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Atanu Saha, Alex Rinaudo

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Downside Risk Protection of Retirement Assets: A New Approach

Atanu Saha – Chairman, Data Science Partners
Alex Rinaudo – Chief Executive, Data Science Partners[1]

Abstract

Over the past few decades, 401(k) plans, IRA accounts, and other self-directed investment vehicles have become the most important pool of retirement savings, leaving retirees exposed to the risk of outliving their assets, a hazard largely absent from traditional pension plans. Prior research has examined asset diversification, annuities, put options, and dynamic withdrawals as ways to mitigate this risk. This study proposes an alternative: explicit downside risk protection (or DRP) at the individual account level. The proposed DRP takes the following form: in years the account suffers a loss, that loss is capped at a predetermined amount. In return for this protection, the account holder gives up a portion of the gains only in years where the account's performance is positive. The net effect of this protection is to reduce the retirement account's downside risk, significantly reducing the likelihood of early account depletion. A Monte Carlo simulation demonstrates that the chance of outliving one's assets over a retirement horizon of 45 years drops from nearly 15% without DRP to about 4% with DRP. Furthermore, by eliminating extreme negative outcomes, DRP has the potential to increase the average portfolio return (even accounting for the cost of protection) while simultaneously reducing the portfolio volatility. This paper also demonstrates that DRP can be profitably offered by a financial institution. It provides lower bound estimates of the rate of return a financial institution is likely to earn by offering DRP to retirement accounts.

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INTRODUCTION

The past few decades have seen a dramatic shift in how most Americans hold their wealth when entering retirement. While forty years ago pension plans dominated retirement assets, for future retirees 401(k) assets or similar retirement assets are by far the most important pool of retirement savings. However, most 401(k) plans do not provide adequate tools to manage downside risk. As a result, many retirees face a significant risk of early asset depletion, i.e., outliving their retirement assets. This paper proposes a new approach for providing downside risk protection for retirement portfolios.

There has been a marked asset shift in the types of retirement accounts in the past four decades. According to Investment Company Institute data, in 1974, 82% of U.S. retirement assets were in pension funds; by 2014 it had nearly halved to 42%, with a majority of retirement assets residing in 401(k) plans, IRA accounts, and other self-directed investment vehicles for retirement assets.[2]

Looking at changes in the mix of retirement assets over time masks the fact that a majority of the pension assets are held by older individuals. According to the Employment Benefit Research Institute, in 2010 only 30% of current private sector plan participants had access to pension plans; in 1979 this figure was higher than 80%. Based on these data, it is reasonable to expect that the share of retirement assets in 401(k) plans, as opposed to pension plans, is likely to increase substantially in the coming years.

Compared with pension plans, 401(k) plans confer certain benefits, such as portability and investment control. These are particularly valuable before retirement (the accumulation phase), as they give individuals more control over their ability to change employment and over the composition of their portfolio. However, during retirement (the withdrawal phase), 401(k) plans expose retirees to risks that are largely absent in pension plans. In particular, 401(k) plans, when compared with pension plans, have two key areas of risk: longevity and income risk.

Longevity risk refers to the unknown amount of time in retirement over which any individual will require income. In a 401(k) plan, retirees have assets that they can choose to invest in and withdraw from as they see fit. However, there is no guarantee that these assets will last for the entire retirement time horizon. This is in contrast to a typical pension plan that provides a predetermined income stream until death, eliminating longevity risk for an individual.

Income risk refers to the uncertainty of the income stream during retirement. 401(k) account holders have a specific balance from which to draw funds and are, therefore, impacted by investment performance. Poor investment performance (downside risk) accelerates the decline in retirement assets, reducing the asset balance left to draw upon.

In light of these risks, both the academic literature and the popular press have paid considerable attention to the issue of risk mitigation. This paper proposes a new approach of providing downside risk protection for a retirement account. The proposed downside risk protection (DRP) takes the following form: in the years where the retirement account has positive returns, the account holder pays a portion of the amount gained and in years where the account suffers a loss, that loss is capped at a predetermined amount. The net effect of this protection is to reduce the retirement account's downside risk, significantly reducing the likelihood of early account depletion.

A Monte Carlo simulation of 50,000 different portfolio return outcomes suggests that the proposed downside risk protection approach markedly reduces the likelihood of early asset depletion. This risk reduction is far more effective than the widely-recommended diversified portfolio of equity and fixed-income assets. Furthermore, downside risk protection, by eliminating extreme negative outcomes, has the potential to increase the average return (even after accounting for the cost of protection) and reduce the volatility of portfolio returns. This paper concludes by demonstrating that downside risk protection can be provided by a financial institution both effectively and profitably with a reasonable cost to investors.

