RETIREMENT MANAGEMENT JOURNAL

A reprinted article from Volume 7, Number 1, 2018

How a New Bond Can Improve Retirement Security

By Adam Kobor, PhD, CFA®, and Arun Muralidhar, PhD

INVESTMENTS & WEALTH INSTITUTE® formerly IMCA

VOLUME 7
NUMBER 1
2018

How a New Bond Can Improve Retirement Security

By Adam Kobor, PhD, CFA®, and Arun Muralidhar, PhD

ABSTRACT

There is a growing retirement crisis, and most of the focus has been on the fact that individuals are not saving enough for retirement, may not have access to pension schemes, and find it difficult to choose from a wide range of retirement investment products. However, the bigger issue might be that the assets and financial products available to investors, including those that offer legal protection to plan sponsors, may not be appropriate for the typical individual saving for retirement. As Merton (2014) notes, the model adopted to plan for retirement for the majority of the population focuses on wealth at retirement as opposed to the level of retirement income that an individual can earn. As a result, current assets and many products are risky from a retirement-income perspective. All else equal, with respect to retirement income, individuals retiring a few years apart can have vastly different outcomes (making retirement outcomes a function of one's conception or retirement date), and this impacts policymakers (and potentially individuals worried about retirement security). A new bond has been proposed to improve retirement security; it includes a forward-start (tied to date of retirement), income-only (because individuals need steady income), real cash-flow stream (linked to appropriate indexes), for a fixed period (tied to average life expectancy). This paper examines standard portfolio choices (e.g., 60/40, target-date funds), along with holding this new bond in isolation, from a retirement-income perspective to demonstrate how this new bond, either individually or when used in standard portfolio choices, could improve retirement outcomes. The paper concludes with a Monte Carlo simulation that further validates the value of this new bond given the potential risks to all investment choices for reasonable future equity, interest rate, and inflation scenarios.

BACKGROUND

There is a global crisis among defined benefit (DB) pension plans because demographics have undermined pay-as-you-go social security systems, and, more recently, central bank monetary policies unintentionally have worsened the funded status of employer-sponsored plans (Preesman 2015; Merton and Muralidhar 2015). Because governments and employers do not want additional pension liabilities, retirement risk is being turned over to individuals by placing them in defined contribution (DC) plans. For most individuals, ensuring retirement security is a challenging task because they are not trained financially to understand compounding or inflation (e.g., Klapper et al. 2015). In addition, the tools available for retirement planning (i.e., replacement rate calculators) lack consistency. For example, the General Accounting Office (GAO) (2016) finds that "[r]esearchers and financial industry professionals develop target replacement rates—the percentage of income to aim for in retirement—based on certain key factors, including spending, household characteristics, and pre-retirement earnings. The GAO analysis of the literature found that calculating an appropriate replacement rate can be complex." For pure illustration, we include a brief example of the replacement rate calculation in the appendix. The number of inputs and forecasts of variables necessary to produce results makes this complex and error prone.

The DB crisis has dire consequences. This paper argues that even those who save enough for retirement are challenged because current assets and investment products, including those that provide plan sponsors with legal safe harbor, do not provide for a safe, liquid, low-cost way for individuals to target a retirement-income level. Brown (2014), Muralidhar (2015), Muralidhar et al. (2016), and Merton and Muralidhar (2017a, 2017b, 2018) have argued for the creation of a new bond (termed either Bonds for Future Financial Security [BFFS] or Standard-of-Living, Forward-starting, Income-only Securities [SeLFIES]). This new bond is designed to match (as closely as possible) the cash flows that investors desire when they reach retirement and includes a forward-start (tied to date of retirement), income-only (because individuals need steady income), real cash-flow stream (linked to appropriate indexes), for a fixed period (tied to average life expectancy). These bonds do not hedge longevity risk but seek to cover the income component during retirement, though Muralidhar et al. (2016) demonstrate how longevity risk can be hedged more efficiently with these new bonds. This paper will demonstrate, using a

VOLUME 7
NUMBER 1
2018

simple historical simulation (and a variation) and some Monte Carlo simulations (given future uncertainties), that creating this bond could improve retirement security across all cohorts.

We begin by highlighting the retirement challenge investors face today given their goals and current range of assets and investment products. Then, we review the retirement investments currently available and highlight retirement risks and simple ways to mitigate these risks. Then, we explore how an investor might consider financially engineering the desired retirement cash flow with current instruments, and the challenges they might face. Next, we present an analysis of BFFS/SeLFIES and estimate how they might be priced and evaluated. Then, we compare BFFS/SeLFIES to standard investments in DC accounts (either a static 60/40 portfolio or a target-date fund [TDF]) from a retirement-income perspective using two historical simulation methods, which is followed by an analysis of how these standard products might be improved by including BFFS/SeLFIES as the bond component in traditional products. We take a forward-looking perspective and use Monte Carlo analysis to examine all these products in light of high equity valuations, rising interest rates, and potentially rising inflation. In short, BFFS/SeLFIES dominate traditional assets and products from a downside-risk perspective and adding BFFS/SeLFIES to traditional products has meaningful value. Finally, we offer some drawbacks to the creation of such bonds and then conclude.

THE RETIREMENT CHALLENGE

We must save during our working years to finance our retirement, but there is a long time gap between the saving and decumulation periods (as much as forty years), with a lot of uncertainty embedded in key parameters. Investors have to answer the following complex questions to prepare for a secure retirement: how much to work, how much to consume or save, which portfolio to invest in, how much to invest in each asset, how to rebalance over time, and how to decumulate assets.

A well-structured, DC retirement saving and investment plan should provide participants with a targeted, inflation-indexed, guaranteed income stream, ideally to death. Let's look at an example. Consider a twenty-five-year-old in 2018, who plans to retire in 2058 (at age sixty-five) and, on average, could live to 2078 (age eighty-five). For simplicity, assume the date of death is known (because longevity issues are addressed in future research [Muralidhar 2018]). If the individual wishes to receive $50,000/year in 2018 dollars, this retirement goal can be visualized in figure 1. Next, she needs to figure out what saving and investment strategy would allow her to achieve this goal (Bodie et al. 2008). For simplicity, we ignore the savings decision and assume that investors save according to a simple fixed pattern and focus on the investment decision. The complex trade-off between saving and investing to achieve a guaranteed income in retirement will be addressed in future research and will be based on offering a practical version of Bodie et al. (1992).

CURRENT APPROACHES TO RETIREMENT INVESTMENTS

A major limitation of the currently available set of investment products is that a low-risk portfolio relative to the desired retirement-income stream is not available to future retirees (i.e., they lead to a cash-flow mismatch and a lot of reinvestment risk). Even a traditional bond portfolio does not have the cash-flow profile shown in figure 1. Inflation-protected securities (Treasury Inflation-Protected Securities, or TIPS) also engender a lot of risk relative to the cash flows in figure 1. First, most bonds offer coupons before one's retirement, and therefore, there is reinvestment risk. Second, the stub repayment of principal would engender a cash-flow mismatch. Third, as Merton and Muralidhar (2018) note, "Even if these payments were adjusted for inflation, they would not be sufficient—for savings invested long before retirement, standard-of-living risk is really significant. The amount needed to maintain one's evolving lifestyle while working is likely to increase over this long horizon, potentially leaving retirees with inadequate savings to cover that higher lifestyle." Financially engineering many of these bonds only raises the cost, complexity, and illiquidity of ensuring retirement security. Finally, adding equities to the investment mix would only exacerbate the risk profile because there is absolutely no guarantee of cash flows.

If existing securities engender risk relative to the cash flows in figure 1, then can any investment approach address this challenge? There are two investment approaches to achieving the target retirement income in figure 1.

