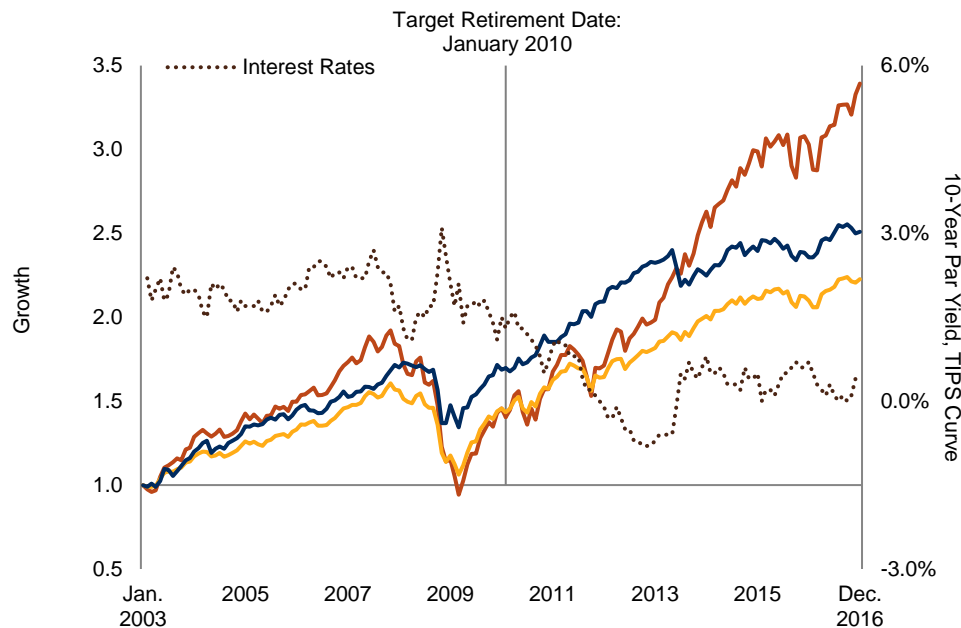
The glide path of the S&P STRIDE Indices is designed to reduce sequencing risk. The dedicated allocation to assets that hedge against the effects of inflation and interest rates on future consumption means that sequencing risk only enters through the exposure to growth assets.

Account Balance Performance

We start by measuring performance in terms of current theoretical account balance, or wealth units. This is a useful starting point, as it is how most traditional performance analysis is conducted, and it provides information about different retirement strategies in various market environments.

Exhibit 5 illustrates the cumulative growth of the S&P STRIDE Glide Path 2010 Index and the average 2010 TDF from 2003 to 2016 (net of fees). To help interpret results, Exhibit 5 also shows the performance of the [S&P 500®](#) over the same period, and we plot the 10-year interest rate as published by the U.S. Federal Reserve Board on a secondary axis.

Exhibit 5: Growth of Wealth and Performance Statistics



Differences in asset allocation are the main drivers of performance in account balance units.

	S&P 500	Average 2010 Target Date Fund	S&P STRIDE Glide Path 2010 Index
Return	9.1%	5.8%	6.8%
Standard Deviation	13.7%	8.2%	8.1%

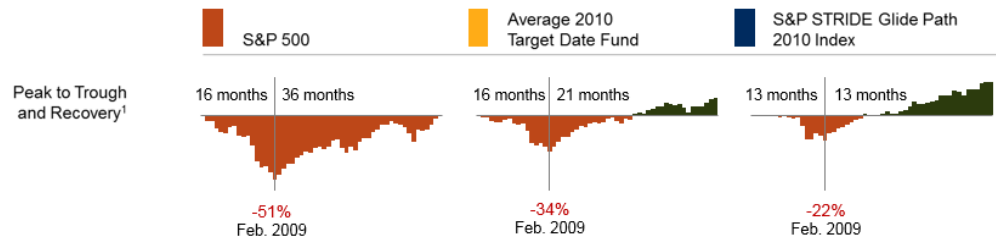
Source: S&P STRIDE Glide Path 2010 Index data from S&P Dow Jones Indices LLC. The average 2010 TDF is the asset-weighted average across the TDF families included in the Morningstar universe. As of December 2016, the data included 57 TDF families. Past performance does not guarantee future results. Chart and table are provided for illustrative purposes and reflect back-tested index data and hypothetical historical performance. Please see the Performance Disclosure at the end of the document for more information regarding the inherent limitations associated with back-tested performance. Indices are not available for direct investment. Index performance does not reflect the expenses associated with the management of an actual portfolio. For more information, see “S&P STRIDE Index Series Description and Disclosures” in the Appendix.

Differences in asset allocation are the main drivers of performance in units. First, a greater allocation to equities at the onset of the financial crisis caused a larger drop for the average 2010 TDF than for the S&P STRIDE Glide Path 2010 Index. The emphasis on the TIPS-LDI index allocation also benefited asset growth, given the decline in interest rates between 2009 and the first quarter of 2013. Exhibit 5 shows that the monthly volatility of the average 2010 TDF and the STRIDE Glide Path 2010 Index are similar over the period considered (8.2% versus 8.1%).

The STRIDE TIPS-LDI index allocation matches the duration of the 25-year theoretical cash flow starting at retirement. The duration of this “cash flow” varies with interest rates and with time to and through retirement. At the point of retirement (2010 in this case), it is expected to be around 10-12 years. This is a longer duration than the typical duration across TDFs, which averages about five years (see section titled “The LDI Risk Management Strategy in Practice” for a discussion).