THE RELEVANT LITERATURE

There is a wide body of literature discussing different strategies that could be implemented by investors or their financial advisors to mitigate premature asset depletion risk for retirement portfolios. These include asset allocation, annuities, and usage of derivative instruments such as put and call options.

Asset allocation

Many studies have discussed static asset allocation strategies. Blanchett (2007) compared a constant allocation strategy to various dynamic strategies and concluded that constant

2 In the rest of the paper, in the interest of brevity, the term 401(k) plan will be used to denote all such self-directed retirement accounts.

allocation strategies are reliably efficient, recommending a 60-40 stock-bond allocation. Israelsen (2015) argued that the classic 60-40 stock-bond allocation might not serve retirement investors, since if interest rates rise, bond returns would be low. He found that having a diversified portfolio with seven asset classes (large- and small-cap U.S. stocks, non-U.S. developed market stock, real estate, commodities, U.S. bonds and cash) was optimal. Ameriks et al. (2001) found that an aggressive portfolio with an 85-15 equity-bond allocation performed well. However, given the high risk of this aggressive portfolio, the authors suggested purchasing fixed-life annuities as well. Lemoine et al. (2010) demonstrated that an aggressive portfolio, with 100% in equities, coupled with a fixed annuity purchased when the portfolio was deemed to be sufficiently large, had the highest chance of success for meeting investment goals.

Other papers have proposed dynamic asset allocation strategies and used glide paths to describe the changing allocation of stocks and bonds. Bodie et al. (1992) argued that younger investors were able to hold more of their wealth in risky assets because of their greater labor market flexibility. This argument led to the traditional glide path, introduced by Bengen (1996), which began with higher equity exposure during the asset accumulation phase and became more conservative by increasing bond allocation when approaching retirement. Milevsky (2012) elaborated on this topic by describing equations that factor in the valuation of human capital to an investor's allocation of stocks. In contrast to Bengen et al. (2014), Delorme (2015) found that rising equity glide paths, where investors gradually increased their equity exposure as they approached retirement, were more successful. Kingston and Fisher (2014) argued that investors should have a "V-shaped" lifetime glide path, where the share of equity investments fell over the asset accumulation phase but then rose during retirement. Blanchett (2015) compared decreasing, increasing, V-shaped, and inverted-V-shaped glide paths, where allocation change was made slowly or quickly. Out of the eight different scenarios tested in many different market environments, he found decreasing fast glide paths had the highest chance of being optimal.

Recent studies have highlighted the importance of market environments in determining optimal glide paths. Kitces and Pfau (2015) argued that investors should factor in how the market was valued when they began investing for retirement. If retirement investors started saving in an overvalued environment, Kitces and Pfau recommended using a rising equity glide path. However, they also found that a static 60% equity allocation was effective for retirees who did not choose dynamic strategies. Blanchett (2015) pointed out that the differences in the findings of the various retirement asset allocation studies were due, in part, to the differing return assumptions for stocks and bonds. His study found increasing equity glide paths to be more successful in higher-return environments, but decreasing equity glide paths were better in lower-return environments.

Annuities

Annuities are another commonly-discussed risk mitigation instruments and have been gaining popularity, particularly since the 2008 financial crisis. A recent study by Allianz reported that 61% of baby boomers feared "outliving my money in retirement" more than death [Bhojwani (2011)]. Retirees' fear of running out of money has bolstered the growth of annuities in the mainstream retirement marketplace.

Various studies have analyzed the benefits of different types of annuities. Scott (2015) found that allocating 10-15% of a retirement portfolio to longevity annuities was comparable to allocating 60% to immediate annuities; hence longevity annuities were better suited for retirees. Finke and Pfau (2015) found that deferred income annuities, which are similar to longevity annuities but with a shorter deferral period, were a good choice for retirees seeking stable income. Horneff et al. (2015) demonstrated that although variable annuities with guaranteed minimum withdrawal benefit riders were expensive, they still improved a retiree's income, especially when purchased before retirement.

Wasik (2015), who described the state of the variable annuity market, found that there were over 220 different products in the variable annuity market with an average fee of 1.4%. He found that guaranteed minimum income benefits raised the annual expense by an additional 1% - 1.15%. In addition, lifetime income benefits added 0.35%-1.25% to the annual expense. Blanchett (2013) highlighted that intermediate fixed annuities were particularly costly in low interest rate environments.