The traditional or mainstream approach takes existing assets and tries to create optimized portfolios, based on modern portfolio theory (MPT), to develop an appropriate investment solution. The traditional 60/40-type portfolios and

Figure 1

REAL CASH FLOW FOR RETIREMENT FOR A TWENTY-FIVE-YEAR-OLD IN 2018

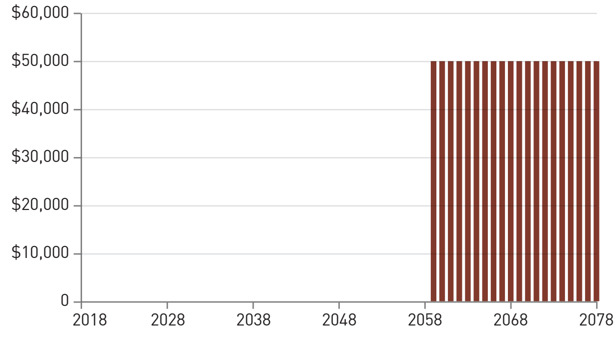
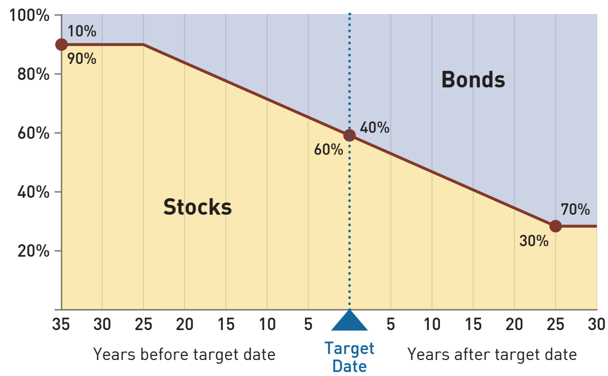


Figure 2 **EXAMPLE OF A THROUGH RETIREMENT TDF ALLOCATION BETWEEN STOCKS AND BONDS**



Source: Overture Financial presentation to Secure Choice Investment Board (of California)

robo-investing are good examples of this approach. However, the theory is much more elegant than practical. First, MPT requires the individual (or advisor) to forecast expected returns, volatilities, and correlations of various assets. This step is then followed by running an optimizer on these assets, which then determines the optimal portfolio for a given level of risk (Markowitz 1952). This approach has many challenges (Muralidhar 2016), but the primary issue is that the finance industry's track record of forecasting expected returns, correlations, and volatilities of assets for current approaches is poor (Housel 2015; *Economist* 2017). If inputs are poor, the recommended portfolios are unlikely to be truly optimal. Therefore, this approach tends to be error-prone, complex, and risky, while simultaneously failing to address the challenges of current instruments.

The practical challenges that individuals face in managing their own retirement portfolios include holding too much company stock (essentially raising single company risk in their retirement accounts), letting allocations drift, chasing last year's winners (implying potentially too much equity risk close to retirement because stocks outperformed bonds in the 1990s), or holding stable value funds, which protected principal (but had low yields and did not ensure a sufficient retirement-income level). To protect investors against bad portfolio decisions, TDFs were introduced in 1994, with the general goal of ensuring that portfolios were de-risked automatically as one approached retirement by moving portfolios into "safe" assets.

TDF assets under management were estimated at $1.44 trillion as of December 31, 2017 (Kilroy 2018), up from $800 billion in 2014 (Yang and Lutton 2015). The growth in TDF assets under management was helped in part by the Pension Protection Act of 2006, which afforded TDFs qualified default investment alternative (QDIA) status. This act allows plan sponsors safe harbor from litigation and thus makes TDFs attractive for plan sponsors to offer participants.

TDFs come in different flavors, including "to-retirement," "through-retirement," and even "risk-based." The basic TDF has a given target date, typically is restricted to years ending in zero or five (e.g., 2020 or 2025), and can be characterized by the following: (1) a starting allocation to a high-level asset allocation (e.g., 90 percent in stocks and 10 percent in bonds, as in figure 2); (2) a glide path (i.e., predetermined rate of reallocation from equity to fixed income and cash); and (3) a desired steady state allocation at the retirement date (for to-retirement TDFs) or at some point post-retirement (for through-retirement TDFs). Through these three parameters, TDFs seek to achieve an average specified asset allocation (and often, the investor delegates many more decisions in the TDF—from diversification to management of currency risk to who manages the fund). The assumed retirement age is typically sixty-five. Figure 2 shows an example of a dynamic stock-bond mix over time based on a through-retirement TDF. The first part of the chart (flat line) demonstrates the starting asset allocation, the subsequent decline in the line captures the glide path, and the final flat line captures the desired steady state allocation at some point in post-retirement.

The 2008 financial crisis revealed the shortcomings of these products. TDFs had been sold to individual investors as a panacea for retirement, but the bottom fell out in the 2008 market collapse. Indeed, 2008 was a watershed year for retirement models and products because it was a stress test unlike any other. For example, Morningstar reported that the 2010 TDF fell 24.6 percent on average in 2008, meaning that TDF investors who planned to retire in 2010 lost nearly one-quarter of their principal two years before their expected retirement date.

What is considered a "safe" portfolio in a TDF actually is risky from a retirement-income perspective. This is obvious because no liquid asset that would be included in the optimization process (stocks, bonds, commodities, alternatives, etc.) has the cash-flow profile plotted in figure 1. So, simple 60/40 portfolios and traditional TDFs have a cash-flow mismatch relative to the goal. As a result, as one nears retirement, the individual is expected to purchase an annuity to lock in a stable retirement income. More recently, qualifying longevity annuity contracts (QLACs) have been given safe harbor to encourage greater use of annuities in retirement portfolios. However, their use in retirement portfolios is limited; Salisbury and Nenkov (2016) note that, "In June 2015, U.S. retirement assets totaled $24.8 trillion, with only 8.6 percent of assets held as annuity reserves."

Annuities are opaque, complex, illiquid, and often expensive, leaving retirement plan participants with the credit risk of the annuity-issuing entity (i.e., the insurance company). The complexity of these instruments has led to low adoption of these contracts in general as noted by Nobel Laureate Franco

VOLUME 7
NUMBER 1
2018

Modigliani in his 1985 Nobel acceptance speech (terming it "the annuity puzzle"). More recently, researchers have established that the complexity has led to low usage in retirement portfolios (Brown et al. 2012). Moreover, there is interest-rate risk because the participant could retire at the worst possible time to buy an annuity, which can be mitigated to some degree by averaging into annuities, but these are not liquid instruments and changes in medical conditions could preclude this from taking place (Bodor et al. 2007a, 2007b). This led to the innovation of target-income funds, or TIFs (Merton 2007, 2010, 2012a, 2013). TIFs allow individuals to pick their level of target income. Vendors financially engineer the portfolio to dynamically allocate between risky assets and a retirement-income replicating portfolio (as in figure 1) to ensure that this target income is achieved. Even with TIFs, which are an improvement over TDFs, current financial instruments (e.g., bonds with a maximum maturity of thirty years) limit the ability to create the target retirement-income profile early in an individual's life, and the outcome is not entirely guaranteed with the dynamic asset allocation process (see Barney [2016] for other issues).

For all these reasons, we call the current approach the "risky approach to retirement investing," and we back up this comment with an historical simulation later on that analyzes BFFS/SeLFIES and Monte Carlo simulations (for simplicity, we will only examine a 60/40 and a TDF portfolio and ignore the TIF portfolio).

A SIMPLE INNOVATION TO MITIGATE RETIREMENT RISKS

People saving for retirement face several risks over the full span of their life cycle. Brown (2014), Muralidhar (2015), Muralidhar et al. (2016), and Merton and Muralidhar (2017a, 2017b, 2018) argue that the challenges of DC plans are solved to some degree by a simple financial innovation. Governments could issue a new bond called either BFFS (Muralidhar 2015; Muralidhar et al. 2016) or SeLFIES (Merton and Muralidhar (2017a, 2017b, 2018)[1]—an inflation-adjusted, income-only bond that starts paying investors on their date of retirement for a fixed period of time (tied to the life expectancy of the population). The need for BFFS/SeLFIES is simple: The riskless retirement asset in a DC plan would be an inflation-indexed, income-only bond that defers payment until retirement and pays till death (as in figure 1). Such an instrument does not exist today. All attempts to recreate this profile through traditional stocks and bonds or purchase such a profile through annuities are suboptimal, as we demonstrate later, because existing assets and products cannot serve as a risk-free asset from the retiree's point of view. Because BFFS/SeLFIES have a maturity equal to average economy-wide life expectancy, they hedge the life expectancy of the entire country and not every individual (but individuals could purchase a financially engineered version of their hedge or buy deferred annuities if they think they will outlive the average and need a longevity hedge). BFFS/SeLFIES would be relatively credit-risk-free assets that guarantee a predefined fixed stream of periodic income indexed to inflation or per-capita consumption to retain a stable standard-of-living. In this paper, we assume that BFFS/SeLFIES are simply linked to the consumer price index (CPI); indexation to standard-of-living indexes will be addressed in future research. Thus, a possible "2058 BFFS/SeLFIES" could be specified as simply as $5 annual income in real terms (measured in today's price levels), paid for twenty years, starting forty years from today as in figure 1.

Before examining the benefit and risks of any investment strategy, it is important to briefly summarize the key market risks a future retiree who desires a target retirement income would face. For simplicity, we ignore other risks such as salary growth risk, longevity risk, medical risks, etc.