Exhibit 6 focuses in on the performance of the three strategies during the peak-to-trough period for the S&P 500, October 2007 to February 2009, and the following recovery. Over a 16-month period ending February 2009, the S&P 500 fell 51% from its peak, and it took 36 months to return to the previous high.

Exhibit 6: Maximum Drawdown and Recovery of Account Balance



1. Represents maximum loss/drawdown for peak to trough of each index from January 2003-December 2016.

Source: S&P 500 and S&P STRIDE Glide Path 2010 Index data from S&P Dow Jones Indices LLC. The average 2010 TDF is the asset-weighted average across the TDF families included in the Morningstar universe. As of December 2016, the data included 57 TDF families. Data from Morningstar Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects back-tested hypothetical historical performance. Please see the Performance Disclosure at the end of the document for more information regarding the inherent limitations associated with back-tested performance. Indices are not available for direct investment. Index performance does not reflect the expenses associated with the management of an actual portfolio. For more information, see “S&P STRIDE Index Series Description and Disclosures” in the Appendix.

The difference in performance between the Average 2010 TDF and the S&P STRIDE Glide Path 2010 Index stems from a fundamental difference in risk management between the two strategies.

It is important to note that over any given period, differences in allocations for one strategy could cause it to perform better than the others; for example, in rising equity markets, the S&P 500 would likely outperform the Average TDF and S&P STRIDE Glide Path 2010 Index. However, market downturns, changes in interest rates, and inflation levels cannot be predicted in advance. Exhibit 6 serves as a good reminder that retirement outcomes can be meaningfully affected by these types of events. The difference in performance between the average 2010 TDF and the S&P STRIDE Glide Path 2010 Index seen in Exhibit 6 may stem from a fundamental difference in risk management between the two strategies. To analyze the implications of these differences in terms of the theoretical amount of income retirees can provide for themselves in retirement, we need to evaluate performance in income terms.

Translating Account Balance Performance Into Income Units Using GRIL

For market participants planning for retirement consumption, the key performance questions can include: How much consumption can I expect my accumulated savings to sustain? What is the uncertainty or variability of that expectation? Evaluating performance in consumption units is important because there are additional factors beyond an account balance that affect retirement income. For example, if an account balance increases at a rate less than inflation, expected income is reduced. Similarly, a lower interest rate means one can sustain less income from the same account balance. Conversely, a lower account balance when interest

rates increase may mean the level of income that can be sustained from savings is unchanged or may be even higher.

We can convert wealth units into consumption units by using the cost, or present value, of GRIL, which is an estimate of the cost of USD 1 of inflation-adjusted income for 25 years commencing at the respective target date. Remember that because the GRIL uses real interest rates (i.e., market data on inflation-protected bonds with various maturities), it gives us information about what it would cost to build a bond portfolio that pays USD 1 each year in retirement, adjusted for inflation, assuming a retirement horizon of 25 years. By dividing an account balance by the appropriate cost of GRIL, participants can estimate the amount of income that savings could sustain over time.

By dividing an account balance by the appropriate cost of GRIL, participants can estimate the amount of income that savings could sustain over time.

Let’s look at an example that describes the concept. In December 2009, Jill decides to retire next month at age 65. She has accumulated USD 1,000,000 in savings and wants to determine the inflation-adjusted consumption that her account balance can sustain over the next 25 years. She can estimate this amount by dividing USD 1,000,000 by USD 20.01, which is the cost of 2010 GRIL at that time. Jill finds that USD 1,000,000 provides an estimated consumption level of USD 49,975 per year for 25 years on an inflation-adjusted basis (Exhibit 7).

Exhibit 7: From Account Balance to Retirement Income

$$\frac{\text{Account Balance}_{(t)}}{\text{PV (GRIL)}_{(t)}} = \text{Estimated Annual Income Stream}$$

Above equation expressed in terms of an income stream commencing immediately

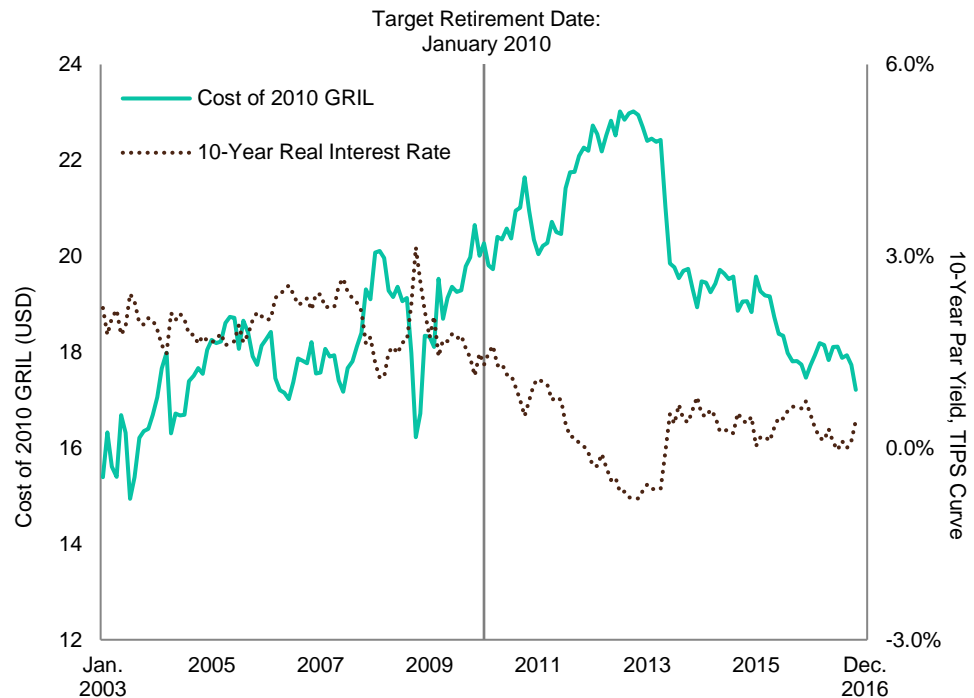
$$\frac{\text{USD 1,000,000}_{(Dec. 2009)}}{\text{USD 20.01}_{\text{PV(GRIL)}_{(Dec. 2009)}}} = \text{USD 49,975}_{\text{Per year for 25 years on an inflation-adjusted basis}}$$

Source: S&P Dow Jones Indices LLC and Dimensional Fund Advisors. Chart is provided for illustrative purposes.