Annuities are often purchased for the security they offer, and despite being thought of as a retirement investment vehicle with a secure return, annuities are not riskless instruments. Xiong and Idzorek (2012) pointed out that annuities, like other financial products, had risks, including default risk and illiquidity risk. The authors argued that these risks should be weighed against the cost of the annuity.

Derivatives

A few studies have focused on options as risk mitigation tools for retirement assets. For example, Simonian (2011) argued that tail risk hedging using put options was necessary for retirement investing because capital preservation was almost as important as return generation for retirees. However, Basu and Drew (2014) used historical data to show that purchasing put options to hedge tail risk was not worth the cost for active or passive mutual fund retirement portfolios. Johnston et al. (2013) also found that, since put options often expire out of the money, writing a call option worth 1% - 3% of portfolio value offered higher returns than a portfolio of fixed income securities and put options. However, put and call options are almost always unavailable in retirement accounts, particularly in 401(k) plan offerings. Even assuming one had the means to purchase put options in a separate account, using put options to properly hedge a portfolio on an ongoing basis can be quite expensive and complex.

Loss protection

Our paper is related to a recent study by Miccolis et al. (2015), which focused on how much a retiree should be willing to pay, in basis points (bps), to "buy" risk-managed investing (RMI), which provides loss protection for retirement assets. Their study examined historical S&P 500 returns to model RMI's costs for various levels of loss protection. They found that the break-even cost ranged between 145 bps and 1,130 bps. The paper also analyzed the 29 instances in the past when the S&P 500 dropped more than 10% and found that had RMI covered half of the losses beyond 10%, it would have provided value to the retiree as long as its cost did not exceed 410 bps. The authors stressed that their cost estimation was conservative since it did not account for other factors, like peace of mind.

Our paper builds on and extends the Miccolis et al. (2015) study in several ways. First, we propose a concrete, implementable strategy through which retirees' assets could have exact, and not approximate, downside risk protection. For example, the RMI strategies discussed in Miccolis et al. (2015) include: tactical allocation of capital based on fundamental analyses of markets; investing in funds whose strategy is to provide equity exposure with less volatility; quantitative, momentum-based strategies that provide a signal to move in and out of certain asset classes or sectors; tail risk hedging, including investing in volatility derivatives, put spreads, etc.; and combinations of these strategies, none of which provide exact downside risk protection. These strategies are complex and require retirees' assets to be managed by a skilled manager. Furthermore, none of these strategies are available as an investment option in a typical 401(k) plan.

Second, our paper turns the conceptual framework of RMI into a viable investment product. In particular, it discusses how downside risk protection can be provided by a financial institution that is managing a 401(k) plan or by a separate financial institution. Importantly, we demonstrate that it can be done both effectively and profitably.

Third, while we use historical data to illustrate the importance of downside risk protection, the analysis and quantification of the probabilities of asset depletion risks are undertaken through Monte Carlo simulation. This quantitative technique provides rigorous estimates of the likelihood of early asset depletion in the uncertain future with and without downside risk protection.

SEQUENCE RISK: AN ILLUSTRATION

While negative returns are always a contributor to asset balance reduction, they are particularly harmful if they occur early in the retirement phase, during which assets are withdrawn each year. The ability for early negative returns to disproportionately affect the value of a portfolio is commonly referred to as sequence risk. This risk has received considerable attention in the literature [see, for example, Kitces (2008), Frank et al. (2011), Basu (2011), Basu et al. (2012), Guyton (2013), Pfau (2014), and Miccolis et al. (2015)].

A hypothetical example illustrates the importance of sequence risk. Consider two accounts that are invested in the same assets but enter the retirement phase one year apart. Figure 1 shows the annual returns of the two retirement portfolios over time and the two starting points of withdrawals.

Although the two accounts start the withdrawal phase one year apart, they are the same in all other aspects: both have the same starting balance when withdrawals begin and both make the same dollar amount of withdrawals each year. Figure 2 shows the outcome for these two accounts. In this figure, the value of the retirement account balance is indexed to 100 at the beginning of the withdrawal phase. It shows that the one-year delay in withdrawal commencement makes all the difference. Account 1 is fully depleted by year 14, while Account 2 provides income through retirement. It is worth noting that while Account 2 provides sufficient retirement income, it also experiences some significant declines in the first few years and does not rise to a level consistently above its initial account balance until year 22 (not shown in the figure).