In the saving/accumulation phase:

- Equity bear market risk would erode the wealth base of retirement savings. While a market crash may in fact offer buying opportunities at the beginning of the accumulation period, it could be devastating if it hits at the end of the savings cycle just before retirement, as was the case for DC portfolios and TDFs in 2008. Also, interest rates usually decline during a market crash, so turning an equity-heavy investment portfolio into annuities at a low level of interest rates would cause a double whammy to the retiree.
- Interest-rate risk is embedded in portfolios if individuals invest in traditional bond instruments and buy an annuity at retirement because of the different durations between the bond portfolio and the deferred annuity.
- Rising inflation could erode the real value or purchasing power of the asset base, usually coinciding with rising nominal interest rates that hurt bond prices and declining equity valuations that would hurt equity-related assets in the portfolio.
- Deflation risk would not hurt the purchasing power of assets directly, but the indirect effects could be serious as well, typically coinciding with declines in equity and other risky asset prices. High-grade government bonds is the asset class that likely would benefit in this environment.

At the time of, and during, retirement (ignoring standard-of-living changes):

- Inflation would be a risk again, especially if retirement savings are not protected against inflation. A fixed nominal annuity would quickly lose its purchasing power amid rising prices.
- Low level of interest rates; while potentially advantageous for asset prices during the saving cycle, low rates make the conversion of savings to an annuity very expensive.

In the context of retirement savings, BFFS/SeLFIES could serve as a risk-free asset from the retiree's perspective; the real purchasing power is guaranteed up front at the time of purchase because these instruments are designed to bridge the saving/accumulation and decumulation phases. However, as with all assets, lower risk also suggests lower possible expected retirement outcomes than riskier assets, and we examine this in more detail later.

FINANCIALLY ENGINEERING RETIREMENT CASH FLOWS

It is natural to question whether the governments should introduce BFFS/SeLFIES type of bonds as new instruments, or if such instruments can be synthetically produced from already existing investment instruments. If a synthetic replication is easy and cheap, then there is no reason to create a new instrument. Conversely, if this is not feasible or if the financial engineering approach is risky, complex, or costly, it behooves the governments to create a new bond that the market demands, especially if governments become the biggest beneficiaries from such an instrument (Merton and Muralidhar 2017a, 2017b, 2018).

The TIPS market would be a natural first step to consider for synthesizing BFFS/SeLFIES. The TIPS market is reasonably liquid, credit risk-free, and has been in existence for two decades in the United States (and apparently has been a good deal for the U.S. Treasury). TIPS provide protection against inflation because the principal is indexed to the CPI. The semiannual real interest rate is fixed, and this rate is applied to the adjusted principal; therefore, like the principal, interest payments also rise with inflation.

Creating zero-coupon securities by stripping coupons and principals of a range of U.S. Treasury notes and bonds is a common practice, and the same approach can be applied to TIPS bonds as well. TIPS are issued in terms of five, ten, and thirty years, and thus sequences of semiannual cash flows with equal real value can be stripped easily from these bonds. Because coupon payments can be sold separately, forward-starting real income streams also can be created by packaging coupon payments together starting several years from today.

However, this approach has two limitations. The first limitation is that the magnitude of the real coupon is defined by the currently outstanding TIPS bond specification. Currently, the real coupons of the outstanding TIPS securities range between 0.125 percent and 3.785 percent. The coupon of the current thirty-year TIPS maturing in 2049 is 1 percent, for instance (and not expressed as real $5). This makes the stripping and recomposition of a range of TIPS to create the cash-flow profile in figure 1 somewhat complex (and not always easy because some cash-flow streams may require partial allocation to a certain bond maturity). The higher the complexity, the greater the risk and cost, and therefore, the greater the price of the stripped version of figure 1.

The second, even bigger, limitation is that the longest maturity TIPS is thirty years and makes TIPS unusable for someone who would retire forty years from now and seek income for an additional twenty years after retirement. In effect, with a maximum maturity of thirty years, TIPS allow only those who are currently fifty-five years old to hedge their retirement income starting at age sixty-five for a period of twenty years. Moreover, as noted earlier, TIPS are risky (because of cash-flow and reinvestment issues) so extending maturity of TIPS to allow the industry to financially engineer them to produce the cash-flow profile in figure 1 is not sufficient.

In short, even if the TIPS maturity extended to the required maturity for our hypothetical twenty-five-year-old modeled in figure 1, this financial engineering is complex, potentially risky (because these transactions will have to be intermediated by a third party), and costly. Moreover, if individuals change their target retirement-income level (e.g., deciding they want to reduce their target retirement income), unravelling these transactions potentially will be complex and costly. Therefore, if financial engineering is needed to create a cash-flow profile and a natural issuer is available for issuance (as argued by the bond proponents), the easiest alternative is to create the new BFFS/SeLFIES bond.

QUICK ANALYSIS OF THE COST AND RISKS OF BFFS/SELFIES

For this analysis, we refer to "annuities" as a twenty-year fixed-term payment as in figure 1. Note that this is quite a special case of annuity design (Milevsky [2006] provides a more detailed overview of various pension annuity valuation approaches). While BFFS/SeLFIES are risk-free from a cash-flow perspective at the time of retirement, the purchase price is clearly a function of the prevailing market environment. If we consider a twenty-year real annuity starting forty years from now, paying a fixed real amount every year, long-term real interest rates would determine the current price. Figure 3 illustrates the history of nominal twenty-year forward interest rates starting in forty years, as well as its real forward rate peer. For this illustration, we assume that ten-year rolling historical CPI rate is a reasonable proxy for future inflation. While this is a somewhat naïve and strong assumption, it illustrates the factors that affect the price of BFFS/SeLFIES.

BFFS/SeLFIES will be priced based on the prevailing real forward interest rates, i.e., in a high-real-interest-rate environment investors can lock in high real purchasing power because the BFFS/SeLFIES price will be low, while in a lower rate period, investors would lock in a lower real income because of a high BFFS/SeLFIES price. For example, a BFFS/SeLFIES can be thought of as a security with the following parameters:

VOLUME 7 NUMBER 1 2018

- Notional value: $100
- Real coupon: 1 percent or $1 per year
- Start date: forty years from today
- End date: sixty years from today
- Price today: $12.12

A future retiree can buy this security today for $12.12. Forty years from now, it would start paying an annual real income of $1 every year until sixty years from today. If real rates are higher (lower), the price of the security would be lower (higher) than $12.12, and therefore the investor can buy more (or less) of this security, assuming a fixed corpus.

In fact, such securities could be designed either in a way that the future real coupon rate is constant, say $1, such as in the example above, or $5 per security, or it also can be designed such that the future real coupon reflects the market conditions at issuance, say, equal to the forward real interest rate. This choice is purely an optical decision, because it makes no difference in financial terms. If the real coupon is always $5, then the security's initial purchase price will fluctuate based on the current interest-rate conditions, i.e., it will be more expensive if rates are low. On the other hand, if the coupon is determined at the time of issuance based on the prevailing forward rates, then the issue price will be relatively stable, but the coupon naturally will be lower in low-yield environments, while higher amid higher and steeper yield curves.

Hypothetically, from 1977–2017, the initial price of BFFS/SeLFIES that pays an income determined by the prevailing twenty-year forward rate annually is estimated to have been quite stable, typically in the range of $10 to $20 (see figure 4). Figure 4 shows the estimated price of a twenty-year real annuity starting in forty years, with a real payment equal to the twenty-year forward real interest rate. In this example, the greater stability in the price of the instrument is established by allowing the annual real amount to fluctuate with changes in interest rates.