This framework can be used for planning purposes at any point in time leading up to and during retirement, providing meaningful information about retirement readiness and allowing market participants to monitor their progress toward achieving their goals.

The cost of retirement consumption is driven by changes in real rates and inflation. Exhibit 8 shows how the cost of S&P 2010 GRIL changes over time, along with 10-year real interest rate (on the secondary axis).

Exhibit 8: Cost of 2010 GRIL Value Over Time and 10-Year Real Rate



Source: S&P Dow Jones Indices LLC and U.S. Federal Reserve System. Data from January 2003 to December 2016. Chart is provided for illustrative purposes.

For Jill, this means that over time, the estimated retirement consumption level will vary, unless her account balance moves in tandem with the cost of retirement consumption. For example, the variability observed in Exhibit 8 shows that a constant account balance can be highly volatile in terms of estimated retirement consumption.

A constant account balance can be highly volatile in terms of estimated retirement consumption.

THE LDI RISK MANAGEMENT STRATEGY IN PRACTICE

The uncertainty about the cost of consumption driven by interest rates and inflation can be hedged using the S&P STRIDE TIPS-LDI index allocation. The estimated consumption over time from this strategy can be calculated by simply dividing the performance of the LDI strategy in account balance units by the cost of GRIL every month (see Exhibit 9). Assuming an account balance of USD 1,000,000 at the beginning of the period (January 2003), initial affordable consumption starts at about USD 65,000. By December 2009, right before retirement, the amount of affordable consumption under the LDI strategy reaches about USD 78,000 in nominal terms (Exhibit 9). However, over these seven years, cumulative inflation was about 19%. This means that by December 2009, the amount of real affordable consumption for the LDI strategy was about USD 65,000 per year in January 2003 U.S. dollars, just like the initial consumption estimate

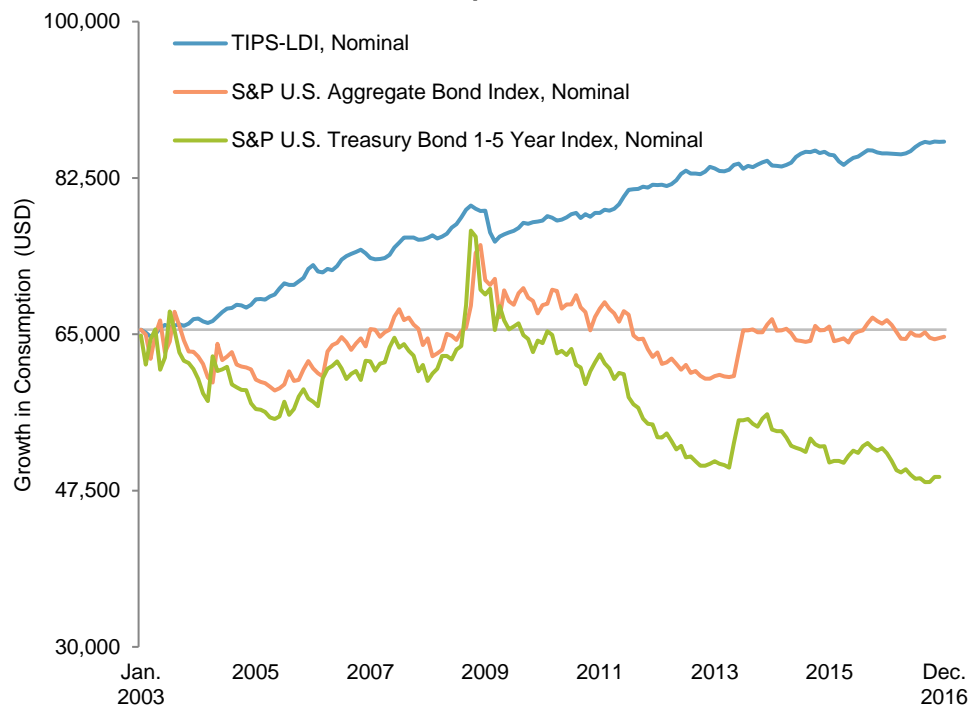
(see Exhibit 9).⁷ In January 2010, we assume a withdrawal amount equal to the amount implied by GRIL each year—so USD 78,000 in the first year, which is equivalent to USD 65,000 in 2003 U.S. dollars.

Stability in the inflation-adjusted consumption estimates is a reflection of the risk management utilized by the S&P STRIDE Indices.

Stability in the inflation-adjusted consumption estimates is a reflection of the risk management utilized by the S&P STRIDE Indices, effectively hedging for changes in interest rates and inflation. The light blue dashed line in Panel B illustrates the evolution of the estimated, inflation-adjusted consumption over time and its stability around the original USD 65,000 estimate in 2003 U.S. dollars (see Exhibit 9).