While one might be inclined to think that the retirement portfolio returns utilized in this example are fabricated, these scenarios are based on actual historical equity returns. In this case, the holder of Account 1 had the misfortune of retiring just as the Great Depression started in 1929, while the holder

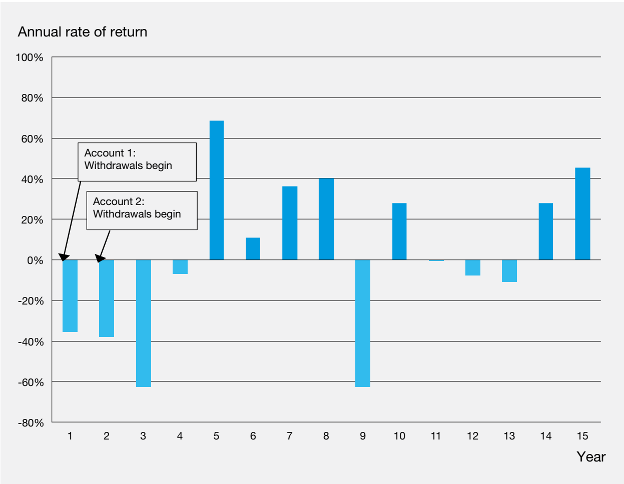

Figure 1 – Annual rates of return of retirement assets over time

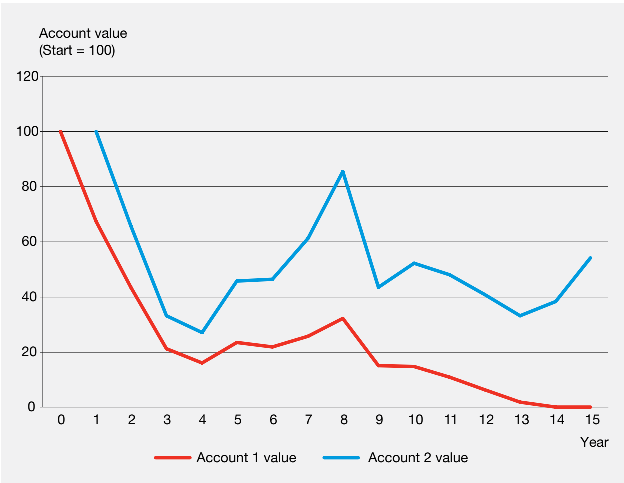

Figure 2 – The retirment account balance over time

of Account 2 retired one year later in 1930. Admittedly these two start years and the associated market returns are extreme examples, but we chose them to illustrate the issue of asset depletion risk as it relates to the timing of negative returns.

One commonly suggested remedy for the retirement asset depletion problem (illustrated in Figure 2 by Account 1) is dynamic withdrawals, as described by Stout and Mitchell (2006), Kitces (2008), Frank et al. (2011), Basu (2011), Blanchett (2013), Guyton (2013), Pfau (2014), and Delorme (2015). In the example of the two accounts discussed above, the withdrawals were set at a constant dollar amount each year. Under dynamic withdrawals, the account holder sets a percentage of retirement assets to withdraw each year rather than a set dollar amount; this allows the retiree to reduce the withdrawal dollar amount when the retirement assets shrink as a result of negative returns.

While it is true that this approach would allow Account 1 to survive the entire retirement horizon (assuming the percentage is set low enough), consider the implications over the first 15 years: under dynamic withdrawals, in 9 of the first 15 years the withdrawal amount has to be less than half of the constant dollar amount, and in no year is the amount greater than the constant dollar amount in the first year.

While it is easy to say that retirees should adjust their spending in accordance with dynamic withdrawals if their portfolio performs poorly, in reality this can be quite difficult given that a majority of retirees' costs are likely to be fixed for necessities such as housing, medical expenses, food, and transportation. As a result, most retirees may think of their withdrawal from retirement assets as a specific dollar amount, and not as a percentage of their assets. While dynamic withdrawals as an abstract concept seems reasonable, it is likely not a practical solution to the asset depletion problem.

Indeed, early asset depletion – not having enough assets to last through retirement – is a key issue on the minds of many retirees. And this issue, in turn, hinges on the risks of negative retirement portfolio performance, particularly large negative returns in the early years of the retirement horizon.

Our paper proposes a new approach to address the early asset depletion risk: explicit downside risk protection at the individual account level. The goal of this protection is to eliminate large negative returns of a retirement portfolio. As discussed in the next section, this type of protection can substantially reduce the risk of asset depletion while maintaining virtually all the benefits of 401(k) plans.

DOWNSIDE RISK PROTECTION: A NEW APPROACH

The DRP proposed in this paper takes the following form: in years where the account has positive returns, the account holder pays a portion of the amount gained; conversely, in years where the account suffers a loss, that loss is capped at a predetermined amount. The net effect of this protection is to reduce the retirement account's downside risk, significantly reducing the likelihood of early account depletion.