Alternatively, the issue or initial price of BFFS/SeLFIES with the same annual real income, say $5, as in say Merton and Muralidhar (2017a, 2017b) would have been more volatile (see figure 5). Prices could have ranged from $10 in the late 1970s, when interest rates were high, to a current level of approximately $60 in the current cycle of low interest rates and a relatively flat yield curve (early 2018). In other words, the volatility in price is impacted by setting a fixed payment amount and the high duration of the bond. In fact, the duration of forward-starting annuities is quite long, especially if purchased well ahead of time. In current market conditions of early 2018, the real duration of a twenty-year BFFS/SeLFIES starting forty years from now would be almost forty-nine years. Of course, BFFS/SeLFIES starting sooner would come with lower duration. The duration of a twenty-year real

Figure 3

HISTORY OF FORTY-YEAR FORWARD TWENTY-YEAR NOMINAL AND REAL RATES AND EXPECTED INFLATION (1977–2017)

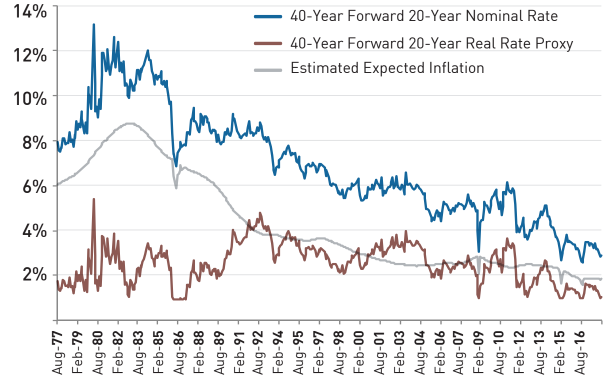


Figure 4

ESTIMATED BFFS/SELFIES PRICE, WITH REAL RATE EQUAL TO FORTY-YEAR FORWARD TWENTY-YEAR REAL RATE (1977–2017)

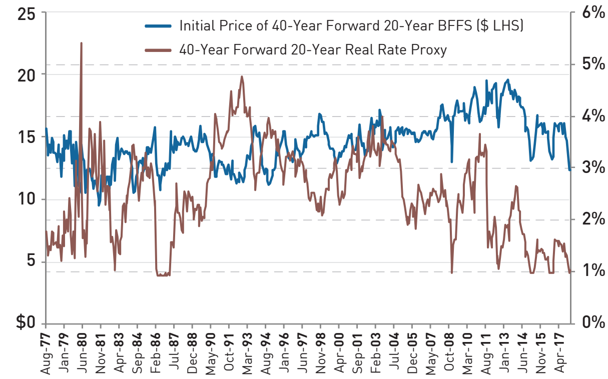
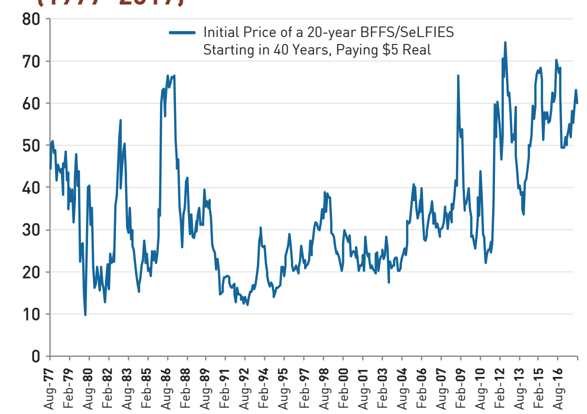


Figure 5

ESTIMATED PRICE FOR TWENTY-YEAR BFFS/SELFIES STARTING IN FORTY YEARS, ASSUMING $5 ANNUAL REAL INCOME (1977–2017)



annuity starting immediately would be just under ten years. The high interest-rate sensitivity of BFFS/SeLFIES is critical to understanding the potential riskiness of this instrument for anything other than retirement planning: BFFS/SeLFIES are risk-free assets for retirement but not for preretirement liquidation.

HOW BFFS/SELFIES COMPARE TO (AND COMPLEMENT) SIMPLE 60/40 OR TDF PORTFOLIOS

While the new bond is purely hypothetical, we can simulate the likely outcomes if these bonds did exist to provide some sense of the benefits they could provide to individuals and society in general. This section compares the results of three strategies: (1) investing 100 percent in BFFS/SeLFIES; (2) investing in a typical 60 percent stock/40 percent bond mix, and (3) investing in a TDF that shifts the equity allocation from 90 percent to 30 percent (so that the time-weighted average equity allocation is 60 percent). Portfolios (2) and (3) are annuitized on the retirement date. For simplicity, we assume zero investment costs (i.e., manager fees, transaction costs) for both strategies—which clearly is not the case in real life because the cost of stock and bond portfolios or current DC investment offerings is likely to be orders of magnitude higher than the cost of BFFS/SeLFIES.

For simplicity, we conducted a historical analysis based on the past forty years (1977–2017) using monthly market data. We assumed ten-year rolling time windows for saving and investing (i.e., accumulation) and a twenty-year retirement spending period (decumulation). Clearly, a ten-year saving period is totally unrealistic for true pension purposes (typically this would be forty years), but limited market data history forces the choice of ten years to ensure that we can display multiple rolling periods. This would be like a fifty-five-year-old starting to accumulate for ten years, retiring at sixty-five, and receiving income for twenty years. Despite this limitation, the results are intriguing.

The three strategies are described as follows:

BFFS/SeLFIES: The individual saves $100,000 in real terms over ten years in equal monthly steps (i.e., $833 real amount monthly) and buys the current SeLFIES that will start paying twenty-year coupons at the time of retirement (ten years after the cycle begins). Recall that the level of annual income paid by a single BFFS/SeLFIES in these simulations does not matter because the focus is entirely on retirement income. The ultimate result is exactly the same regardless of whether the coupon of each BFFS/SeLFIES is the same at any time, or whether it is designed such that the coupon is determined based on the prevailing forward real interest rates. To illustrate this, consider the following two types of BFFS/SeLFIES issued in the current market environment (see table 1).

60/40 portfolio: The individual saves a total of $100,000 in real terms over ten years in equal monthly steps (i.e., $833 real amount monthly) and invests the savings balance in a 60 percent equity (S&P 500 Index)/40 percent bond (Bloomberg/Barclays U.S. Treasury Index) portfolio with monthly rebalancing.[2] At the time of retirement (ten years after the cycle begins), the individual converts the final savings balance to a twenty-year real-annuity/retirement-income stream at the prevailing interest rates.

Figure 6 illustrates the real cumulative asset growth over rolling ten-year periods, assuming a total $100,000 real savings. The line starts in January 1987 because we're measuring the rolling ten-year real growth of portfolios that started investing in January 1977 (the next dot on the chart would be the ten-year period starting in February 1977, and so on). The real final balance line is reminiscent of a roller coaster, validating the claim that investing in a stock-bond portfolio results in highly variable retirement-wealth outcomes (not easily mitigated by investing in TDFs as shown later) from one cohort to the next. Figure 6 shows that two equity crises, marked by the sharp declines in the real final balance line (2000 and 2008), could

Table 1

ALTERNATIVE BFFS/SELFIES SPECIFICATIONS—IMPACT ON PRICING AND LOCKING IN RETIREMENT INCOME

	Coupon Based on Current Real Forward Rates	Coupon Always $5
Real Coupon	$1.0370	$5.00
Issue Price	$18.8440	$90.8624
Number of Securities $833 Buys per Month	44.2051	9.1677
Total Annual Real Income Bought	$45.84 (44.2051 × $1.0370)	$45.84 (9.1677 × $5.00)

Note: Real coupon, annuity issue price, and the number of securities are rounded to the second digit.

VOLUME 7
NUMBER 1
2018

impact retirement wealth outcomes seriously. Interestingly, figure 6 also demonstrates that investors can end up easily with less than the starting investment amount ($100,000), in real terms, over ten-year investing cycles.

TDF portfolios: The individual saves a total of $100,000 in real terms over ten years in equal monthly steps (i.e., $833 real amount monthly) and invests the savings balance in the TDF. The TDF starts with a 90 percent allocation to equities (S&P 500 Index) and the remaining balance of in bonds (Bloomberg/Barclays U.S. Treasury Index) portfolio.[3] Every month, the allocation to equities is reduced by 0.5 percentage points and shifted to the bond portfolio; therefore, the ending equity allocation after ten years is 30 percent, with 70 percent in bonds. At the time of retirement (ten years after the cycle begins), the individual converts the final savings balance to a twenty-year real-annuity/retirement-income stream at the prevailing interest rates.

While a volatile final balance is disconcerting to investors, figure 6 just scratches the surface of a retirement portfolio's true risk. Figure 7 illustrates the main risk factor at the time of retirement: How much retirement income would this portfolio buy if a retiree decided to convert the investment portfolio to a retirement-income stream at the end of the ten-year accumulation period? This analysis is a bit more complex than the one in figure 6 because in addition to asset market volatility, there is one additional complication: the volatility of the cost of a twenty-year real annuity (impacted by then prevailing interest rates).

As the twenty-year (estimated) real interest rates declined during 1977–2017 (figure 7, left axis), the price of an annuity that pays $1 real for twenty years increased over the past decades (figure 7, right axis). Figure 7 reflects the simple inverse relationship between interest rates and prices, which may explain why annuity purchases have not been robust over the past few decades over and above the fact that they are complex (Brown et al. 2012).

Figure 8 shows the rolling results of the annual real income available by converting the 60/40 (in figure 6) and TDF investment portfolios to a twenty-year real annuity after ten years of investment. Figure 8 also includes the result of directly buying BFFS/SeLFIES throughout the investment cycle, rather than having the savings invested in risky assets (where even the bond investment in the 60/40 or TDF portfolio is risky).

