Designing a Pension Funding Derivative

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ABSTRACT

Interest rate changes and volatile equity returns have contributed to significant funding and expense volatility for defined benefit plans in recent years. This paper will describe the design of an option contract with payouts that are tied to the combined impact of interest rates and investment returns on the funding level of a defined benefit pension plan. Current derivatives used by plan sponsors can limit exposure to one of these risks; however, a derivative that combines these risks may provide more targeted protection to a plan sponsor at lower cost. This paper discusses several considerations in designing such a derivative. It will also briefly discuss pricing of the option. Finally, the difference in potential outcomes between plan funding with and without option ownership will be demonstrated. As an outcome of the design work, a new way to visualize pension risk that may be useful in sponsor accounting disclosures will be shown.

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1. Introduction

Increases in the level of and variability in defined benefit pension plan costs have been a major concern for plan sponsors. Despite the shift from defined benefit to defined contribution plans, defined benefit plans still constitute an important portion of the financial landscape. According to the Federal Reserve Board,[1] assets in private defined benefit plans amounted to $2.3 trillion as of the third quarter of 2012. Not only do these plans own significant assets, but also the liabilities owed by these plans to participants are often larger. According to a recent Milliman study of the funding level of the largest corporate pension plans in November 2012 the funded percentage (assets in pension trusts/plan liabilities) was 74 percent.[2] Plans sponsored by state and local governments have similar funding problems. The funding deficit for public plans has been estimated to be $700 billion according to an issue brief by the Congressional Budget Office.[3] The same study indicated that using different methods and assumptions may increase that number to $2–3 trillion.

Two surveys of pension plan sponsors have indicated the two primary economic drivers of pension concern as interest rates and return on assets. A 2010 survey of pension plan sponsors by Vanguard showed that interest rate and equity market risk were viewed as "very important" or "extremely important" by more sponsors than the other risks listed.[4] Another survey of plan sponsors regarding

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[1] "Flow of Funds Accounts of the United States: Flows and Outstandings Third Quarter 2012," Board of Governors of the Federal Reserve System, Table L116.b, Private Pension Plans Defined Benefit Plans, http://www.federalreserve.gov/releases/z1/Current/z1.pdf.

[2] John Ehrhardt and Zorast Wadia, "Milliman Analysis: November Brings a $33 Billion Funded Status Improvement" (Milliman, December 2012).

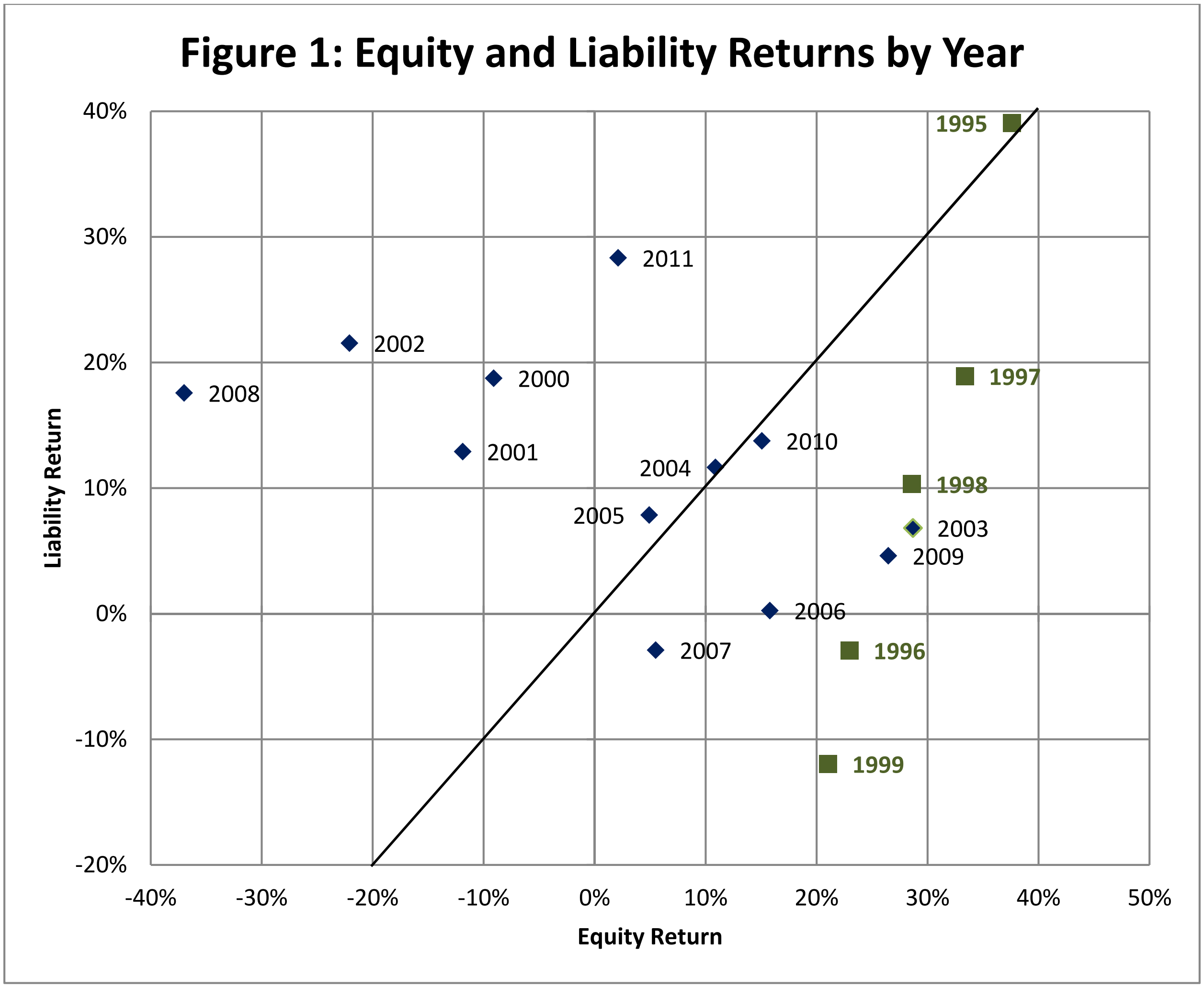
[3] "The Underfunding of State and Local Pension Plans," Economic and Budget Issue Brief, Congressional Budget Office, May 2011, http://www.cbo.gov/sites/default/files/cbofiles/ftpdocs/120xx/doc12084/05-04-pensions.pdf.

