A PUBLIC POLICY PRACTICE NOTE

Measuring Pension Obligations for Difficult-to-Value Plan Provisions

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Developed by the
Pension Committee

American Academy of Actuaries

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Introduction

This practice note was developed by the Pension Committee of the American Academy of Actuaries. The purpose of the practice note is to provide information to actuaries on current or emerging practices in which their peers are engaged regarding defined benefit pension plan provisions that may be difficult to adequately measure using traditional valuation procedures, as well as to provide a framework for thinking about appropriate valuation procedures in this area and to help with the evolution of ideas and practices.

The intended users of this practice note are the members of the actuarial organizations that are governed by the actuarial standards of practice (ASOPs) promulgated by the Actuarial Standards Board (ASB). It is anticipated that this practice note will be helpful to actuaries, but it is not an interpretation of ASOPs and is not intended to be a codification of generally accepted actuarial practice. Actuaries are not in any way bound to comply with practice notes or to conform their work to the practices described in this or any other practice note. While many issues are discussed in this practice note, other approaches and interpretations are possible, and it is likely that new approaches will evolve on this topic.

This practice note is not intended to be a "cookbook," yet it does contain examples. While the focus is on the measurement of pension obligations, as discussed, the techniques discussed in this practice note could also be useful for risk analysis, investment policy analysis, and plan design.

Overview

In ASOP No. 4, *Measuring Pension Obligations and Determining Pension Plan Costs or Contributions*, section 3.5.3 provides guidance on plan provisions that are difficult to measure. The ASOP notes that "Some plan provisions may create pension obligations that are difficult to appropriately measure using traditional valuation procedures." The ASOP provides the following examples of such plan provisions:

- "gain sharing provisions that trigger benefit increases when investment returns are favorable but do not trigger benefit decreases when investment returns are unfavorable";
- "floor-offset provisions that provide a minimum defined benefit in the event a participant's account balance in a separate plan falls below some threshold";
- "benefit provisions that are tied to an external index, but subject to a floor or ceiling, such as certain cost of living adjustment provisions and cash balance crediting provisions"; and
- "benefit provisions that may be triggered by an event such as a plant shutdown or a change in control of the plan sponsor."

In practice, actuaries may be encountering difficult-to-value plan provisions more frequently as plan sponsors, trustees, and other interested parties adopt plan designs that are intended to result in more stable cost patterns than the traditional defined benefit paradigm but that retain some of the positive features of defined benefit plans, such as longevity pooling or alignment with workforce management objectives. Some of these new plan designs may introduce asymmetry into the distribution of possible outcomes. This asymmetry may be a consequence of a transition from one design to another, features triggered only under certain conditions, or provisions that share some of the risks inherent in defined benefit plans between plan participants and plan sponsors. In some of these designs, benefits vary depending on asset performance or other measures tied to economic performance. Often additional mechanisms are introduced to limit or smooth the effect of these economic variables on participant benefits.

This practice note is intended to help actuaries identify significant plan provisions that are potentially difficult to value using traditional valuation procedures and to discuss possible approaches to measuring obligations or quantifying risk associated with such plan provisions.

This practice note focuses on situations where the benefit variability is defined by the terms of the plan or is otherwise inherent in the normal operations of the plan. It does not address potential modifications to the value of the pension obligations due to changes in the benefits provided under a plan due to unusual events such as the reduction in benefits to the Pension Benefit Guaranty Corporation (PBGC) guaranteed level or benefit suspensions due to potential insolvency, or potential modifications to benefits under multiemployer plans in critical status.

Some of the approaches discussed in this practice note may require specialized expertise, or involve models that go beyond what a pension actuary might have encountered in their normal practice. In keeping with Precept 2 of Code of Professional Conduct, the actuary may decide in these situations that it is appropriate to decline the assignment or engage others with sufficient expertise in these areas.

ASOP No. 4 states that for difficult-to-measure plan provisions, “the actuary should consider alternative valuation procedures, such as stochastic modeling, option-pricing techniques, or deterministic procedures in conjunction with assumptions that are adjusted to reflect the impact of variations in experience from year to year.” The standard also states that “When selecting alternative valuation procedures for such plan provisions, the actuary should use professional judgment based on the purpose of the measurement and other relevant factors.” Finally, the standard requires the actuary to disclose, in any actuarial communication prepared to communicate the results of the work, a description of the methods used to value any such significant benefit provisions, such that another actuary qualified in the same practice area could make an objective appraisal of the reasonableness of the actuary’s work.[1]

Accordingly, one potential approach to measuring pension obligations[2] for plans that may contain difficult-to-value plan provisions would be the following:

1. identify whether the plan has any significant provisions that may be difficult to adequately measure using traditional valuation procedures;[3]
2. if the plan has such provisions, consider using alternative valuation procedures, using professional judgment and taking into account the purpose of the measurement and other relevant factors;
3. disclose the approach taken (possibly including any decision not to use an alternative valuation procedure).