Exhibit 9: Evolution of Estimated Consumption, TIPS-LDI Versus Intermediate Bonds

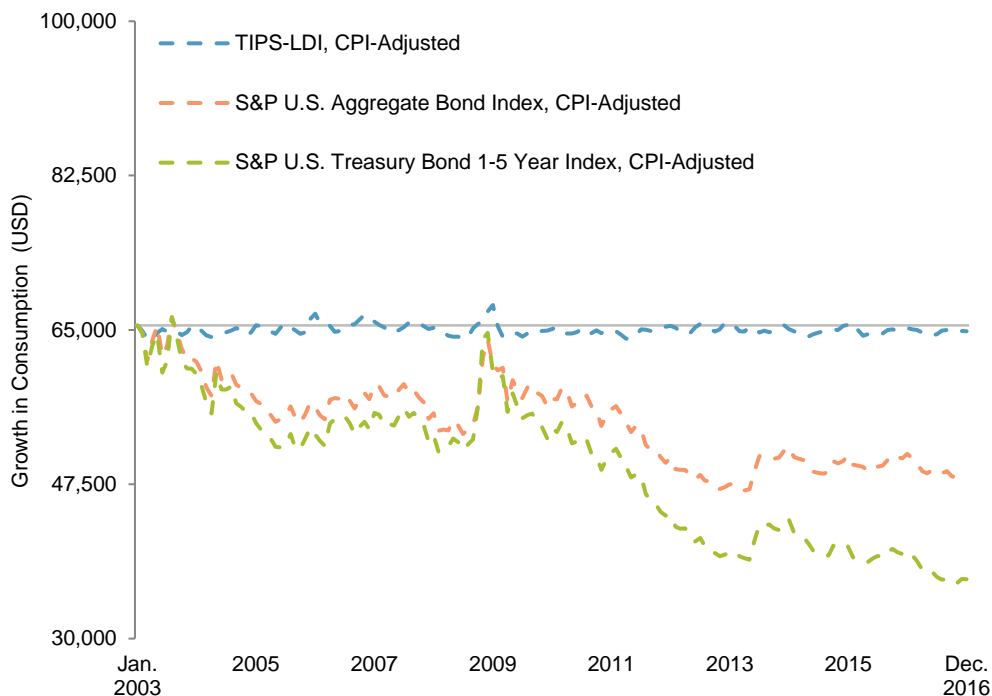
Panel A: Nominal Estimated Consumption



Source: S&P Dow Jones Indices LLC and Dimensional Fund Advisors. Back-tested data from January 2003 to December 2016. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects back-tested and hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

⁷ In other words, because of inflation, the USD 78,000 estimate in December 2009 can afford the same basket of goods and services as USD 65,000 in January 2003.

Panel B: CPI-Adjusted Estimated Consumption (2003 U.S. Dollars)



Source: S&P Dow Jones Indices LLC and Dimensional Fund Advisors. Back-tested data from January 2003 to December 2016. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects back-tested hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Panel C: Theoretical Estimated Consumption

RISK MANAGEMENT STRATEGY	JANUARY 2003 (USD)	DECEMBER 2009 (USD)	MARCH 2013 (USD)
TIPS-LDI, Nominal	64,180	77,728	83,408
TIPS-LDI, CPI-Adjusted	64,893	65,109	64,817
S&P U.S. Aggregate Bond Index Nominal	64,955	68,259	60,222
S&P U.S. Aggregate Bond Index CPI-Adjusted	64,669	57,178	46,798
S&P U.S. Treasury Bond 1-5 Year Index Nominal	64,871	64,282	50,365
S&P U.S. Treasury Bond 1-5 Year Index CPI-Adjusted	64,585	53,846	39,139

Source: S&P Dow Jones Indices LLC. Nominal represents the income estimate seen in nominal U.S. dollars over time; CPI-adjusted represents real purchasing power. Table is provided for illustrative purposes and reflects back-tested hypothetical historical performance. Indices are not available for direct investment. Index performance does not reflect the expenses associated with the management of an actual portfolio. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Once retirement commences, the liability considered by GRIL declines by USD 1 for each year into retirement.

Prior to the target retirement date (January 2010, in the case of Exhibit 9), the liability considered by GRIL is a 25-year stream of annual USD 1 inflation-adjusted income. Once retirement commences (again, January 2010 in Exhibit 9), the liability considered by GRIL declines by USD 1 for each year into retirement (e.g., 24 years in 2011, 23 years in 2012, etc.). Exhibit 9 assumes that at and throughout retirement, each month, Jill withdraws one-twelfth of the estimated consumption. For example, in

January 2010, the estimated consumption is USD 78,000, so she “withdraws” USD 6,500 for the month, and her account is decreased by the same amount. Over time, the estimate under the LDI investment increases to keep up with inflation (light blue line in Panel A of Exhibit 9), and her theoretical purchasing power stays close to the initial estimate of USD 65,000 in January 2003 U.S. dollars (light blue dashed line in Panel B of Exhibit 9).

Let’s compare the LDI performance with other fixed income strategies used in TDFs. A common strategy across TDFs is to achieve broad exposure to the bond market during accumulation and increase focus on shorter-term government and Treasury securities as the target date nears. For example, consider the [S&P U.S. Aggregate Bond Index](#) as representing the performance of a U.S. market-wide strategy and the [S&P U.S. Treasury Bond 1-5 Year Index](#) as representing the performance of short- to intermediate-term U.S. Treasuries. As seen in Exhibit 9, both of these indices have greater variability in inflation-adjusted consumption units than the S&P STRIDE’s 2010 TIPS-LDI Allocation (TIPS-LDI Allocation). The annualized volatility is 7.1% and 8.7% for the two indices, respectively, versus 1.9% for the S&P STRIDE LDI. More importantly, at the end of 2009, estimated nominal consumption for the two indices was USD 68,259 and USD 64,282, respectively (USD 57,178 and USD 53,846 in January 2003 U.S. dollars). This means that real consumption declined from the January 2003 level by about 13% and 18%, respectively, for the S&P U.S. Aggregate Bond Index and the S&P U.S. Treasury Bond 1-5 Year Index.