[4] Kimberly A. Stockton, "Survey of Defined Benefit Sponsors, 2010," Vanguard Group, February 2011, http://us.vocuspr.com/newsroom/ViewAttachment.aspx?SiteName=vanguardnew&Entity=PRAsset&AttachmentType=F&EntityID=787025&AttachmentID=d738c02d-aba4-4f9d-b2dc-67d1943ce6f4.

risks to a pension plan cited interest rates and equity returns as two of the three (the third was longevity) most cited risks to a pension plan.[5]

Since the turn of the millennium, poor returns on equities combined with decreasing interest rates have taken a toll on funding levels for defined benefit plans. Figure 1 compares the annual S&P 500 total return on the *x* axis with the liability return for the illustrative pension plan used for the Citigroup Pension Liability Index on the *y* axis. The Citigroup Pension Liability Index return measures the increase in the illustrative pension plan's liabilities over a year due to interest rate changes. As interest rates drop, the value of future benefits rises because those future payments are discounted less with the lower rates. This figure maps the increase in liabilities against equity returns from 1995 to 2011. Years plotted to the right and below the diagonal line indicate years in which equity returns were higher than the increase in liabilities. This should be a good outcome for many pension plans. Alternatively, those years to the left and above indicate years in which equity returns did not keep up with liability increases, which would indicate a poor result for many plans. Several of the years to the right were in the 1990s, during that decade's bull market. The years since 1999 have not been as kind, with decreasing interest rates driving up the liabilities coupled with mediocre equity returns.

[5] "2010 Pension Risk Management Global Survey," *Pension Benefits*, pp. 10–11, June 2010, http://www.aon.com/attachments/thought-leadership/2011prmsurvey_sponsor_final.pdf.



Sources: Citigroup and Morningstar. Liability returns are from *Citigroup Pension Liability Index* (Citigroup 2012); the spreadsheet with the rates and liability returns can be found at http://soa.org/Professional-Interests/Pension/Resources/Pension-Section.aspx. The Standard & Poor's 500 Index returns are from *Ibbotson SSBI 2012 Classic Yearbook: Market Results for Stocks, Bonds, Bills, and Inflation 1926–2011* (Chicago: Morningstar, 2012), p. 34 .

Not only were those more recent years often tough on pension plans, but also some of them were very difficult as evidenced by the distance these years' points are from the diagonal line. That distance would indicate liability increases that far outpaced equity returns.

This paper discusses the potential for a derivative that, if owned by a plan or sponsor, could alleviate some or all of the impact of such years. The derivative is designed to limit the impact of these two drivers on pension funding status. Table 1 illustrates the relationship of these two drivers on pension funding. In the upper left hand corner, with good equity returns and increasing interest rates, funding statuses will improve. If both of these risk drivers move the other way with poor equity returns and decreasing rates, funding statuses will also reverse, and deficits will increase. The other two quadrants will have the two drivers working against each other, and the final impact will be determined by the size of the two impacts. A derivative that protects against one of these drivers will pay both in the red quadrant as well as in one of the yellow quadrants. Certainly the fact that the derivative owner is getting paid more often rather than less often is better. However, the greater likelihood of the derivative paying means a higher up-front cost. Ideally, we would be able to develop a derivative that provides protection only when it is needed. That should keep the costs lower and the payouts targeted to when they are needed. This paper primarily discusses the design of such a derivative.

Table 1
Impact of Various Economic Outcomes on Pension Plans

	Good Equity Returns (Increases Assets)	Poor Equity Returns (Decreases Assets)
Increasing interest rates (lowers liability measure)	**Good for Pension Plans**	**Mixed Results**
Decreasing interest rates (raises liability measure)	**Mixed Results**	**Bad for Pension Plans**

= Interest Rate Option Payoffs

= Equity Option Payoffs

We attack the development of this derivative in several steps, as follows:

- Describe a pension plan whose funding status we wish to protect
- Decide on the metric we are attempting to control
- Develop an index of the chosen metric that can be used to calculate payoffs
- Discuss the basic design of the derivative
- Estimate a price for the derivative
- Discuss how well the new derivative manages the funding risk for the plan and
- Simulate how well the derivative works for plans that differ from the sample plan.

2. Sample Pension Plan

In order to develop a derivative that targets the combination of interest rate and equity moves that cause a pension plan financial stress, we first need to define the plan that we are attempting to manage. Through this plan, which we will refer to as the sample plan, we will calculate the impact of changes in these two financial variables.

Defined benefit pension plans can differ in many ways, including the benefits offered, plan participant characteristics, funding status, and investment policy. Despite these differences, many plans have two fundamental characteristics. First, they are exposed to significant interest rate risk because the duration of the benefit liability is much longer than the fixed-income investments owned by the plan. It is also often the case that the liabilities are also larger than the fixed-income portfolio, which exacerbates the interest rate risk due to dollar duration exposure. The second common characteristic is that the plans own significant assets other than fixed-income securities. These can be equities, real estate, or alternative investments. Ideally, the value of these assets will grow more quickly than the liabilities do over time. However, short-term volatility between the liability measure and the value of these assets is common. This leads to volatility in plan funding and costs. The sample plan we use in this paper exhibits these two characteristics. In Table 2 we describe several of the main attributes of the plan and why those attributes are chosen.

Table 2 **Sample Plan Attributes**	
Attribute	Rational for Choice
Benefits are no longer accruing	Pension professionals would describe this plan as “frozen.” Many plans are now in this state. Once a plan is frozen, the primary drivers of the plan are financial rather than human resource concerns. By using a frozen plan, we avoid changes in the benefit stream due to accruals over time.
Benefits are calculated and paid as life annuities	We chose this benefit pattern over lump-sum designs, such as cash balance plans, to lengthen the benefit stream and increase interest rate risk. Most plans are either designed with life annuity benefits or have a material legacy liability with these types of benefits.
The plan is underfunded	As discussed in the first section, many plans are underfunded. Our sample plan exhibits this characteristic.
The plan has significant equity investments	Plans often have a large portion of their investments in assets other than fixed-income investments.

Now that we have discussed some of the main plan design and investment parameters, we need to determine the participant group and benefits so that the plan’s benefits can be projected. The participant group is composed of both retirees collecting benefits and active and terminated vested participants with deferred benefits. Statistics for the participant group are shown in Table 3.

Table 3 **Sample Plan Participant Statistics**			
	Count	Average Age	Average Annual Accrued Benefits

Participants with deferred benefits	794	44.2	$10,738
Retired participants in payout status	390	72.7	11,318
Total participants	1,184	53.7	10,929

Accrued benefits were adjusted to groups by age for active and deferred vested participants using a reasonable progression of average service, as older workers would generally have more service. Pension benefits for older retirees are assumed to be smaller than those of younger retirees, because there is no cost of living adjustment and their benefits were determined years earlier and not adjusted for inflation since that time.