The actuary may also need to consider the provisions of ASOP No. 56, *Modeling*, and, depending on the nature of the assignment, ASOP No. 51, *Assessment and Disclosure of Risk Associated with Measuring Pension Obligations and Determining Pension Plan Contributions*.

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[1] The disclosure requirements are in section 4.1 of ASOP No. 4.

[2] Other issues, such as the effects of different cost allocation methods, may also be more complicated in the presence of difficult-to-value plan provisions but are beyond the scope of this practice note.

[3] Note that ASOP No. 1, section 2.6, states that “The guidance in ASOPs need not be applied to immaterial items.” And section 2.12 discusses different uses of the word “significant.” In some cases, the actuary may need to do some analysis to determine whether a given provision is significant.

This practice note is organized as follows:

The first section discusses identifying difficult-to-value plan provisions and areas in which those provisions could be especially important.

The next section introduces a variety of alternative valuation techniques that could potentially be applied to difficult-to-value plan provisions and discusses strengths and weaknesses.

The final section discusses considerations in selecting a valuation approach, including the purpose of the measurement; applicable requirements, such as those that apply to funding and accounting measurements; and other considerations, such as which valuation techniques might better fit particular types of plan provisions.

Appendix A illustrates the application of the Monte Carlo valuation approach introduced in the section on alternative valuation techniques. It provides a framework that might be adapted to real-world situations by looking at the effect of difficult-to-value provisions on a liability measure and on the distribution of benefits and present values.

Appendix B provides a generalized formula that describes the valuation of pension benefits, which may be helpful when considering how to value difficult-to-value benefits. It also discusses the various simplifications typically made to this general formula when completing pension valuations using approaches common today. This formula provides a theoretical basis for considering the analytical approach presented in this practice note as an extension of current practice.

Identification of Difficult-to-Value Plan Provisions

Difficult-to-value plans generally include provisions that do not fall neatly within the usual categories of plans with unit or service-based formulas expressed in the form of an annuity or lump sum. Difficulties in valuation may derive from a plan provision that causes liabilities to respond asymmetrically to changes in the economic environment or contains choice (optionality). However, just because a plan design is uncommon does not mean that it will be difficult to value (e.g., a pure variable annuity[4] where the maximum benefit limitations of Internal Revenue Code (IRC) §415(b) are not a concern). In addition, a plan may have a difficult-to-value feature, but that feature might not have a material value, in which case the actuary might decide to take a simplified approach.

The four design features listed below can create valuation challenges. This list is not exhaustive; undoubtedly, there are others. For each category, the discussion includes examples and a list of questions an actuary might ask to assess if a specific design fits into this category. Some designs can have characteristics that fall into more than one category.

A characteristic of most of these designs is that it is difficult, if not impossible, to define a portfolio of assets that reasonably matches the anticipated cash flows across a variety of economic conditions. As a result, there may not be a well-developed market to settle these benefits. Such a settlement market could be a useful indicator for the actuary performing a valuation.

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[4] A variable benefit in which the plan sponsor can be fully insulated from gains or losses due to investment performance. More detail can be found in the *Variable Annuity Plans* practice note.

Design features:

Feature 1: Competing formulas

This type of plan provision provides benefits that are expressed as a comparison between two (or more) formulas (e.g., greater of, lesser of, or the difference between two or more formulas). In some cases, the formulas may be very similar, differing in only one aspect. In others, they may be substantially different. Most commonly, the larger of the two as of the benefit commencement date "wins" and therefore establishes the amount of subsequent payments. In some situations, however, the comparison may continue to apply at set intervals (e.g., annually), determining the amount paid until the next comparison date. The comparison may be made on an individual-by-individual basis, without reference to how benefits are being determined for other participants. The comparison also may be based on the funded status of the plan.

A simple example would be a cash balance plan required to comply with the "preservation of capital" provisions of IRC §411(b)(5) (preservation of capital "floor" or any other cumulative "floor"). In this case, one formula would be the cash balance formula with full adjustments for interest / return that could be positive or negative, while the other formula would be the sum of the annual pay credits.