Figure 8 highlights the following critical points:

- As expected, the TDF real annual income line is a little less volatile than the simple 60/40 real annual income line

Figure 6

FINAL BALANCE OF 60/40 INVESTMENT STRATEGY OVER TEN-YEAR CYCLES (REAL TERMS)

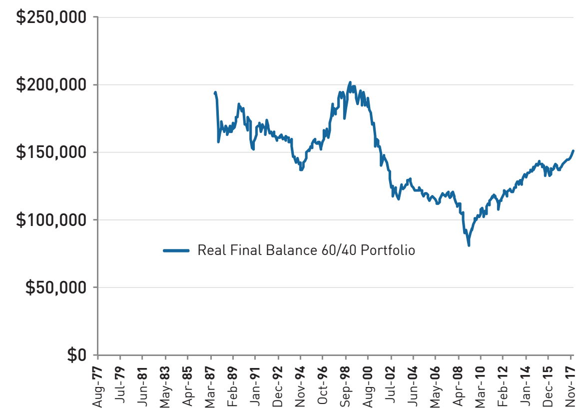


Figure 7

ESTIMATED TWENTY-YEAR REAL INTEREST RATE AND TWENTY-YEAR REAL ANNUITY FACTOR

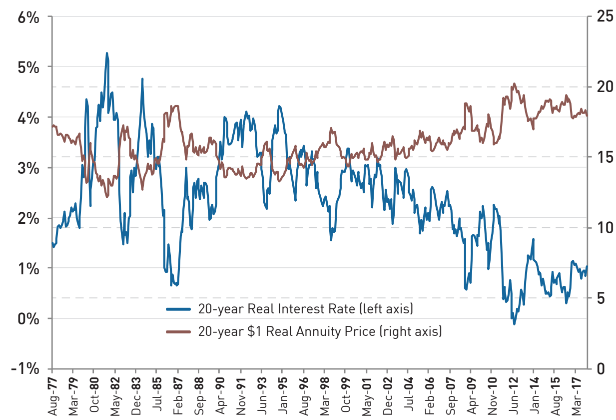
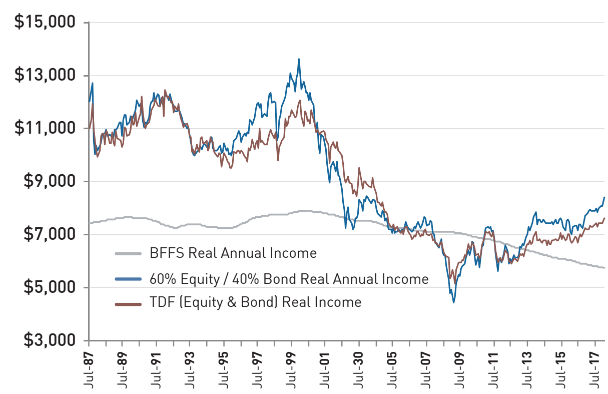


Figure 8

ANNUAL REAL INCOME GENERATED: TWO RISKY STRATEGIES (60/40 PORTFOLIO AND TDF) VS. BFFS/SELFIES



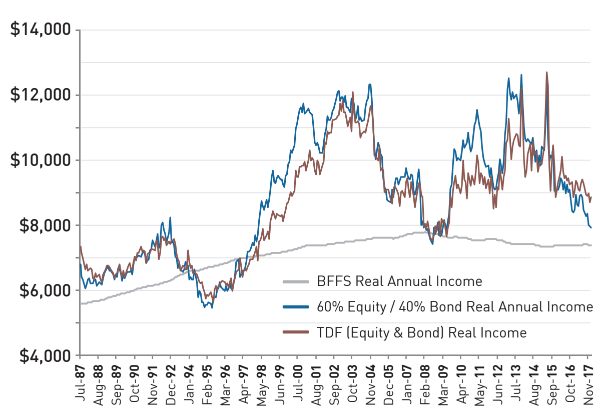
(but also as expected, neither strategy dominates the other because both outcomes are volatile).

- The somewhat stable gray line (i.e., the annual real income generated by buying SeLFIES with a coupon equal to the prevailing forward real rate every month) illustrates the concept of a risk-free asset from a retirement-income point of view. While this line declined during 1987–2017 (much like the other two lines) as a result of the historical decline of real interest rates, the gray line is more stable and smooth than the 60/40 portfolio (blue line) or TDF portfolio (red line). This conveys the key point that investing in BFFS/SeLFIES is very low risk when viewed from a retirement-income perspective. There are periods over which the outcome from BFFS/SeLFIES dominates the equity-heavy portfolios (i.e., if the individuals retire during a secular bear market).
- The blue and red lines (i.e., the real annual income offered by an indexed annuity after ten years of investing in 60/40 and TDF portfolios, respectively) also declined over the full observation period as a result of the 2000–2002 tech bubble crash and 2008–2009 financial meltdown, as well as the corresponding low level of interest rates. However, the bigger issue is the roller-coaster nature of the retirement outcomes, even from a retirement-income perspective. It appears that the blue and red lines validate the claim that current investment approaches result in highly variable outcomes.

While the 60/40 (and TDF) strategy overall outperformed the strategy of buying BFFS/SeLFIES over this time period (average real annual income of $9,087 versus $7,156, respectively), its downside risk potential also was more severe. Downside risk is a key measure of risk in managing portfolios and captures the volatility of negative outcomes (as opposed to the volatility of both positive and negative outcomes). The

Figure 9

ANNUAL REAL INCOME GENERATED BY TWO RISKY STRATEGIES (60/40 PORTFOLIO AND TDF) VS. BFFS/SELFIES, 1977–2017 WITH TIME REVERSED



downside risk for a classic 60/40 or TDF portfolio can be the most severe when equities collapse; however, these periods also result in declining interest rates (because investors rush to bonds as a safe asset). This leads to a double whammy if the investor has to purchase an annuity at the same time. Moreover, the average outperformance of the 60/40 or any TDF portfolio over the past forty years is absolutely no guarantee or indication of what might transpire over the next 100 years. Therefore, BFFS/SeLFIES might provide some, if not the entire population, with a robust investment alternative for retirement portfolios.

Clearly, the 60/40 strategy, with its highly variable outcomes from one rolling period to the next, would lead to sharp differences in the standard of living for identical individuals who just happen to start their careers and retire a few years apart. The blue and red lines in figure 8 do not bode well for ensuring retirement security in a state or country because of the high level of unpredictability in outcomes. Retirement income across cohorts a few years apart could be vastly different—in a way, one's retirement income becomes a function of when the individual was conceived. On the other hand, systematically buying BFFS/SeLFIES smooths the real yield risk over time, and the investor potentially also benefits from the steepness of the yield curve because ten-year forward twenty-year interest rates exceed spot twenty-year rates as long as the prevailing yield curve is upward sloping. With central banks raising rates globally, one easily could see the blue line in figures 7 and the gray line in figure 8 following a very different trajectory in the future from those between 1997 and 2017.

Here's another example of a different trajectory. We inverted the data and reverse market movements (e.g., January 1, 1997, is switched with December 31, 2017, and so on). The results of this simulation are provided in figure 9. Every data series got reversed. Note: Bond returns are negatively impacted due to rising interest rates. Bonds would have a lower average return due to the reversed and thus rising secular rate pattern. Equity returns just reversed order, but their average return remained the same. A possible refinement could be dissecting equity returns to dividend + earnings growth + price/earnings (P/E) ratio change, and somehow adjust P/E changes and earnings growth to the yield environment. But this would be based on various strong assumptions, and therefore, we chose the simple reverse historical simulation.

In the final historical analysis, we modeled a variation on the 60/40 and TDF strategies—instead of investing in the Bloomberg/Barclays U.S. Treasury Index, these portfolios invest in BFFS/SeLFIES. For simplicity, in figure 10, we plot the result of the TDF strategy with the proposed bonds. This example illustrates that BFFS/SeLFIES also can be applied in existing pension-savings schemes such as TDFs. While this simulation might suggest that TDFs with bonds offer a higher real income in retirement compared to the TDF with BFFS/SeLFIES, there are clearly many periods when this is not true. This is a riskier strategy because traditional bonds are risky (and this was a period of secular decline in interest rates, so it may not be the best strategy going forward if rates should rise).