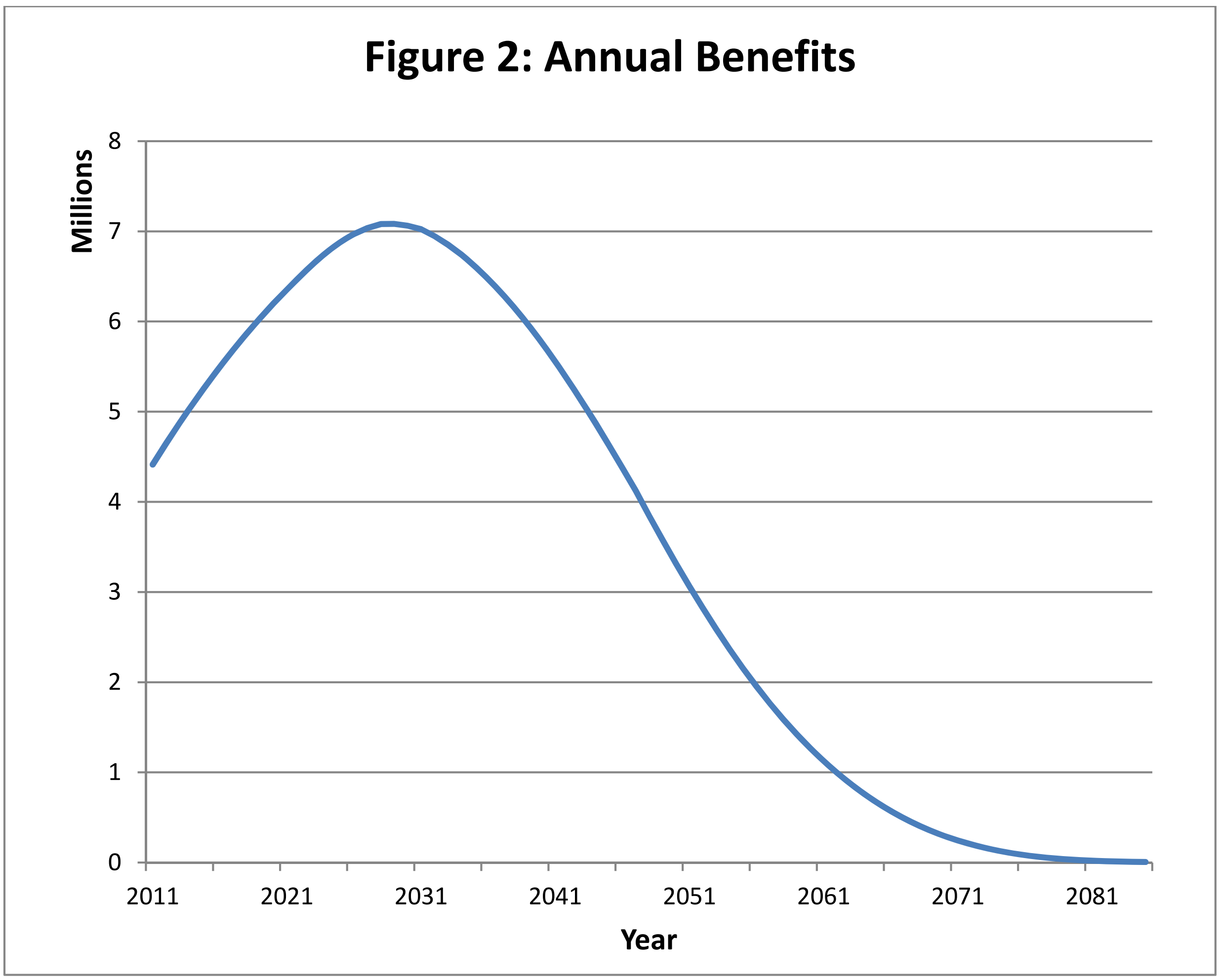
The main actuarial assumptions regarding mortality and interest rates are listed in Table 4. The benefit levels were scaled so that the actuarial liability for the plan using these assumptions would come to $100 million at the beginning of the year. This would enable easy scaling of the derivative to a particular plan's size.

Table 4
Valuation Assumptions

Initial valuation date	December 31, 2010
Initial interest rates	Citigroup Pension Liability Curve Rates as of December 2010
Mortality assumptions	IRS Notice 2008-85 2010 Static Mortality[a] Ages 61 and under: nonannuitant mortality rates Ages 62 and over: annuitant mortality rates
Male/female mix	50%/50%

a. Internal Revenue Service Notice 2008-85, Oct. 20, 2008, http://www.irs.gov/irb/2008-42_IRB/ar09.html.

A visual display of the benefit stream is shown in Figure 2. As can be seen from the figure, the plan has significant benefits due further out than 30 years, a situation that is common in defined benefit pension plans. The sample plan is assumed to be 80 percent funded, so there is an initial funding deficit of $20 million.