To illustrate the effect of DRP on the performance of retirement portfolios, there needs to be a basis for modeling outcomes in an uncertain future. Incorporating the assumption that the market's past performance over many years is a reasonable basis to model a likely range of outcomes for the future, we use equity and bond returns from 1926 through 2014. Over these 89 years, a portfolio comprised of 50% large-cap U.S. equity and 50% small-cap U.S. equity, has an average annual return[3] of 10.9% and a volatility of 23.2%. Of the 89 annual returns, 25 are negative; 9 are worse than -15%.

The proposed DRP has the following specific structure: a retirement portfolio's returns cannot be worse than -15% in any given year. To pay for this protection, the account holder gives up 10% of gains in years with a positive investment return.[4] To illustrate, consider an account which starts with $100 and has an investment performance of -20% in that year. In this case, DRP would kick in and instead of losing $20, the account balance would fall only by $15, the portfolio receiving $5 from the DRP provider. Conversely, an account with $100 that experiences a return of +20% would only go up by $18 with the remaining $2 being paid to the provider of DRP.

As discussed earlier, negative returns can have a disproportionately adverse effect when they occur in the early years of the retirement time horizon. Specifically, the impact of the sequence of large negative returns matters because of dollar withdrawal, as opposed to a withdrawal based on a percent of retirement assets. For example, Figure 3 revisits the scenario discussed earlier in which two similar accounts with different retirement start dates had very different outcomes. In the figure, the dashed lines show the original account balances using actual returns. The solid lines show the balances with DRP. As the figure clearly shows, DRP has a significant positive impact on both accounts. In particular, Account 1, which was fully depleted by year 14 of retirement (dotted red line), is no longer depleted with DRP and, in fact, shows healthy account balance growth for the entire retirement horizon (solid red line).

As discussed earlier, even a single difference in the sequence of negative returns can make a significant difference in the ultimate outcome. At the outset it is not known when negative returns will impact a portfolio; hence, it is necessary to model the impact of negative returns, particularly large negative ones, at various points in time during the retirement period. A Monte Carlo simulation based on actual historical equity returns is used to create 50,000 different sequences of equity returns. Each iteration of the simulation draws a random set of returns from the set of 89 annual historical equity returns.

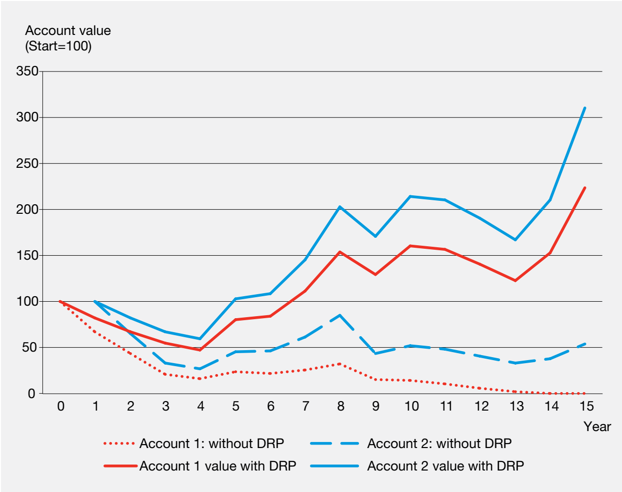

Figure 3 – Impact of DRP

As a result, each simulation iteration is based upon actual returns data, but the sequence of the returns is different for each iteration. This simulates the varying effect of negative returns early or late during a retirement horizon. Some iterations have few negative annual returns, others have a mix of positive and negative returns, and in some cases most of the negative returns occur very early on in the retirement period. It is this latter sequence of returns that leads to the highest risk of asset depletion.

Before running the simulation, two more inputs are required: the time horizon of the portfolio and withdrawals for retiree's expenses.

Retirement time horizon

According to the Social Security Administration, the average 60-year-old can expect to live a little over 22 years. But this means that 50% of individuals will live beyond 22 years after turning 60. Since no one knows ahead of time whether they will live more or less than average, the retirement time horizon used here is double the average, 45 years.[5] This virtually guarantees that the Monte Carlo simulation has accounted for

3 All annual returns discussed in this article are based on logarithmic returns.
4 These cutoffs can and should vary depending on the return and volatility characteristics of the portfolio. For example, downside protection of -15% on a bond portfolio makes little sense. We will also explore the impact of downside risk protection with a different threshold on a mixed stock-bond portfolio below.
5 While this parameter is held constant in the Monte Carlo simulation, the authors have also evaluated random time horizons based upon probabilities in the SSA life tables and found this did not affect the results. According to the SSA lifetables, less than 0.5% of people live more than 45 years after age 60.

the entire period over which a retiree may need to draw upon assets from the retirement account. In other words, this simulation eliminates longevity risk from the analysis. Thus, for each iteration of the simulation 45 annual stock market returns are randomly drawn (with replacement) from the 89 data points (with year-matched inflation rates).