FORWARD-LOOKING ANALYSIS

To get a better perspective on the retirement benefits generated by different investment strategies, we ran Monte Carlo simulations over a future forty-year horizon, taking the market conditions of early 2018 into consideration. Because the equity market has been in an extended bull run (close to ten years), central banks potentially are raising interest rates (as opposed to the previous three decades of declining interest rates), and inflation easily may rise in the future from relatively low levels, there are meaningful risks to any retirement portfolio. To ensure a comprehensive future simulation, we simulated five risk factors: three factors for the nominal yield curve (level, slope, and curvature), inflation, and equity returns. For the simulation, we also needed to make the following long-term assumptions:

- We expected the annual inflation rate to fluctuate around 2.5 percent. This inflation expectation is close to, or just a bit higher than, the consensus expectation for the long run.
- We expected the nominal return from equities to be 6.6 percent over the long run. This projection is based on our expectation of approximately 2.5 percent inflation, combined with 2 percent long-term real earnings growth, 2 percent dividend yield, and unchanged P/E valuation.
- We expected the nominal yield curve to shift upward from its current level to levels that are closer to the typical interest-rate levels observed over longer historical periods, as depicted in figure 11. To be more specific, this yield curve shift assumption is reflective of a long-term federal funds rate target of 3 percent, based on the current Federal Open Market Committee's communications, as well as a term premium of around 100 basis points (bps). Note that these assumptions would lead to an average expected nominal total return of 4.6 percent from bonds over the forty-year time horizon.

Comparing our long-term baseline equity and bond return expectations, the reader may note that in this illustrative setting, equities would be expected to outperform bonds by 200 bps. This 200-bps equity risk premium may seem too low, and it is indeed lower than equities' excess returns of around 300 bps over long-duration Treasuries over the past decades. At the same time, we also hint caution: We could observe a four-decade period when U.S. equities mildly underperformed long-duration Treasuries, namely during 1968–2008. Also, while equities in the United States offered 300-plus bps premium over bonds during the past century, there are countries where equities did not serve investors that well. In Japan, for example, the Nikkei Index hit its all-time high of 38,957 on December 29, 1989. At the time of writing this study almost three decades later, the Nikkei is still well below that level (22,693 as of June 21, 2018).

It is important to emphasize, nevertheless, that these assumptions are arbitrary and for illustration only, and the reader may use different, or multiple sets of assumptions in practical applications. In practice, different assumptions can be used as scenario or stress test analysis to evaluate the peculiarities of distinct market and macroeconomic environments.

In this framework, in a similar way to the historical analysis, we compared various saving and investing strategies (60/40, TDFs, BFFS/SeLFIES, 60 equities/40 BFFSs, TDFs with BFFS/SeLFIES) described earlier but with the following simple differences: (1) we simulate the forty-year forward twenty-year rates to price the annuity (as opposed to the ten-year forward

Figure 10
ANNUAL REAL INCOME GENERATED BY TDF WITH TRADITIONAL BONDS AND BFFS/SELFIES

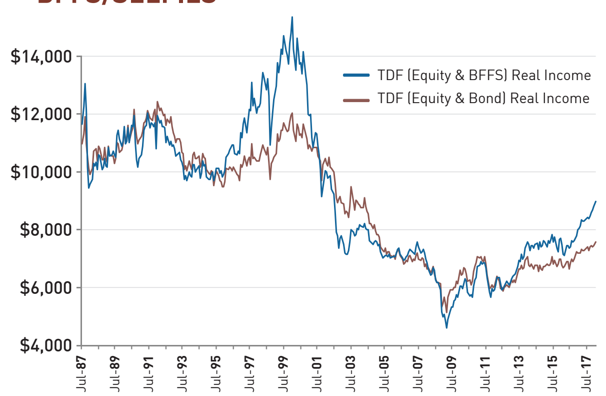


Figure 11
CURRENT AND LONG-TERM EXPECTED YIELD CURVE

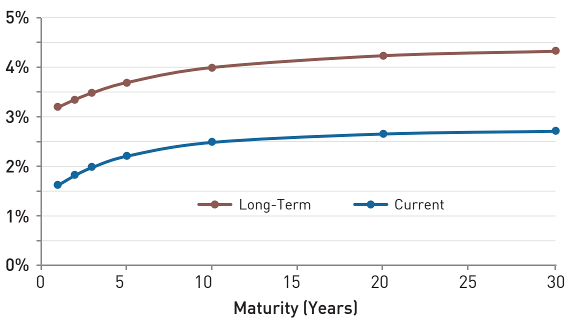


Table 2

FINAL REAL BALANCE FROM STANDARD INVESTMENTS (PERCENT OF TOTAL REAL SAVINGS)

Final Real Balance	Final Real Balance as a Percent of Savings	100% Bond	60% Equity/ 40% Bond	Glide Path with Bond
Average	311%	164%	237%	228%
Standard Deviation	334%	53%	146%	127%
95% Highest	814%	260%	503%	462%
75% Highest	375%	193%	294%	278%
Median	209%	155%	199%	194%
25% Lowest	125%	127%	140%	144%
5% Lowest	66%	96%	87%	97%

Figure 12

FINAL REAL BALANCE FROM INVESTMENTS (PERCENT OF TOTAL REAL SAVINGS)

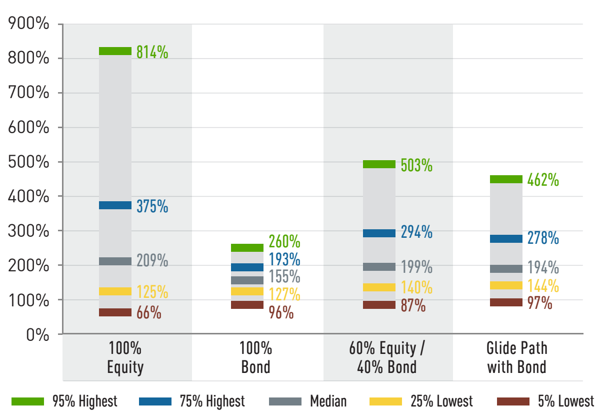
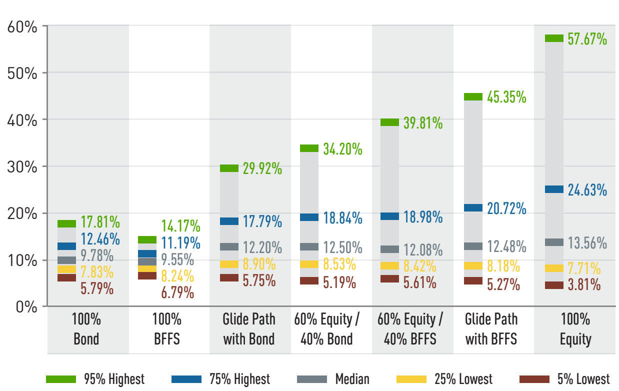


Figure 13

FINAL REAL ANNUAL INCOME FROM INVESTMENTS (PERCENT OF TOTAL REAL SAVINGS)



twenty-year rates); (2) the TDF goes from 90 percent to 30 percent equity over forty years, not ten years; and (3) rebalancing is quarterly.

In table 2 and figure 12, we summarize the distribution of the simulated real final investment balances as a percentage of total real savings over the forty-year periods for standard investment choices.

Rather than focus solely on retirement wealth, table 3 summarizes the simulated distributions of real retirement-income purchasing power across all strategies and figure 13 illustrates the same analysis. This is more closely linked to the retirement perspective and includes BFFS/SeLFIES. When comparing the ultimate simulation results of real retirement-income purchasing power, we express the annual real income generated by these strategies as a percentage of the total real retirement savings. For example, if someone saved real $1 million dollars over forty years, then 10 percent would mean $100,000 annual real income. Clearly, the equity-heavy portfolios have a greater dispersion than one invested entirely in bonds. We also notice that BFFS/SeLFIES have the lowest risk but also the lowest expected return. This is fairly natural because we label this instrument as the risk-free asset from the retiree's future income perspective.

The results support the introduction of BFFS/SeLFIES into the mix of investment products for retirement purposes:

1. The 100 percent invested in the BFFS/SeLFIES portfolio has the lowest risk when it comes to buying future real retirement income. It also has the lowest standard deviation of possible outcomes and the most benign downside risk (as measured by the highlighted 6.8 percent value in the fifth-lowest percentile in table 3).