Additionally, between October 2008 and March 2013, interest rates declined, causing the cost of GRIL to increase (see Exhibit 8). Over this period, returns of the S&P U.S. Aggregate Bond Index and the S&P U.S. Treasury Bond 1-5 Year Index did not keep pace, resulting in a decline in estimated consumption. Assuming the same withdrawals as under the LDI scenario, by March 2013 estimated nominal consumption for the two indices declined to USD 60,222 and USD 50,365, respectively (USD 46,798 and USD 39,139 in January 2003 U.S. dollars).⁸ Our analysis shows that fixed income investments not tied to the retirement liability or GRIL, like the S&P U.S. Aggregate Bond Index and S&P U.S. Treasury Bond 1-5 Year Index, can subject savers to interest rate and inflation risk, both of which also introduce sequencing risk in retirement.⁹ These results also have implications for our comparison of the S&P STRIDE Glide Path 2010 Index against the average 2010 TDF in consumption units, as traditional TDFs tend to allocate more assets to short-term fixed income as the target date approaches. Duration mismatches between TDFs’ fixed

Fixed income investments not tied to the retirement liability or GRIL can subject savers to interest rate and inflation risk.

⁸ The discrepancy between the S&P U.S. Aggregate Bond Index and S&P U.S. Treasury Bond 1-5 Year Index for the period is due in part to the S&P U.S. Aggregate Bond Index’s exposure to a positive credit premium in the period.

⁹ To learn more about using LDI in retirement planning, see Massi De Santis, “Retirement Planning: An Introduction to Liability-Driven Investing”, Dimensional Fund Advisors, 2015.

income allocations and required future retirement income are common. Looking across TDFs, the average effective duration is five, with seemingly little variation approaching retirement.¹⁰

Having this risk management tool may help market participants to decide how much uncertainty in future consumption they are willing to take in order to increase expected future income. In contrast, by combining short- to intermediate-maturity bonds to a growth portfolio, market participants may reduce expected returns (relative to a growth portfolio) without a corresponding reduction in interest rate, inflation, sequencing risk, and ultimately in-retirement consumption risk. Thus, they could obtain a worse risk/return tradeoff relative to the LDI.

Systematically Reducing Income Risk

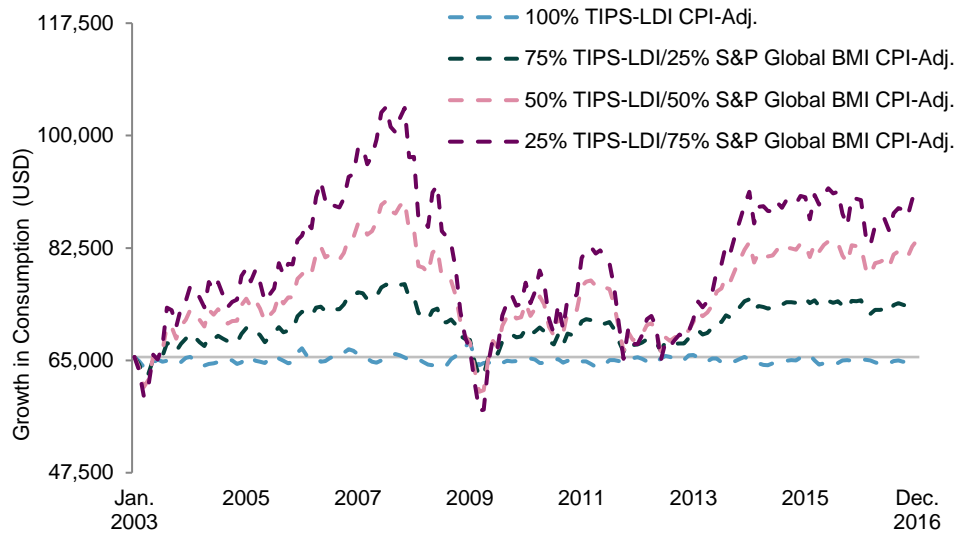
We saw above that the S&P STRIDE's 2010 TIPS-LDI Allocation is effective and may be superior to short-term fixed income at hedging inflation and interest rate risks, as well as including long-term income assets. From 2003 to 2016, a hypothetical portfolio fully invested in the S&P STRIDE 2010 TIPS-LDI allocation would have grown nominal income at approximately the growth rate of CPI, essentially resulting in an inflation-protected income stream for 2010 retirees.

The actual S&P STRIDE glide path transitions gradually from primarily growth assets to TIPS-LDI. It reaches a 75% allocation to TIPS-LDI at retirement. In order to demonstrate how income risk may be mitigated as this shift occurs, we now seek to illustrate the income-generating performance of several hypothetical static allocations of TIPS-LDI and global equities.

Having the right risk management allows market participants to decide how much uncertainty in future consumption they are willing to take in order to increase expected future income.

¹⁰ Source: Morningstar, based on effective duration on 2,364 share classes of TDFs in the Morningstar Direct Open End Fund Database, as of December 2016.

Exhibit 10: The Historical Trade-off Between Inflation-Adjusted Income Growth and Income Security With Varying Levels of Global Equities Exposure (in 2003 U.S. dollars)



Source: S&P Dow Jones Indices LLC and Dimensional Fund Advisors. Back-tested data from January 2003 to December 2016. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects back-tested hypothetical historical performance. Indices are not available for direct investment. Index performance does not reflect the expenses associated with the management of an actual portfolio. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance. Blended indices are hypothetical.