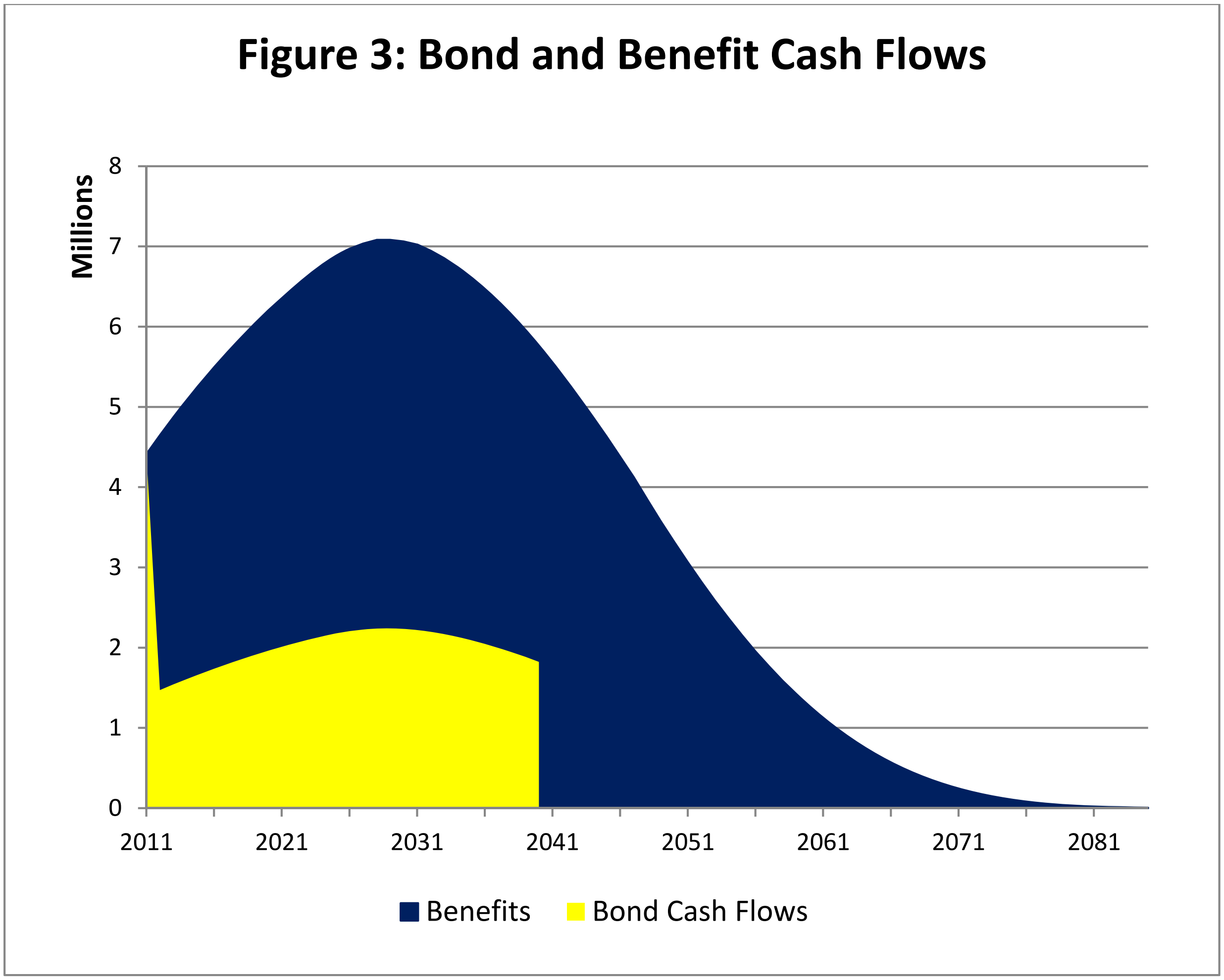


The initial allocation of investments is 60 percent equities and 40 percent fixed income. This was often a traditional asset allocation for pension plans. The fixed-income portfolio includes cash and short-term investments that cover the first year of benefit payments of approximately $4.4 million. The rest of the fixed-income portfolio was built to cover 32 percent of the benefit payments in years 2 through 30. This fixed-income allocation was chosen so that the plan has adequate short-term liquidity while stretching the remaining assets to the 30-year window that is investable in taxable bonds. The balance sheet for the sample plan and the Macaulay duration statistics are shown in Table 5.

Table 5
Beginning Balance Sheet for Sample Pension Plan

	Amount	Macaulay Duration
Liabilities	$100,000,000	13.7
Assets		
Equities	$48,000,000	
Fixed income	$32,000,000	7.1 (including first-year cash), 12.1 (bond cash flows years 2–30)
Total assets	$80,000,000	
Funding surplus/(deficit)	($20,000,000)	15.2 (benefit less the bond net cash flows)

The funding duration is calculated by examining the liability cash flows not covered by the fixed-income cash flows. The benefits and fixed-income cash flows are shown in Figure 3. All cash flows are modeled as occurring at midyear, so the last fixed income cash flow is midyear of 2040 and none after that point.



3. Determining the Metric to Manage

Financial risk to a pension plan sponsor can materialize in several ways: cash contributions can rise, income statement costs can rise, the balance sheet impact can reduce sponsor net worth, or the plan's funded status could be adversely impacted. There is often a strong causality relationship between these effects that makes them occur at the same time. In determining a metric to manage by way of the derivative, we considered each of these impacts.

The use of a cash contribution or income statement metric posed several challenges. The main issue is that the rules for determining these impacts varied significantly by plan type and sponsor. The cash contribution rules for government, union, and private employer plans are all different. Cash contributions can also be influenced by elections made in prior years that do not directly reflect the financial health of the plan. We have similar differences between plan sponsors for income statement impact. Another concern was that the year-by-year change in these two metrics may be either positively or negatively leveraged to the actual change in the plan's financial status.

We also looked at the funded status as a percentage of plan liabilities. Funded status percentage, which is defined as the value of the plan's assets as a percentage of plan liabilities, is often used as a measure of plan funding health. It is also often a contributing factor in determining cash contributions. We chose against this measure for one reason. A plan can have the same funded status percentage from one point in time to the next, and the sponsor may have absorbed a loss. For example, if a plan begins the year with $1 billion in plan liabilities and $800 million in assets and ends the year with $1.1 billion and $880 million in assets, the funded percentage has stayed 80 percent; however, the dollar funding deficit has grown from $200 million to $220 million. We suspect that most sponsors would not view this as a break-even proposition.

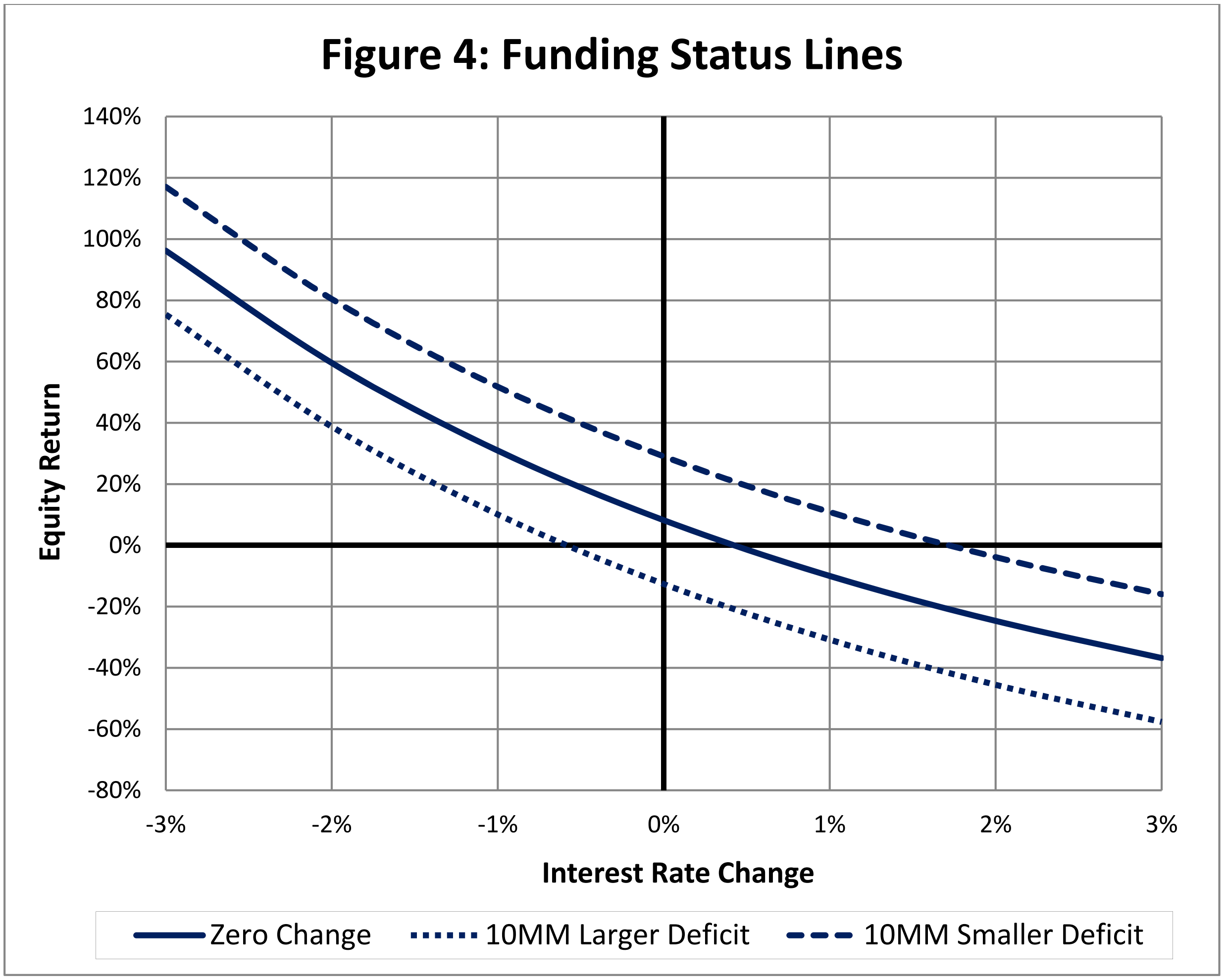
We therefore used the metric of the actual raw dollar deficits for the sample plan. We believe that, by targeting that metric directly, we more closely track the actual impact to the sponsor of the two risks we are attempting to manage. The dollar deficit often contributes to cash contribution and income statement impacts, as well as any balance sheet recognition. It also allows the sponsor to directly tie the management of the deficit size to the sponsor's economic size and resources. The one item it may not manage as well is the funding percentage in the rising interest rate environments. However, this risk can be more manageable, because rising interest rates reduce the risk that funding deficits will grow to an unmanageable size.