Retiree's expenses

The most commonly suggested sustainable withdrawal amount is 4% of assets at the start of the retirement period, first approximated as a general rule by Bengen (1994). Our simulation starts with the assumption that the account holder will require 4% of their account balance in the first year and then that dollar amount will grow by the (year-matched) inflation rate each year.[6] That is, in the Monte Carlo simulation, in each iteration, the equity return and inflation rate are drawn from the same year. For the reasons discussed earlier, we do not consider dynamic withdrawals, where the amount withdrawn each year fluctuates with the account value.

Our paper's main inquiry is the likelihood of early asset depletion; that is, given a fixed starting balance and an inflation-adjusted annual withdrawal amount, what is probability that a retirement account with uncertain investment performance will be depleted before the end of the retirement horizon of 45 years?

Table 1 shows the results for early asset depletion probability across 50,000 simulations for an all-stock, an all-bond, and a stock-bond hybrid portfolio. It is clear from the results in Table 1 that an all-bond portfolio's risk is unacceptable – the likelihood of early asset depletion is extremely high, at 50%. This is largely explained by the lower average returns of bonds.[7] The best performing portfolio is a mix of stocks and bonds.

To illustrate the outsized effect negative returns can have in the first few years, consider two different scenarios, one where DRP is utilized only for the first 10 years of the retirement period and the other where DRP is in place for all 45-years. Table 2 shows the estimated probability of asset depletion over time for an all-equity portfolio, with and without DRP.

The first row shows the estimated asset depletion probabilities at years 25 and 45 assuming no DRP. The results across 50,000 simulations show that by year 25 there is an 8.4% probability of asset depletion; by year 45 this probability is 14.6%. In the partial DRP scenario – with DRP in place for the first 10 years – the probability of asset depletion by year 45 is cut by nearly half to 7.9%. In the full DRP scenario, in which the protection is in effect for the entire 45-year period,

Asset allocation	Estimated probability of asset depletion	Annual return	Annual standard deviation
All stocks	14.6%	10.9%	22.9%
60-40 bond-stock split	8.8%	8.5%	10.3%
All bonds	50.0%	5.7%	8.0%

Table 1 – Effect of asset allocation on early asset depletion risk

Downside risk protection	At year 25	At year 45
None	8.4%	14.6%
Partial (DRP years 1-10)	2.7%	7.9%
Full (DRP for all 45 years)	1.6%	4.3%

Table 2 – Estimated probability of early asset depletion (all stocks)

Downside risk protection	Annual average return	Annual volatility
None	10.9%	22.9%
Partial (DRP years 1-10)	11.1%	21.6%
Full (DRP for all 45 years)	11.6%	16.8%

Table 3 – Portfolio performance

the probability of asset depletion at year 45 is cut again nearly by half to 4.3%. Notably, this probability is also less than half of the asset depletion probability of the 60-40 bond-stock hybrid portfolio, which is 8.8%, as shown in Table 1. Thus, DRP provides a far superior protection than the widely-used recommendation of retirement asset diversification.

Importantly, DRP not only reduces the risk of early asset depletion but it also improves the risk-return characteristics of the portfolio. Table 3 shows the estimated average annual returns and volatility of the returns of retirement assets under the three scenarios. Since the returns are logarithmic, the averages shown in this table are geometric and not arithmetic means. The first row provides the benchmark, with no DRP. In this case, the average annualized return is 10.9% and the annualized volatility is 22.9%. As shown in the table, the addition

6 Inflation data from Ibbotson.
7 The average returns for the various assets shown in Table 1 (and in subsequent tables) are based on logarithmic returns; as a result, the averages are geometric and not arithmetic means.

Downside risk protection	Median balance	5th percentile
None	65x	-12.5x
Partial (DRP years 1-10)	75x	-2.9x
Full (DRP for all 45 years)	97x	1.2x

Table 4 – Portfolio balance at year 45

of DRP has the dual benefit of increasing average return while decreasing volatility. The difference of 0.7% in average annual returns between the "no DRP" and "full DRP" scenarios might not seem much, but over a 45-year horizon this small difference has a cumulative impact of over 37%!