One can think of the S&P STRIDE glide path as shifting through the static profiles embodied in the exhibit, from greater income growth potential to enhanced income security.

Exhibit 10 compares the previous example of a 100% TIPS-LDI allocation to various hypothetical, monthly rebalanced portfolios of TIPS-LDI and the S&P Global BMI Net Total Return Index. The S&P STRIDE glide path progresses from nearly all equity (95%) to 75% TIPS-LDI/25% global equities at the target date. Exhibit 10 depicts the trade-off between income growth and income security at varying levels of static equity exposure, thereby providing a means for grasping the potential impact of S&P STRIDE's glide path strategy on the mitigation of income risk through time. One can think of the S&P STRIDE glide path as shifting through the static profiles embodied in the exhibit, from greater income growth potential to enhanced income security, except that in the live index this transition is done on a continuous basis and more smoothly than would be implied by shifting across static allocations.

Several characteristics of the hypothetical static portfolios may further our understanding of the basic trade-off between income growth and income risk. In Exhibit 11, we see that the most aggressive portfolio (75% equities) would have theoretically generated 1.4 times the inflation-adjusted income of the 100% TIPS-LDI portfolio by December 2016. However, that income growth would have been accompanied by a significantly higher level of income uncertainty. The annualized standard deviation of hypothetical income afforded with the most aggressive portfolio is about 12.8%, compared with 2.3% for the 100% TIPS-LDI allocation. In other words, to earn 40% more income, one would have had to accept well over five times

the risk (as measured by standard deviation). On the other hand, a significant degree of hypothetical income growth was obtainable with a modest amount of equity exposure and a relatively mild increase in income uncertainty—as shown by the 75% TIPS-LDI/25% equities portfolio.

Exhibit 11: Income Growth Versus Income Volatility

Based on CPI Adjusted Income Affordability (2003 U.S. dollars), 2003-2016	25% TIPS-LDI/ 75% S&P BMI	50% TIPS-LDI/ 50% S&P BMI	75% TIPS-LDI/ 25% S&P BMI	100% TIPS-LDI
Multiple of 100% TIPS-LDI Income as of December 2016	1.4	1.3	1.2	NA
Annualized Standard Deviation of Income (%)	12.8%	8.7%	4.7%	2.3%
Multiple of Standard Deviation of 100% TIPS-LDI Income	5.4	3.7	2.0	NA

Source: S&P Dow Jones Indices and Dimensional Fund Advisors. Back-tested data from 2003 to 2016. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects back-tested hypothetical historical performance. Indices are not available for direct investment. Index performance does not reflect the expenses associated with the management of an actual portfolio. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance. Blended indices are hypothetical.

The 75% TIPS-LDI/25% equities portfolio is quite similar to S&P STRIDE’s allocation at each index’s target date.

We are now ready to compare the S&P STRIDE Glide Path 2010 Index against the average 2010 TDF in consumption units.

Evaluating Index Performance in Consumption Units

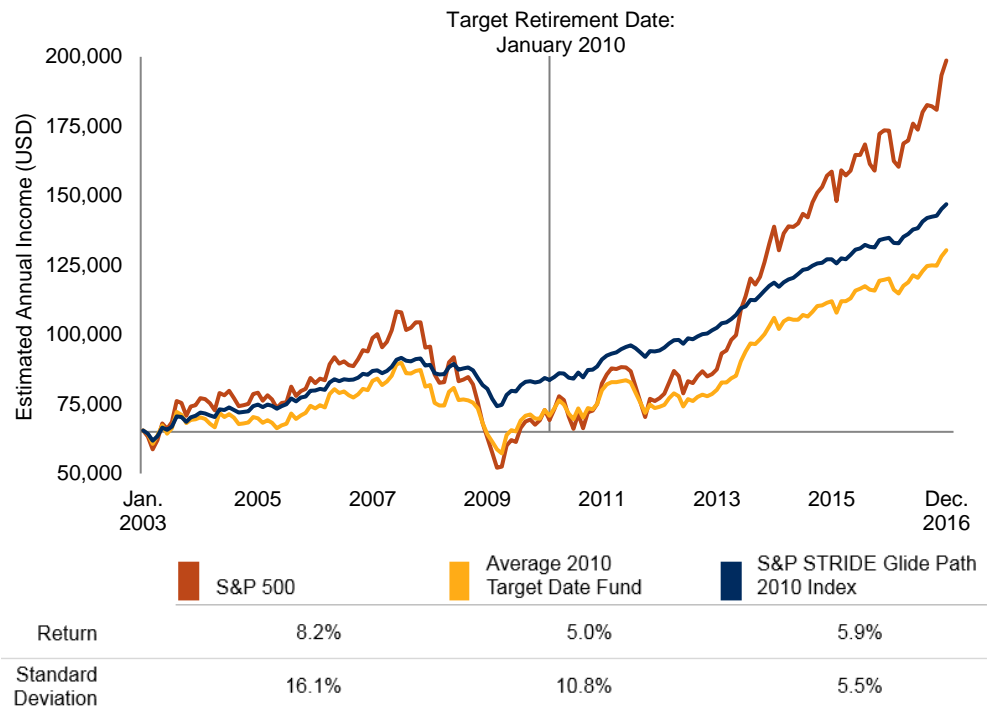
The S&P STRIDE Glide Path 2010 Index allocation in January 2003 starts with approximately 50% of the assets in the TIPS-LDI allocation. The remaining 50% is allocated to global equities (43%) and global nominal fixed income (7%). The TIPS-LDI allocation increases over time and reaches 75% in December 2009.