4. Visualizing and Disclosing Risk

One way to look at a sponsor's risk tolerance is to determine how much of a change in the pension deficit (in terms of dollars) would cause financial strain for the sponsor. Although funding contributions generally lag the emergence of an increase in the deficit, rising deficits are a good indicator of higher future cash contributions. Increased deficits can lead to higher reported expense and balance sheet impacts and, if severe enough, can cause challenges to the plan sponsor to raise capital. The derivative developed here is designed to attack the dollar amount of the deficit directly. By using this as a measure of the index and therefore the payout of the derivative, the owner of the derivative can limit the changes in the dollar amount of underfunding to an amount that is manageable to that plan sponsor.

One way to look at the impact of equity returns and interest rates on a pension plan is to map funding levels one year out against the ending interest rates and equity return combinations that would generate that deficit size. Figure 4 shows the combination of these items that produces no change in the deficit as well as either a $10 million increase or decrease in the funded status. Here, interest rate changes are parallel shifts in the yield curve (with a floor of one basis point for certain down shifts). This figure gives the reader a good sense of what various changes in the two economic outcomes would have on funding status. To develop this figure, the pension actuary can estimate the impact of interest rate changes on plan liabilities, and the fixed-income manager could estimate the impact of interest rate changes on that portfolio. Finally, the equity return impact is just algebra. These impacts could be combined into a graph, like Figure 4. Currently, public companies with defined benefit plans generally disclose a sensitivity test of the discount rate for liabilities and expected rate of return on pension expense. These impacts are described in terms of the impact they would have had on expense for the most recent past year the impact or the liability disclosed at the last balance sheet date.

We believe that the information in Figure 4 would be more useful to readers than the current disclosure. This figure enables a reader to get a sense for how exposed a plan is to these risks, and it combines the impacts of these risk drivers instead of dealing with each one on its own. It is also forward looking to what might happen over the next year instead of how historical information would have changed. The reader can also estimate the impact of his or her own expectations of equity returns and interest rate changes on the plan's deficit amount. A similar figure could be developed for pension expense.



5. Simulating What Might Happen

In order to get feedback on the effectiveness of the derivative to manage risk and to find a way to price the derivative, we wanted to use a model that would develop multiple scenarios of future interest rates and equity returns. Our source for those scenarios was the economic scenario generator from the Society of Actuaries and the American Academy of Actuaries.[6] This generator takes an initial set of treasury interest rates and generates scenarios of what might happen to interest rates as well as various types of investment funds. We used the generator to develop 1,000 scenarios of spot treasury rates after one year as well as returns on an S&P index fund over the year.

The model generates treasury rates at several key points on the yield curve. Because we needed AA spot rates similar to those in the Citigroup Pension Discount Curve for discounting both plan liabilities and bond cash flows, we compared the treasury spot rates at December 2010 for the treasury bonds to the spot rates for AA bonds in the Citigroup data as of December 2010. Based on the difference in rates we could develop a spread above the treasuries at each spot rate. We added that spread to the appropriate modeled spot rate for each scenario. To develop the full spot yield curve, we linearly interpolated between each key rate to get a full set of spot rates. This approach causes all variability in rates to be due to the changes in treasury rates.

This work developed a full set of AA interest rates and an equity return for each of 1,000 scenarios. The statistics for these scenarios can be found in the tables below. We will use these scenarios later in the paper. Table 6 provides statistics for these modeled scenarios. It is clear from the statistics that the simulator, on average, produced flatter yield curves than the initial curve by raising the short-term rates while lowering the longer-term rates.

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[6] Economic Scenario Generator, Version 7.0.4 (April 2012 Updates), developed by the Society of Actuaries and the American Academy of Actuaries. The main webpage for the generator is http://www.soa.org/research/software-tools/research-scenario.aspx. We used the December 2010 curve as our starting point. In addition we set the 20 year mean reversion point to 4.13 percent equal to the starting 20-year rate.

Table 6 Statistics for Interest Rate and Equity Return Simulator				
		Simulated AA Rates One Year Out		
	Equity Returns	1-Year Spot	10-Year Spot	30-Year Spot
Initial rate	N/A	1.04%	4.77%	5.88%
Maximum	59.9%	4.20	6.46	6.92
99.5%	55.1	3.75	6.17	6.83
99.0%	52.1	3.41	6.07	6.69
75.0%	18.7	2.07	5.04	5.67
50.0%	8.30	1.57	4.75	5.38
25.0%	−1.70	1.12	4.47	5.11
1.0%	−28.4	0.76	3.89	4.42
0.5%	−30.8	0.76	3.83	4.32
Minimum	−55.3	0.76	3.63	4.12

6. Derivative Design

Three aspects of the derivative design need to be considered. First, how long should the life of the derivative be? Second, what type of derivative should we use? Finally, how should we develop the index on which the derivative is based? We will address the first two questions in this section. The next section will answer the third question.

The optimal life span of the derivative does not have a clear answer. Pension plans are long-term entities. The eventual cost of the plan to the sponsor is determined by the long-term experience of the plan. Therefore, long-lived options probably have a place in this environment. However, for this analysis, we designed and priced an option with a term of one year. The one-year term options have significant advantages over longer-term options.