VOLUME 7
NUMBER 1
2018

Table 3

REAL ANNUAL RETIREMENT INCOME (PERCENT OF TOTAL REAL SAVINGS)

	1 100% Equity	2 100% Bond	3 60% Equity/ 40% Bond	4 Glide Path with Bond	5 100% BFFS/ SeLFIES	6 60% Equity/ 40% BFFS/ SeLFIES	7 Glide Path with BFFS/ SeLFIES
Average Annual Real Income Bought	20.3%	10.5%	15.3%	14.7%	9.9%	16.1%	17.6%
Standard Deviation	22.9%	3.8%	10.2%	8.8%	2.4%	14.0%	17.6%
95% Highest	57.7%	17.8%	34.2%	29.9%	14.2%	39.8%	45.4%
75% Highest	24.6%	12.5%	18.8%	17.8%	11.2%	19.0%	20.7%
Median	13.6%	9.8%	12.5%	12.2%	9.6%	12.1%	12.5%
25% Lowest	7.7%	7.8%	8.5%	8.9%	8.2%	8.4%	8.2%
5% Lowest	3.8%	5.8%	5.2%	5.8%	6.8%	5.6%	5.3%

Columns (1) to (4) compare the real annual incomes generated by traditional investments, and columns (5)–(7) show the results from investment portfolios that use BFFS/SeLFIES. As the green fields of column (5) suggest, BFFS/SeLFIES alone would be the lowest risk option. The blue fields of (3) and (6) suggest that replacing bonds with BFFS/SeLFIES in a 60 percent equity/40 percent bond portfolio would result in higher average annual real income, and also more benign downside (5 percent lowest income) potential. While the standard deviation of possible annual real incomes generated by a 60 percent equity/40 percent BFFS/SeLFIES portfolio exceeds that of a 60 percent equity/40 percent bond portfolio, the generated distribution is more skewed to the upside in column (6) versus column (3). Similarly, BFFS/SeLFIES make the expected annual income and upside potential more attractive when introduced in a glide path portfolio (see orange-shaded cells in column (4) versus (7)), albeit the downside tail is somewhat longer in this case.

2. In the context of the 60/40 portfolio, if we replace bond investments by buying 40 percent worth of BFFS/SeLFIES, both expected income (column 3 versus column 6 in table 3) as well as downside risk would improve.

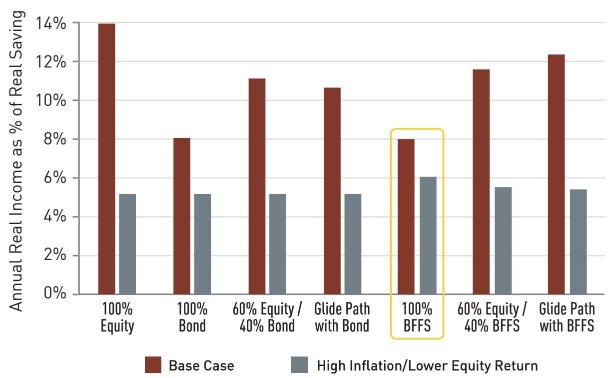
3. In the context of the glide path strategy, when we replace bond investments by BFFS/SeLFIES buying, most of the improvement is apparent by the upside potential (column 4 versus column 7 in table 3).

It's worth noting that some of these strategies are not fully comparable. While the 60/40 asset mix seems to be equivalent to the 60 percent equity and 40 percent BFFS/SeLFIES, in fact there is a material difference between the two: The classic 60/40 mix is rebalanced quarterly, whereas there is no rebalancing between equities and BFFS/SeLFIES. In a trending market, this can cause additional performance differences.

Finally, we also highlight a scenario when BFFS/SeLFIES would show its true benefit (see figure 14). Consider the following hypothetical scenario: a high inflationary period (expected CPI shifts from 2.5 percent to 5.0 percent), 100 bps higher interest rates, but a lower equity-return expectation (5 percent instead of 6.5 percent). In such a scenario, demonstrated by the red bars in figure 14, 100 percent invested in BFFS/SeLFIES would be the strongest performer strategy compared to the others. Of course, we don't know *ex ante* whether such a scenario truly would materialize in the future, but it may happen, and in that case, BFFS/SelFIES potentially would outperform all other investment strategies in our study. In practice, this also suggests that the investment strategy an investor chooses should reflect the investor's expectations or concerns about future market conditions. Alternatively, given investors' portfolio choices, one could impute their implied expectations on inflation, interest rates, and equity markets and use such an implied view to calibrate and validate if this is their true belief (thereby improving the governance of these funds).

Figure 14

BASE CASE COMPARED WITH HIGH INFLATION AND LOWER EQUITY RETURN SCENARIO



POTENTIAL DRAWBACKS TO BFFS/SELFIES

Muralidhar et al. (2016) list a number of potential drawbacks to these new instruments, and we briefly summarize them here. First, this is an untested market and raises the question of whether the market will accept a coupon-only bond instrument. The market has been receptive to zero-coupon bonds and because BFFS/SeLFIES are nothing more than a variation on a zero-coupon strip, this may not be too big a drawback. Second, demand for this bond is still unclear and pricing will be a challenge initially because the yield curve does not extend this far currently. Therefore, pricing will be driven entirely by demand and supply and, in turn, establish the appropriate rate on the yield curve. Third, for these bonds to be effective, they have to be issued regularly; otherwise, they may not meet the demand and will create scarcity for the existing issuance. This raises the fourth potential drawback—these bonds may have limited appeal at current rates unless other lower credit issuers enter the market to offer a credit spread over the government curve. Fifth, the choice of inflation index to which the bonds will be indexed will need to be established and clearly monitored. Because standard-of-living indexes are not as popular as traditional consumer inflation indexes (e.g., CPI), initially the TIPs-based index might be the easiest way to establish the market for such bonds. There is a danger that governments may find the issuance of these bonds to be attractive because they collect monies immediately but postpone their repayment to future governments. As a result, this could lead to excessive issuance and some restraint will need to be placed on governments by either rating agencies or institutions such as the International Monetary Fund. Finally, these bonds were designed to focus on average economy-wide longevity risk, but they do not hedge individual longevity risk. As noted earlier, individuals could purchase deferred life annuities. However, Muralidhar (2018) offers a related innovation, longevity-indexed variable expiration (LIVE) bonds that hedge longevity risk. Muralidhar (2018) demonstrates how a mix of BFFS/SeLFIES and LIVE allow an individual to plan for an effective retirement that allows them to achieve a target retirement income through uncertain death.

CONCLUSION

In this study, we argue that the assets and financial products available to investors, including those with QDIA status, may not be appropriate for the typical individual saving for retirement because a guaranteed asset allocation strategy implies no guarantee of retirement income—which is what individuals need to ensure a safe retirement. Current assets and products are risky from a retirement-income perspective. As demonstrated, all else equal, individuals retiring a few years apart can have vastly different retirement-income outcomes. BFFS/SeLFIES, a new bond instrument designed from the perspective of improving retirement security, has been proposed. It would be a bond with a forward-start (tied to date of retirement), income-only (because individuals need steady income), real cash-flow stream (linked to appropriate indexes), for a fixed period (tied to average life expectancy). This paper showed how this bond could be priced, and the factors that influence its price (and its potential risks in nonretirement portfolios). We then examined standard portfolio choices (60/40 portfolios and TDFs) from a retirement-income perspective, along with holding this new bond in isolation, to demonstrate how this new bond, either individually or when used in standard portfolio choices, could improve retirement outcomes. We conducted the analysis on both a historical simulation and using a Monte Carlo simulation that further validates the value of the new bond given the potential risks to all investment choices based on future equity, interest rate, and inflation scenarios. In some future economic scenarios (high inflation, higher interest rates, and weaker equity markets), BFFS/SeLFIES would be the least risky investment and the most financially attractive. From both an individual and social welfare perspective, governments could improve welfare by issuing such bonds.

Adam Kobor, PhD, CFA®, is director of investments at New York University. Contact him at adam.kobor@nyu.edu.

Arun Muralidhar, PhD, is an adjunct professor of finance at George Washington University and founder of Mcube Investment Technologies, LLC. Contact him at asmuralidhar@mcubeit.com.

APPENDIX

Asad-Syed et al. (1998) provide an example of a replacement rate analysis, which is illustrated in table A-1. Table A-1 presents the case of a twenty-five-year-old with a starting salary of $50,000 who hopes to retire at age sixty-five. In an ideal world with no uncertainty, if the individual makes contributions of 10 percent of annual salary (with nominal 4 percent salary growth), expects to live twenty years post retirement, and earns 8 percent returns (with 3 percent inflation), the individual can generate a retirement-income stream equal to 72 percent of final salary, or 142 percent of average salary, from retirement through death. Alternatively, targeting 100 percent replacement of final salary leads to the specific recommendation that the individual needs to save 13.90 percent of annual salary during the contribution period. Allowing for uncertainty in any of these parameters clearly complicates the analysis.