Let us return to Jill’s example. She started in January 2003 with USD 1 million. Each month during the sample period, Jill can take her account balance and estimate her expected retirement consumption by dividing it by the cost of 2010 GRIL. We can repeat the same calculation assuming she invested her savings in the industry average of TDFs and the S&P 500. Exhibit 12 illustrates the level of estimated consumption in retirement for Jill under these alternatives.¹¹

We believe that the 75/25 mix is a reasonable allocation if one’s goal is to gain income security while preserving a potential for income growth in retirement.

¹¹ Prior to the target retirement date (January 2010 in the case of Exhibit 12), the liability considered by GRIL is a 25-year stream of annual USD 1 inflation-adjusted income. Past retirement (again, January 2010 in Exhibit 12), the liability considered by GRIL declines by USD 1 for each year into retirement (e.g., 24 years in 2011, 23 years in 2012, etc.). This, combined with the fact that Exhibit 12 assumes no withdrawals are actually made from the account after 2010, means that the amount of affordable annual consumption after 2010 would naturally be expected to increase year-over-year into retirement.

Exhibit 12: Growth of Estimated Retirement Income



Source: S&P 500 and S&P STRIDE Glide Path 2010 Index data from S&P Dow Jones Indices LLC. The average 2010 TDF is the asset-weighted average across the TDF families included in the Morningstar universe. As of December 2016, the data included 57 TDF families. Data from Morningstar. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects back-tested hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance. Indices are not available for direct investment. Index performance does not reflect the expenses associated with the management of an actual portfolio. For more information, see “S&P STRIDE Index Series Description and Disclosures” in the Appendix.

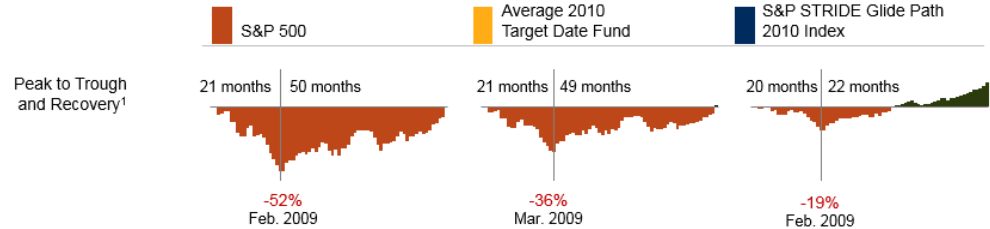
The annualized volatility of monthly changes in the estimates under the average 2010 TDF is about twice the volatility of the S&P STRIDE Glide Path 2010 Index over the sample considered.

Most noticeable from the Exhibit 12 is the difference in the variability of the consumption estimates between the strategies. The annualized volatility of monthly changes in the estimates under the average 2010 TDF is about twice the volatility of the S&P STRIDE Glide Path 2010 Index over the sample considered (10.8% versus 5.5%).

With the S&P STRIDE Glide Path 2010 Index, estimated consumption is USD 84,000 as of December 2009, which is higher than the USD 78,000 estimate achieved with the TIPS-LDI component only. The variability of consumption estimates is also higher than that of the LDI component only (5.5% versus 1.9%). The estimated consumption for the average 2010 TDF is USD 72,000 as of December 2009, with significantly more variability over the period (10.8%). What explains this difference?

Two years from retirement, the 2008-2009 financial crisis resulted in large changes to equity values and interest rates. Exhibit 13 shows growth of consumption over the October 2007-February 2009 period (the same peak-to-trough and recovery period we evaluated for the S&P 500 earlier).

Exhibit 13: Maximum Drawdown and Recovery of Estimated Retirement Income



1. Represents maximum loss/drawdown for peak-to-trough of each index from January 2003-December 2016.

Source: S&P 500 and S&P STRIDE Glide Path 2010 Index data from S&P Dow Jones Indices LLC. The average 2010 TDF is the asset-weighted average across the TDF families included in the Morningstar universe. As of December 2016, the data included 57 TDF families. Data from Morningstar Indices are not available for direct investment. Performance does not reflect the expenses associated with the management of an actual portfolio. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects back-tested hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance. Indices are not available for direct investment. Index performance does not reflect the expenses associated with the management of an actual portfolio. For more information, see "S&P STRIDE Index Series Description and Disclosures" in the Appendix.

The large drawdown we see for the average 2010 TDF is in large part a result of the higher equity allocation.

The large drawdown we see for the average 2010 TDF is in large part a result of the higher equity allocation (28% versus 49%). Notice that the drawdown for the average 2010 TDF is greater in income units than it was in account balance units. This is because of the decline in interest rates that started in October 2008 (see Exhibit 8). In contrast, the drawdown for the S&P STRIDE Glide Path 2010 Index is lower in consumption units than in wealth units due to the appropriate risk management framework.

The difference in risk management strategies is much more visible after equity values began to recover in February 2009. Notice that while equity values rebounded, the cost of future consumption or GRIL increased due to a decline in interest rates that lasted until March 2013. This means that right after the financial crisis, savers in TDFs were hit by a decline in the purchasing power of their account balance in consumption units. As a result, the nominal consumption level did not reach the pre-crisis level until April 2013 (49 months), well into retirement for a 2010 retiree. This is an example of how interest rate changes and inflation can cause a loss in consumption and introduce sequencing risk.