First, the one-year term coincides with the financial disclosure period of many sponsors. By holding the term of the option to the same period as the financial disclosure period, sponsors can target the exact amount of risk they are willing to take between financial statements. They can then buy a contract that very closely matches their needs and know that the payoff or valuation will closely match those needs. Second, by limiting the term to one year, we suspect that the market may be deeper, because suppliers and speculators do not tie themselves to long-term commitments. Different pension plans will have different long terms risk management needs, but many could use short-term protection as part of their risk management. They could regularly buy the one-year derivatives as they are needed. By using these shorter instruments, sponsors can adjust their purchases from year to year to reflect changing funding levels, investment policies, and risk tolerances. Finally, owning a one-year option limits that credit risk of the sponsor to the counterparty to just the one year.

The second derivative design issue is what type of derivative to design. We chose to use an option. The option allows the sponsor to determine how much tail risk to mitigate based on its needs and the costs. An option also allows the sponsor to keep all the upside potential of an unhedged position less the cost of the option. We believe this design element is important. Sponsors who have decided to own significant stakes of equities or other non-fixed-income investments in their plans have usually done so because they expect those investments to outpace liability increases over time. An option design enables these sponsors to continue with that fundamental strategy while reducing the downside risk. Finally, an option is easier to understand than some more exotic derivative designs, an attribute which may increase its adoption rate.

We assumed that the option would be European in design. That design only allows for exercise at contract expiration. Allowing early exercise may present a challenge as some of the inputs to the index formula may not be constantly available. Lack of such inputs may make calculating early exercise payoffs difficult or impossible.

7. Development of the Index

In order to develop the index upon which the option payouts are based, we need several pieces of information. First, we need to know the plan design and investments for which the index is developed.

Second, we need to determine what type of changes to the risk drivers for which we will attempt the index to match the outcomes.

We will use the sample plan described earlier to develop the index. One thing to note with regard to interest rate moves is what set of cash flows we are using to measure the interest rate index. Because we have assumed a frozen plan, no new benefits are being added during the year. Therefore, the benefits we project for each subsequent calendar year at year end are the same as what we projected for that calendar year at the beginning of the year. Also, as we stated while discussing the sample plan, the first year of benefits are paid out of fixed-income assets.

The Citigroup index is developed using liability-only cash flows. That is appropriate for that index, as that index is a liability measure. Because we are measuring the impact on funding status for our index, we want to measure the impact on both liabilities and assets. Therefore, in developing the interest rate index, we are using the net cash flows (benefits paid – fixed income cash flows) in each projected year. In Figure 3, that is represented as the space colored blue above the yellow-filled bond cash flows.

To calculate the index, we attempted two methods. First we calculated the actual results at various equity returns and parallel shifts in the yield curve. In the down shifts, if the shift forced the simulated rates to zero or negative, we floored the rate at that term to one basis point. So in the larger down shifts, the moves are not exactly parallel. We can then devise an index formula that simulates the funded status at these test points. We chose not to use that method here. It relies on parallel (or near-parallel) shifts, and we wanted the formula to hold up with interest rate moves that twisted the yield curve.

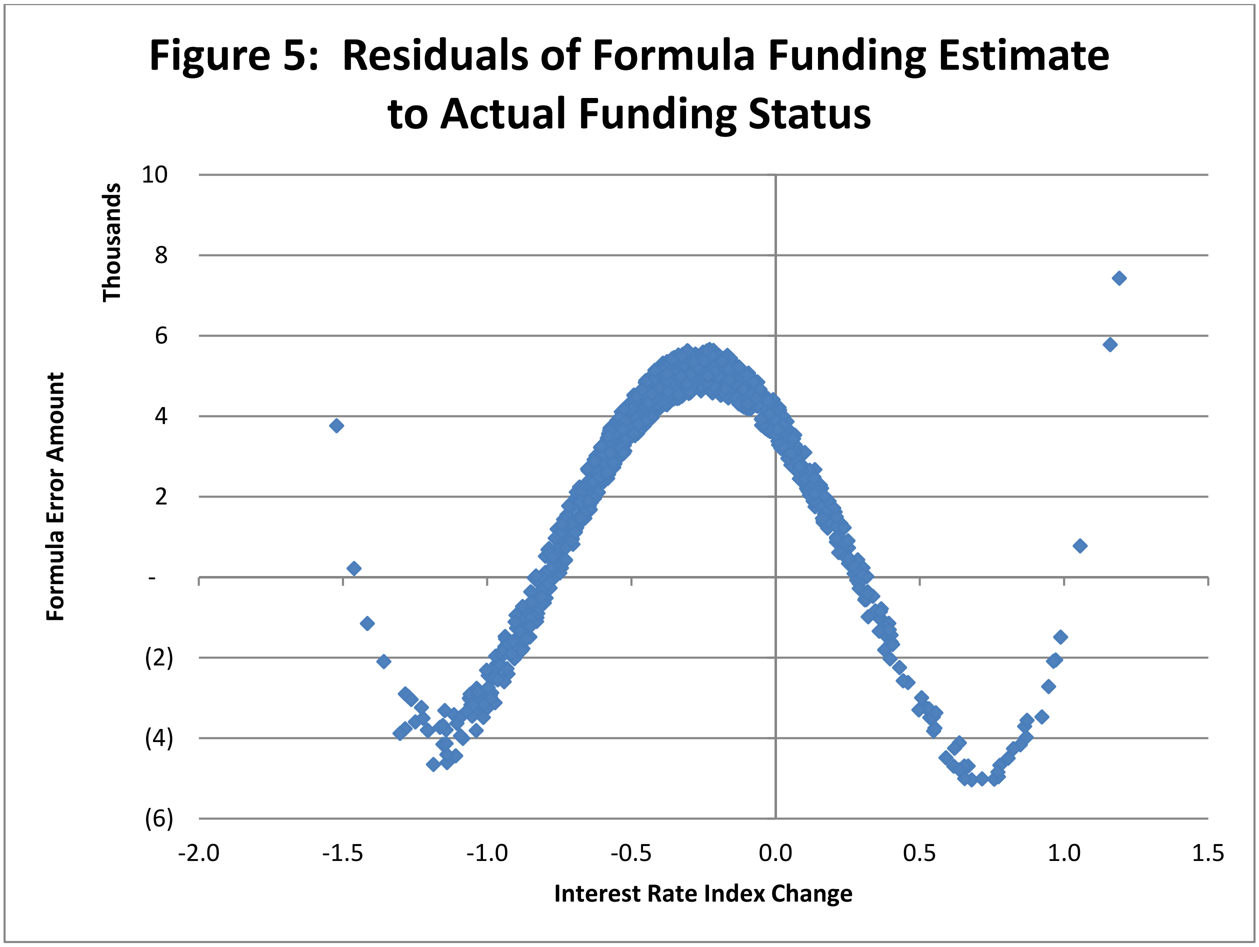
The method we used instead was to calculate the funded status at each of the 1,000 simulations for interest rates and equity returns we discussed earlier. The index function should be a function of the equity return and interest rate measure. We know the equity return in each simulation. To determine the interest rate index, we calculated the level interest rate that would develop the same funded status on the interest rate side as the full yield curve simulated for that scenario. We also calculated the index rate that developed the same liability amount net of bond values at the beginning of the year. That rate was 5.447 percent as of December 2010. The interest rate index change was the index rate from each simulation less the starting index rate of 5.447 percent. With the deficit amount, equity return, and interest rate index change for each simulation, we could work to develop a formula that closely estimated the funding status for each simulation. Our method was largely trial and error, but we could use certain principles. First, how do equity returns change the funded status? This issue was easy to deal with. We simply adjusted the funding status by the dollar exposure to the equities multiplied by the total return in the year. The interest rate change was more complicated. Duration and convexity impacts would suggest a quadratic formula based on interest rate changes. Such a formula works well. However, at some points, the differences between the formula results, and the actual results were somewhat noticeable. By adding a cubic term to the function, we got quite a good fit to the actual results. Finally, the constant was set so the error terms centered around zero. The formula developed is shown below.