Other cash balance designs include more complicated cumulative floors or caps on benefits (e.g., based on a fixed rate of return applied to historical pay credits). Similarly, variable annuity designs might have some combination of caps, floors, or other smoothing mechanisms that make them difficult to value.

Floor offset plans are another example of competing benefits, where the net benefit payable is the difference between one formula (typically a traditional benefit from a defined benefit [DB] plan) and another formula (typically the annuitized value of an actual or hypothetical defined contribution account balance), but not less than $0. In this case, it is really the $0 floor that complicates the calculation, as it otherwise might be reasonable simply to value the two formulas independently and then take the difference.

The following situations could raise questions about whether the liability measure captures the potential value of the competing formulas:

- A floor (minimum) benefit that is not being valued because it is not expected to apply as a result of the assumptions being used (for example, expectations as to market experience that is assumed not to vary from year to year).

- The greater of more than one formula, but only one benefit is valued because the other depends on factors that have value but not in the "expected" case.

Feature 2: Adjustments based on market outcomes

These designs typically adjust benefits based on market measurements or the plan's funded status. Some public sector plans, for example, include provisions that reflect a gain-sharing feature. Gain sharing is generally used to describe provisions of retirement programs that use investment earnings over a target level to provide additional benefits. Generally, these designs tend to be asymmetric (sharing of gains but not losses). Gain-sharing features may also apply when the plan's funded status exceeds a specific threshold. Where the adjustment depends on funded status, this dynamic may complicate modeling because an individual participant’s benefit cannot simply be modeled as a function of the plan formula and the assumed economic environment, because it also depends on the benefits of other participants and the plan’s asset experience as well.

These outcomes may include “tail events”—scenarios considered unlikely but with significant potential impact. Examples include scenarios that would trigger the preservation of capital floor for the market return cash balance plan discussed under Feature 1 above.

Questions to consider when evaluating designs dependent on market outcomes include:

- If the benefit is variable, is the distribution of outcomes symmetric around a mean, or is the distribution asymmetric? Where there is asymmetry (which may be indicated by significant differences between mean and median outcomes), more sophisticated valuation techniques may be useful.

- How significant is the value potentially held in tail events? Is the degree of asymmetry and the resulting value of the benefits heavily dependent on underlying assumptions about the distribution of market outcomes?

- How does the distribution of potential outcomes compare to that of a more standard plan type?

Feature 3: Participant Choice

Some designs permit individuals to choose between benefit formulas or different options. The choice may occur before benefits accrue, periodically throughout the participant’s career, at benefit commencement, or even while benefits are being paid. Choice introduces the possibility of adverse selection if the value of the options being offered depends on characteristics such as longevity, length of career, pay progression, or economic variables in a manner that is not uniform.

While adverse selection is an important issue—particularly when a new plan feature is being added and where past experience may not be helpful—it doesn’t necessarily raise the types of issues covered in this practice note. If the actuary makes a reasonable estimate of the level of selection bias, and if the factors driving selection bias are expected to remain fairly constant over time, then traditional models can often capture the associated cost.

Adverse selection often depends on factors that are largely independent of economic conditions. In these situations, the actuary might reflect the effect of adverse selection by adjusting assumptions used in the traditional actuarial model, rather than by using some of the more advanced techniques discussed in this practice note. For example, if a lump sum option is expected to be more heavily utilized by those in poor health, the actuary could adjust the mortality assumption for participants assumed to take the annuity to reflect their generally better health status.

However, where the relative values of options vary depending on economic conditions, then more sophisticated approaches may be appropriate. For example, if the level of subsidy incorporated in a lump sum varies depending on economic conditions—as might be the case when the plan uses a fixed lump sum conversion interest rate (or the better of fixed and variable rates)—then the opportunity for selection bias adds another dimension to the analysis.

If a plan pays a lump sum that is calculated using the better of a fixed rate or a variable rate, then when interest rates rise such that the fixed rate comes into play, the lump sum will be relatively more valuable than it was when the variable rate applied. This change could drive more participants to elect the lump sum option. If most participants were already electing the lump sum option, then this might simply devolve into a matter of competing formulas (Feature 1). But if a substantial number of participants had been electing the annuity, then the change in economic environment could have a meaningful effect on participant behavior, bringing selection bias into play and making the valuation of the option more complex. Even for valuations that are completed while interest rates are low, it may be appropriate to reflect the additional cost associated with this effect given the possibility of rising rates in the future.