Thus, in addition to allowing the account holder to maintain all the benefits of a 401(k) account, and providing explicit rather than approximate downside protection, DRP provides a net benefit to the account holder in terms of higher average returns. This is in sharp contrast to other available options discussed earlier, in many of which annual costs are 1% of assets or more.

Table 4 illustrates the impact of this benefit by showing the account balances at year 45; the account balance at year 45 is expressed as a multiple of the initial balance. As one would expect, given the higher average returns and lower volatility, the median outcome and 5th percentile outcome (across 50,000 outcomes) are both markedly better for the portfolios when DRP is in place.

The impact of DRP on a stock-bond mixed portfolio

A stock-bond mixed portfolio typically will have lower volatility (and lower downside risk) than the stock-only portfolio considered so far. As a result, for DRP to provide meaningful downside risk protection, the threshold needs to be different depending on the mix of stocks and bond assets in the portfolio. Monte Carlo simulation can also be used to demonstrate the efficacy of DRP for a portfolio that has 60% bonds (equal weighting of corporate and government bonds) and 40% stocks. For this portfolio, we examine DRP with the following structure: portfolio losses are capped at -6% and in return the account holder gives the DRP provider 5% of the gains in years when the portfolio earns a positive return. Monte Carlo simulation demonstrates that DRP provides a meaningful reduction in early asset depletion probability: from 8.8% without DRP to 5.6% with DRP. The portfolio also earns a higher average annual return and experiences a lower return volatility with DRP in place. These results illustrate that by modifying the downside cap and the upside payment, DRP can work in portfolios with different mix of asset types.

CAN DRP BE OFFERED PROFITABLY?

We have modeled DRP, for a stock-only portfolio, with a cost of 10% of gains in years with positive returns. In this section, we show that this cost is sufficient to create reasonable profits for the provider of DRP.

We begin by modeling the DRP provider's cost of hedging the exposure it faces from offering downside protection. For an all-equity portfolio, the asset holder gives up 10% of the positive returns and portfolio's losses are capped at -15% in any given year. It follows, therefore, that the DRP provider's payoff structure is the converse of this: it gains 10% of the positive returns and faces the full amount of the loss beyond -15%. This return profile is shown in Figure 4.

In this figure, the value of the portfolio for which protection is provided is denoted by S, and its current value is S_0. When the value of the portfolio exceeds S_0, the DRP provider gets 10% of the gain (note the dashed line is a 45° line). When the portfolio value falls below $0.85 \times S_0$ the provider faces the full amount of the loss beyond $0.85 \times S_0$. The DRP provider's payoff structure is depicted by the thick solid line. It has three separate segments: when $S > S_0$ it has an angle of 4.5°, (i.e., one-tenth of 45°); between S_0 and $0.85 \times S_0$ it is flat with zero payoff; and when $S < 0.85 \times S_0$ it is negative at a 45° angle.

Thus, the DRP provider's payoff is identical to one faced by an investor who is holding a portfolio comprised of long call and short put, with the call being at the money and the put 15% out of the money, and the ratio of put-to-call is 10-to-1; that is, there are 10 out-of-the-money puts for every at-the-money call. The DRP provider can fully hedge this exposure by buying 10 puts (15% out of the money) and selling an at the money call. The DRP provider's net cost of hedging depends on the

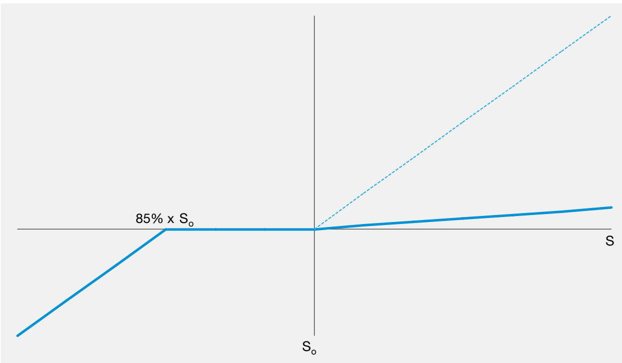

Figure 4 – The DRP provider's payoff structure

Underlying volatility	Call revenue	Put revenue	Net revenue
10%	$0.50	($0.12)	0.38%
15%	$0.70	($0.74)	-0.04%
20%	$0.89	($1.79)	-0.89%
25%	$1.02	($3.44)	-2.42%

Assumptions: 1-year options, 2% risk free rate. Call, at the money, covering 10% of portfolio value. Put, 15% out of the money, covering 100% of the portfolio value.

Table 5 – Net hedging cost for DRP provider

volatility of the underlying portfolio. These hedging costs, at various levels of volatility, are shown in Table 5.