$$D_t = 1{,}000{,}000\,(-0.131\,I^3 + 1.223\,I^2 - 10.299\,I - 48\,E + 23.701)$$

where

$D_t = Funding\ deficit\ at\ year\ end$
$I = Interest\ rate\ index\ change\ in\ year$ (5 percent expressed as 5.0)
$E = Equity\ return\ in\ year$ (5 percent expressed as 0.05)

The error terms in our process are all within approximately $6,000, which is quite reasonable for an index measured in the tens of millions. They do exhibit a pattern as shown in Figure 5, which plots each scenario's error amount against the change in the interest rate index for that scenario.



One issue with using this method to determine the formula is that our sample only contains interest rate changes of 150 basis points in either direction from the initial index rate.

With the move, though slow, to liability-driven investing in pension plans, one may wonder why the option designed here has significant equity exposure and shorter-term bond investments. The fact is that a number of plans have exposures similar to the sample plan here. This option will not meet the needs of all plans, but it could assist in the risk management of a large number of plans.

Now that we have a formula, we can develop the price of and the payoff from the option. Once we have the price of the option at various strike prices we can analyze the effectiveness of owning the option on deficit variability relative to the cost of the strategy.

8. Pricing the Option

To price the option here at a given strike price, we used the results from the 1,000 scenarios. We first calculated the payoff, if any, at the end of the year for each scenario. We then discounted that payoff back at the AA one-year rate assumed at the beginning of the projection. Instead of discounting the payoffs at the risk-free rate, we used the AA rate. This allows for pricing in some counterparty credit risk to the option owner. If some credit enhancement is available, such as a centralized exchange with margin requirements, a lower discount rate may be appropriate. This generated the present value of the payoff for each scenario. To calculate the value of the option, we determined the average payoff present value over the 1,000 scenarios.

The advantage of this method is that it is an objective measure of the option price on an expected-value basis. Using this method also says that, on an expected value basis, the sponsor is indifferent between buying the option or not. It does, however, change the distribution of the results at the end of the year.

We assumed that the sponsor would buy the option outside of plan assets. By buying the option with outside funds, investment allocation within the plan is unaffected. The resulting deficits shown in the analysis below reflect the actual plan deficit, any payoff from the option, and the premiums of the option with interest on the option at the AA rate for the year. If there is a payoff, the sponsor would have those funds available to contribute to the plan if so desired. If the sponsor would purchase the option with plan assets, the sponsor would need to determine which initial assets to sell to pay for the option. This change in investments would require a slightly different index formula.

Using the method described above, we calculated the premium required for the option as well as the distribution of the funding deficits, reflecting the premium paid for the option. The right-hand column shows the results had no option been purchased.

Table 7
Funding Results at Various Option Strategies

Financial Results ($ millions)	Strike Price				No Option Purchased
	10 Million	20 Million	30 Million	40 Million	
Option premium	13.5	5.6	1.2	0.1	N/A
Scenarios with a payoff (out of 1,000)	912	656	229	31	N/A
Statistics for ending deficit (reflecting price of option)					
Maximum	23.7	25.7	31.2	40.1	59.4
99.50%	23.7	25.6	31.2	40.1	48.4
99%	23.7	25.6	31.2	40.1	44.4
75%	23.7	25.6	30.6	29.5	29.4
50%	23.7	25.6	25.2	24.1	24.0
25%	23.7	23.0	18.5	17.4	17.3
1%	15.3	7.3	2.9	1.8	1.7
0.50%	10.9	2.9	(1.6)	(2.6)	(2.8)
Minimum	7.4	(0.7)	(5.1)	(6.2)	(6.3)

9. Impact of the Option

Ownership of the option has two clear impacts. First, it does reduce the volatility of results. Adverse outcomes cannot get worse than a maximum ending deficit, which is a function of the strike price and the premium for the option. The sponsor can decide how much adverse risk they are willing to take by selecting an option with an appropriate strike price. Second, in the median and better scenarios, a plan sponsor is better off not owning the option. The cost of the option is weighing down results when the results are better than the strike price.

The optimal strategy for a plan sponsor will be dictated by the sponsor's risk tolerance and the actual option prices in the marketplace. However, it is noticeable that more than one percent of the scenarios without option ownership have ending deficits greater than $40 million. That is twice the initial deficit. Although 1 percent is a small chance, it is not impossible. According to these calculations, an option which could effectively cut off the risk beyond that point can be purchased for $0.1 million.

10. Sensitivity Testing

The option constructed above was designed with a particular plan in mind. Although it shares many primary characteristics with a large number of pension plans, it is reasonable to wonder how well a derivative based on the index formula would mitigate the risk for a plan with different specifications. To answer this, we perform two sensitivity tests by separately making two changes to the sample plan.

Variation 1: This plan has the all the same specifications as the sample plan, except the bond investments are shorter in duration. This exposes the plan to larger interest rate risk, particularly to the long end of the curve. To shorten the duration, we changed the bond cash flows to match exactly the benefit cash flows for the first six years and 98 percent of the cash flow in the seventh year. The present value of those cash flows is still $32 million. However, now the duration of bond cash flows after the first year has shortened from 12.1 years to 4.0 years. The duration of the net cash flows (benefits minus bonds) has lengthened from 15.2 years to 20.0 years. The option payoffs are still based on the index formula developed using the sample plan. Table 8 shows a comparison of the statistics for owning the option at various points compared to the unprotected position.