In contrast, in October 2007, 67% of the S&P STRIDE Glide Path 2010 Index was allocated in the TIPS-LDI component. This limited the drawdown in both wealth and consumption units. In addition, the LDI allocation hedged the impact of declining interest rates during the equity rebound. For example, between March 2009 (when the rebound started) and December 2009 (right before retirement), the cost of 2010 GRIL increased by 10.6% and CPI by 1.7%. At the same time, the TIPS-LDI returned 14.0%, hedging the increase in the cost of consumption. By way of comparison, the S&P U.S. Aggregate Bond Index and S&P U.S. Treasury Bond 1-5 Year Index returned 5.9% and 1.3%, respectively, over the period, significantly lagging the increase in the cost of the liability. The

benefits of the LDI strategy extend beyond risk management. This strategy is also important to help investors plan towards retirement and monitor their progress. Retirement investors are often shown estimates of projected future income. As Exhibits 9 and 12 illustrate, income projections can be sensitive to future market performance, inflation, and changes in interest rates, and there is no reliable way to say what those will be in the future. Without proper risk management, estimates are unlikely to be useful. For income estimates to be meaningful to investors planning for retirement, they need a solution that manages risks relevant to the outcome. If the goal is future consumption, the investment solution should manage consumption risk. This way, the uncertainty about future consumption can be reduced over time as participants approach retirement, providing some clarity about the estimate of in-retirement consumption their savings may support.

CONCLUSIONS

When evaluating the performance of an investment, it is important to measure performance relative to the goal. In planning for retirement, one goal typically is to be able to fund a desired standard of living for all the years in retirement. Given the dependencies of affordable consumption on interest rates and inflation, account balances may not provide a full picture of how much a retiree will be able to consume during her retirement life, so measuring performance by looking at the evolution of account balances is probably not enough. Instead, it may be beneficial to evaluate performance in consumption units that are consistent with the goal.

In this analysis, we evaluated the performance of an income-focused approach relative to traditional TDFs, a popular method of investing for retirement. When evaluated in wealth units, we observed differences in performance but found little information about the effectiveness of either approach to provide clarity or certainty around consumption in retirement.

When evaluated in a consumption unit framework, we saw meaningful differences between the two approaches. As a tool to help managing the relevant risks, the S&P STRIDE Glide Path 2010 Index can provide meaningful information about estimated levels of consumption in retirement, whereas the Average 2010 TDF showed large swings in expected retirement consumption. From a planning and monitoring perspective, highly variable estimates are not an effective investment solution for the goal.

Evaluating the effectiveness of retirement solutions in consumption terms also helps to understand the benefits of using an income-focused approach to meet retirement consumption goals. If participants have tools that provide meaningful information and an investment strategy that manages the relevant risks, they can be better informed about their retirement readiness and more empowered to make decisions that can improve retirement outcomes.

When evaluated in a consumption unit framework, we saw meaningful differences between the two approaches.

APPENDIX

S&P STRIDE Index Series Description and Disclosures

In response to the need for income-focused benchmarks within defined contribution plans, on Jan. 11, 2016, S&P Dow Jones Indices (S&P DJI) launched the S&P Shift to Retirement Income and Decumulation (STRIDE) Index Series.

The series features multi-asset class income-based indices tied to target retirement dates. Dimensional Fund Advisors worked collaboratively with S&P DJI to develop the glide path, inflation hedging, and duration hedging techniques used in these indices.

Index Series Description

The S&P Shift to Retirement Income and Decumulation (STRIDE) Index Series comprises 12 multi-asset class indices, each corresponding to a particular target retirement date. The asset allocation for each index in the series is based on a predetermined life-cycle glide path. Each index is fully investable, with varying levels of exposure to equities, nominal fixed income securities, and inflation-adjusted bonds.

The S&P STRIDE Index Series represents a strategy that builds a portfolio of assets to support a hedged stream of inflation-adjusted retirement income. The indices also provide a new framework for benchmarking TDFs that focus on delivering similar results. The indices are individually composed of asset class indices (an index of indices), and the index series includes target date years in five-year increments (vintages). Each index vintage covers a full life cycle of accumulation (during what are generally considered working years) and decumulation in retirement years. Beginning 20 years before each target date, the indices gradually re-allocate some of their weight from accumulation constituents to inflation-adjusted income constituents. This process is analogous to dollar cost averaging into income-producing assets. The income portion consists of a duration-hedged combination of Treasury Inflation Protection Securities (TIPS) indices. The duration of the combined TIPS indices is matched monthly to the duration of a hypothetical retirement income cash flow stream that begins at the target date and lasts for 25 years.

For More Information

General: <http://spindices.com/index-family/multi-asset/sp-stride>

Index Series Methodology: <http://spindices.com/documents/methodologies/methodology-sp-stride-index-series.pdf>

Example and more data: <http://spindices.com/indices/multi-asset/sp-stride-glide-path-2005-index-total-return>

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Past performance of the Index is not an indication of future results. Prospective application of the methodology used to construct the Index may not result in performance commensurate with the back-test returns shown. The back-test period does not necessarily correspond to the entire available history of the Index. Please refer to the methodology paper for the Index, available at www.spdji.com for more details about the index, including the manner in which it is rebalanced, the timing of such rebalancing, criteria for additions and deletions, as well as all index calculations.

Another limitation of using back-tested information is that the back-tested calculation is generally prepared with the benefit of hindsight. Back-tested information reflects the application of the index methodology and selection of index constituents in hindsight. No hypothetical record can completely account for the impact of financial risk in actual trading. For example, there are numerous factors related to the equities, fixed income, or commodities markets in general which cannot be, and have not been accounted for in the preparation of the index information set forth, all of which can affect actual performance.

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