In this table, the column "call revenue" shows the proceeds from selling the call (which is one-tenth the price of the call) and the "put revenue" reflects the cost of buying the put. Table 5 shows, when the underlying annualized volatility is 25%, the hedging cost is 242 bps points. In this table, the options have been priced utilizing the Black-Scholes option model. We have also examined market prices for one-year-out, exchange-traded options for SPY, an ETF that tracks the S&P500 index. The observed market prices of the options suggest that the DRP provider's hedging cost is consistent with those shown in Table 5; it is approximately 252 bps.[8]

The foregoing option-based analysis is conservative as it does not account for the various forms of additional revenue the DRP provider might receive from holding the assets of the DRP purchasers. For example, the DRP provider might be able to lend out securities being held in the DRP accounts and earn security lending fees. These lending fees could potentially offset the DRP provider's hedging costs. Furthermore, in most years, the DRP provider would not have to pay out any money (since annual returns worse than -15% are relatively rare), but would instead be receiving cash flows from DRP purchasers equal to the 10% of the gains in positive-return years. The cash flows the DRP provider receives could be invested in relatively safe assets and returns of this investment could also defray its hedging costs.

To examine the DRP provider's most likely returns under various market conditions, we undertook a Monte Carlo simulation using the same method described earlier in this paper: random sequences of equity returns are drawn 50,000 times from the set of 89 historical annual equity returns. The DRP provider's pay-off structure is assumed to be identical to the one depicted in Figure 4. We have ignored the security lending income, but have assumed that the DRP provider's account balance earns the return it receives from the DRP purchaser plus the annual T-bill rate. In the Monte Carlo analysis, we find that the DRP provider earns, on average, an annualized return of 240 bps, which is approximately equal to the hedging cost of 242 bps, noted above.

The fact that the DRP provider likely earns a positive return is intuitive and consistent with historical data on market performance. In the past 89 years, there were 64 years where the market returns were positive; this suggests, on average, a DRP provider would be receiving a positive cash flow from DRP purchasers in 72% of the years. There were only nine years with returns worse than -15%; this means that the DRP provider would, on average, be paying out to DRP purchasers in 10% of the years.

Like any insurance, the proposed DRP approach works for two key reasons: (a) extreme negative events, where the insurance provider has to make payments, are rare; and (b) the insurance purchasers are diversified. For the case at hand, even assuming all accounts hold identical assets, the accounts would be diversified by anniversary dates, thereby creating multiple cutoffs with different payouts each year. However, in our Monte Carlo analysis of the profitability of the DRP provider, we have assumed that all retiree accounts have identical equity portfolios with identical anniversary dates. This is clearly unrealistic in assessing the profitability of the DRP provider because typically the accounts will not have identical anniversaries; as a result, the severity or the frequency of the losses would vary from one retirement account to the next. This diversity can only improve the cash flows for the DRP provider.

CONCLUSION

Our study proposes explicit downside risk protection of retirement portfolios. The proposed DRP ensures that a portfolio's annual return can never be worse than a floor chosen by the protection provider, thereby eliminating extreme negative outcomes and protecting the portfolio against sequence risk. In return, the portfolio pays a portion of the gains to the protection provider only in years with positive returns. The Monte Carlo simulation has shown that with DRP, the chance of

8 The market prices of options reflect volatility skew, while Black-Scholes model assumes identical volatility for put and calls. The market prices of the options reflect an average implied volatility of approximately 25% for puts and about 13% for calls.

premature retirement asset depletion drops from 14.6% to 4.3%. DRP also reduces volatility of returns and increases the average return (net of protection cost) of the portfolio. Furthermore, we also show that DRP can be provided profitably by a financial institution.

The results of our paper should be of interest to financial institutions offering wealth management services for several reasons. First, they underscore how early asset depletion risk is enhanced by losses in a retirement portfolio, particularly when the losses occur in the early years of a retirement horizon, reinforcing the importance of downside risk protection. Second, our paper provides a viable alternative to the existing risk mitigation products and tools available in the marketplace by proposing a method for explicit and exact downside risk protection rather than approximate and expensive alternatives. Third, because we demonstrate that DRP can be provided profitably by a financial institution, it is indeed a win-win situation: retirees have the benefit of markedly lower risk of outliving their assets and of potentially earning higher average returns even after paying for the protection, and the financial institution managing the retirement assets can enhance the cash flows they receive from asset management by providing DRP to the retirees. Because this financial product is currently not provided by institutions, DRP presents an opportunity to create a differentiated and profitable service that could increase the likelihood of retention and growth of assets for the financial institutions.

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