Table 8
Funding Results for Variation 1

Financial Results ($ millions)	Strike Price				No Option Purchased
	10 Million	20 Million	30 Million	40 Million	

Option premium	13.5	5.6	1.2	0.1	N/A
Scenarios with a payoff (out of 1,000)	912	656	229	31	N/A
Statistics for ending deficit (reflecting price of option)					
Maximum	29.1	31.1	36.6	45.0	64.3
99.50%	28.5	30.4	36.0	44.6	52.3
99%	28.2	30.2	35.7	43.8	47.9
75%	26.3	28.2	32.5	32.0	31.9
50%	25.6	27.3	27.1	26.1	25.9
25%	24.8	24.5	20.1	19.1	18.9
1%	15.5	7.4	3.0	1.9	1.8
0.50%	10.9	2.8	(1.6)	(2.7)	(2.8)
Minimum	7.8	(0.2)	(4.7)	(5.7)	(5.9)

Variation 2: Again, this plan has all of the same specifications as the sample plan, except that the investment mix is 40 percent equity and 60 percent bonds. By changing this mix, we have reduced the plan's exposure to equity investments and also reduced the exposure to interest rates because of the higher fixed-income investment. The fixed-income investments are invested similarly to the sample plan's portfolio. There is sufficient cash and short-term paper to cover the first-year benefits. The remainder is invested to cover a pro rata share of benefit payments for years 2 through 30. In the sample plan, that pro rata share was 32 percent. With the higher fixed-income allocation, we can now cover 50 percent. Results of option ownership to this plan are shown in Table 9.

Table 9
Funding Results for Variation 2

(Financial Results in $ MM)	Strike Price				No Option Purchased
	10 Million	20 Million	30 Million	40 Million	
Option premium	13.5	5.6	1.2	0.1	N/A
Scenarios with a payoff (out of 1,000)	912	656	229	31	N/A
Statistics for ending deficit (reflecting price of option)					
Maximum	29.5	27.6	30.4	35.9	49.4

99.50%	28.2	27.4	30.1	35.2	41.3
99%	28.1	27.1	29.8	35.0	38.4
75%	25.1	25.3	27.4	27.8	27.7
50%	23.4	24.0	24.8	23.8	23.7
25%	21.8	22.1	20.3	19.2	19.1
1%	17.3	13.3	8.8	7.8	7.7
0.50%	16.3	10.2	5.8	4.7	4.6
Minimum	13.7	8.1	3.7	2.6	2.5

As can be seen from these results, the option still provides significant risk management in the most extreme scenarios. It may be possible to provide bespoke options to sponsors based on a particular plan's risk profile; however, a deeper market may develop if a standardized option that meets most sponsors' needs can be developed.

In Figure 6, we compare the deficit distributions using the three investment strategies (sample, variation 1 and variation 2) with the outcomes for sample plan assuming ownership of the deficit funding option with a $30 million strike price. As expected, the option strategy performs well in stressed scenarios. What is striking is how little is lost in the advantageous scenarios. By adopting the reduced equity strategy, you reduce your risk, but not as much as the option strategy. The reduced equity strategy outperforms the option strategy in the median to moderately adverse outcomes, but at the risk of much larger deficits at more adverse outcomes. This comparison indicates the development of such an option may be very advantageous to plan sponsors.

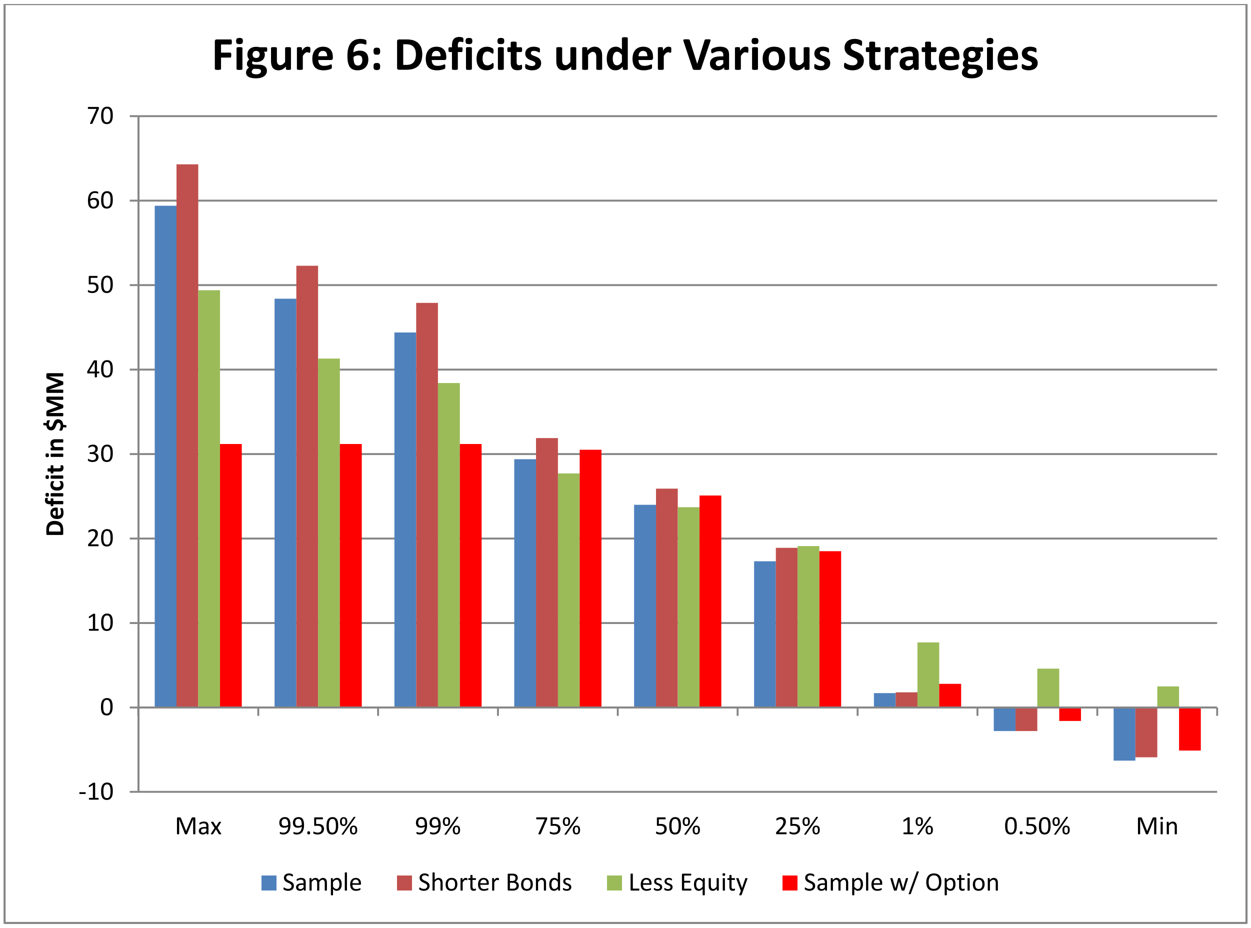


Figure 6: Deficits under Various Strategies
Deficit in $MM
70
60
50
40
30
20
10
0
-10
Max
99.50%
99%
75%
50%
25%
1%
0.50%
Min
Sample
Shorter Bonds
Less Equity
Sample w/ Option