Table A-1

A VERY BASIC REPLACEMENT RATE CALCULATOR

Input	Output
Details About the Individual	**Expected Retirement Outcomes**
Current age .... 25 Retirement age .... 65 Current salary .... $50,000 Initial account balance .... $0 Contribution rate 10%	Balance at retirement .... $2,284,673 End career salary .... $240,051 Average career salary .... $121,740 Expected replacement rate on final salary .... 71.94% Expected replacement rate on average salary .. 141.85%
Details About the Individual	
Expected salary increase (nominal) .... 4.00% Expected return on contributions (nominal) ... 8.00%	
Assumptions After Retirement	
Life expectancy .... 20 years Expected return (nominal rate) .... 8.00% Expected benefit inflation 3.00%	
Calculation of Contribution Rate Given a Certain Replacement Rate Target	
Target replacement rate 100.00%	Contribution rate if targeting final salary .... 13.90% Contribution rate if targeting average salary 7.05%

ENDNOTES

1. EDHEC (2018) recommends the French government issue such bonds.
2. Data for this simulation was extracted from Bloomberg, LLC.
3. Data for this simulation was extracted from Bloomberg, LLC.

REFERENCES

Asad-Syed, K., A. Muralidhar, and R. J. P. van der Wouden. 1998. Determination of Replacement Rates for Savings Schemes. *Investment Management Department, Model Development Paper 1*. World Bank, Washington, DC.

Barney, L. 2016. More Than Withdrawal Strategy Needed for Retirement Income. *PlanSponsor Magazine* (January 29). http://www.plansponsor.com/More-Than-Withdrawal-Strategy-Needed-for-retirement-income/.

Bodie, Z. 2001. Retirement Investing: A New Approach (February). *The Pensions Institute, Discussion Paper* PI-0105. https://ssrn.com/abstract=260628.

Bodie, Z., R. C. Merton, and W. Samuelson. 1992. Labor Supply Flexibility and Portfolio Choice in a Life Cycle Model. *Journal of Economic Dynamics and Control* 16, no. 3–4 (July–October): 427–449.

Bodie, Z., J. Treussard, and P. Willen. 2008. The Theory of Optimal Life-Cycle Saving and Investing. CFA Research Foundation Publications 2008, no. 1 (February). CFA Institute.

Bodor A., K. Deryck, and A. Kobor. 2007a. What If? Foregone Returns for Mandatory Fully-Funded Defined Contribution Pension Plan Members in Hungary in Association with the Incomplete Regulatory Environment. *Unpublished White Paper*. Retirement Reform Roundtable in Budapest, May 2007.

———. 2007b. Asset Allocation and Performance of Fully-Funded Defined Contribution Plans in Hungary – Historical Experience and Future Challenges. *Presentation to the Retirement Reform Roundtable in Budapest*. (May).

Brown. A. 2014. The Case for a New Form of Gilt. Schroders Talking Point (July). http://www.icpmnetwork.com/wp-content/uploads/2016/04/Alan_Brown_Pre_Reading_1_Rob_to_review_2_pp.pdf.

Brown, J. R., A. Kapteyn, E. F. P. Luttmer, and O. Mitchell. 2012. Do Consumers Know How to Value Annuities? Complexity as a Barrier to Annuitization. Santa Monica, California: RAND Corporation. http://www.rand.org/pubs/working_papers/WR924.

Economist, The. 2017. Analysts Struggle to Make Accurate Long-Term Market Forecasts (August 31). https://www.economist.com/news/finance-and-economics/21727899-historically-high-valuations-equities-complicate-task-analysts-struggle.

EDHEC. 2018. Pour L'Émission D'Obligations Retraites par L'état Ou Comment Réconcilier Les Français Avec La Finance En La Rendant Vraiment Utile. EDHEC Risk Institute, Paris, France.

Government Accountability Office (GAO). 2016. Better Information on Income Replacement Rates Needed to Help Workers Plan for Retirement. GAO-16-242 (March 1). https://www.gao.gov/products/GAO-16-242.

Housel, Morgan. 2015. The Blind Forecaster: Who Pays These People? Motley Fool (February 25). http://www.fool.com/investing/general/2015/02/25/the-blind-forecaster.aspx.

Kilroy, M. 2018. Target-Date Funds the Engine Powering Continued Growth. *Pensions & Investments, Special Report: DC Managers* (July 23). http://www.pionline.com/article/20180723/PRINT/180729977/target-date-funds-the-engine-powering-continued-growth.

Klapper, L., A. Lusardi, and P. van Oudheusden. 2015. Financial Literacy Around the World: Insights from the Standard & Poor's Ratings Services Global Financial Literacy Survey. *World Bank Development Research Group* (November). Washington, DC. http://gflec.org/wp-content/uploads/2015/11/Finlit_paper_16_F2_singles.pdf.

Markowitz, Harry. 1952. Portfolio Selection. Journal of Finance 7, no. 1 (March): 77–91.

Merton, R. C. 2007. The Future of Retirement Planning. In *The Future of Life-Cycle Saving & Investing*, Z. Bodie, D. McLeavey, and L.B. Siegel (eds.). Research Foundation of the CFA Institute. Charlottesville, Virginia.

———. 2010. Next Generation Retirement Planning. Presented at *Pensions & Investments*, West Coast Defined Contribution Conference, October 24–26, San Francisco, California.

———. 2012a. Observations on Financial Education and Consumer Financial Protection. In *Life-Cycle Investing: Financial Education and Consumer Protection*, Z. Bodie, L. B. Siegel, and L. Stanton (eds.). Research Foundation of the CFA Institute. Vol. 2012, no. 3 (November). Charlottesville, Virginia.

———. 2012b. Funding Retirement: Next Generation Design. JASSA: *The Finsia Journal of Applied Finance* vol. 2012, no. 4 (winter): 6–11.

———. 2013. Applying Life-Cycle Economics: An Income-Oriented DC Retirement Solution that Integrates Accumulation and Payout Phases. U.K. Nest Conference on Retirement (June). London, United Kingdom.

——— . 2014. The Crisis in Retirement Planning. *Harvard Business Review* (July–August). https://hbr.org/2014/07/the-crisis-in-retirement-planning.

Merton, R. C., and A. Muralidhar. 2015. Monetary Policy: It's All Relative. *Pensions & Investments* (April 16). http://www.pionline.com/article/20150416/ONLINE/150419916/monetary-policy-its-all-relative#.

——— . 2017a. Time for Retirement SeLFIES. *Investment & Pensions Europe* (April): 3–4. https://www.ipe.com/reports/special-reports/ipe-at-20/ipe-at-20-time-for-retirement-selfies/10018263.article.

——— . 2017b. SeLFIES Can Improve the Nation's Retirement Security. *PlanSponsor Magazine* (November 20). https://www.plansponsor.com/selfies-can-improve-nations-retirement-security/.

——— . 2018. SeLFIES for India: These Long-Term Bonds Can Fund India's Infrastructure Needs and Improve Retirement Security. *The Times of India* (February 5). https://blogs.timesofindia.indiatimes.com/toi-edit-page/selfies-for-india-these-long-term-bonds-can-fund-indias-infrastructure-needs-and-improve-retirement-security/.

Milevsky, M. A. 2006. *The Calculus of Retirement Income. Financial Models for Pension Annuities and Life Insurance*. Cambridge, United Kingdom: Cambridge University Press.

Muralidhar, A. 2015. New Bond Would Offer a Better Way to Secure DC Plans. *Pensions & Investments* (December 14). http://www.pionline.com/article/20151214/PRINT/312149974/new-bond-would-offer-a-better-way-to-secure-dc-plans.

——— . 2016. Goals-Based Investing, the KISS Principle, and the Case for New Financial Instruments. Working Paper. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2715053.

——— . 2018. Managing Longevity Risk: The Case for Longevity-Indexed Variable Expiration (LIVE) Bonds (July 1). https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3224236.

Muralidhar, A., K. Ohashi, and S.H. Shin. 2016. The Most Basic Missing Instrument in Financial Markets: The Case for Forward-Starting Bonds. Journal of Investment Consulting 16, no. 2: 34–47.

Preesman, L. 2015. Dutch Pension Funds' Coverage Ratios Plummet in January. *Investment & Pensions Europe* (February 3). https://www.ipe.com/countries/netherlands/dutch-pension-funds-coverage-ratios-plummet-in-january/10006519.article.

Salisbury, L., and G. Nenkov. 2016. Solving the Annuity Puzzle: The Role of Mortality Salience in Retirement Savings Decumulation Decisions. *Journal of Consumer Psychology*. 26, no. 3: 417–425.

Yang, J., and L. P. Lutton. 2014. 2014 Target-Date Fund Landscape. *Morningstar Target Date Series Research Paper*. Chicago, Illinois (April 1).

INVESTMENTS & WEALTH INSTITUTE®
formerly IMCA

5619 DTC Parkway, Suite 500
Greenwood Village, CO 80111
Phone: +1 303-770-3377
Fax: +1 303-770-1812
www.investmentsandwealth.org