Questions to consider for identifying situations when participant choice could significantly affect the value of plan benefits:

- Are there known adverse selection opportunities for plan participants in the plan design? Is this applicable for a large group of participants? If past election rates have been low, are there market conditions or other factors that could change this in the future?

- Does the plan have participant "options," and what type of "extra" value might there be for participants who elect those options? Might the extra value depend on the discount rate (e.g., optional forms of payment elections)?

Feature 4: Discontinuous Distribution of Costs or Benefits

In some plans, a specific event may trigger an additional benefit or a change in the benefits that a plan provides. Examples include benefit provisions that may be triggered by an event such as a plant shutdown or a change in control of the plan sponsor. These benefits may be dramatically more valuable than the plan's standard benefits—sometimes several times more valuable. Generally, these provisions are weighted by a probability of occurrence or are disregarded entirely. While a weighted average measurement might represent the best estimate or expected value of the provision, it will either be high (if the event doesn't occur) or low (if the event occurs), rather than falling in the middle of a continuous distribution.

The discontinuous nature of the cost distribution distinguishes this type of feature from the others covered in this practice note. While a best estimate or expected value might be appropriate for purposes of a funding or accounting measurement, it may be possible to demonstrate that the actual cost will be far removed (in one direction or the other) from the expected value. Normally when faced with a costly contingent event, one might look to the insurance market to manage the associated risk. However, the nature of the risk inherent in a plant shutdown or similar benefit may be difficult to insure against. The concept of a market-based measure of the cost of such a feature will be similarly difficult to assess. The actuary may want to consider disclosing the maximum cost of the contingency, pursuant to any ASOP No. 51 risk discussion.

Some questions that might be useful in identifying a non-continuous distribution of benefits include:

- Are there benefits not being valued, and is the potential value of these benefits significant? What actions or factors would result in these benefits becoming payable? Are any of these dependent upon employer choice or factors not traditionally recognized in a plan valuation? What disclosures are warranted for these benefits that are not being valued?
- Does the benefit depend on current or future projected funding level or level of assets?

Alternative Valuation Techniques

Typical valuation approaches for defined benefit pension plans have developed in response to the circumstances surrounding their use. They reflect the plan designs, computational capabilities, and regulatory and financial reporting framework of the past several decades. To the extent that these factors change, evolution in valuation approaches to accommodate can be expected to follow. This section of the practice note discusses a range of techniques that could potentially be applied to difficult-to-value plan provisions.

The traditional valuation approach projects future payments based on a single economic and demographic scenario, and then determines the liability as the present value of those future payments discounted to the present using a single discount rate, or an array of discount rates that vary by duration. This approach is reflected in the funding and accounting rules that apply to most pension plans in the U.S. The assumptions reflected in the single scenario may represent estimates of the basic underlying factors—such as inflation, interest rates, asset returns, mortality, or turnover—or they may be adjusted to reflect their effect on factors that more directly drive future payments under the plan. Some examples of these adjustments include:

- Consider a plan that adjusts benefits annually based on the lesser of actual inflation for the prior year or 2%. One approach would be to use the assumed rate of inflation and then set the assumed cost-of-living adjustment (COLA) at the lesser of this amount and 2%. If the assumed rate of inflation exceeds 2%, the resulting COLA assumption would be 2%. An alternative approach, which reflects the effect of the COLA on projected benefits, is to consider the expected distribution of future COLAs, rather than separately considering the components of the COLA. Reflecting the likelihood that inflation in some future years could fall below 2%, even though the average rate is expected to exceed 2%, could result in an assumed COLA of less than 2%.

- Consider a cash balance plan that provides an annual interest credit equal to the greater of the yield on one-year Treasuries or 4%. This is similar to the previous example, but with a floor, rather than a cap. If the long-term assumed yield on one-year Treasuries is 3%, then simply taking the greater of this amount and 4% would produce an assumed interest credit of 4%. Considering the distribution of future yields and the likelihood that that yield could exceed 4% in some years would likely produce an assumption that is higher than 4%.

- Consider a floor-offset plan. In such an arrangement, the contribution to a profit-sharing plan offsets the cost of a defined benefit promise. Valuing the defined benefit liability using traditional approaches may involve projecting the account balance and the defined benefit, comparing them, and discounting the net defined benefit to the present. To accomplish this, the actuary might first set assumptions about the projection and the future comparison basis, and then use this assumption to project the net benefits that are used in the valuation.

Although this approach successfully captures the value of the benefit that is *anticipated*, it does not assign any value to other possible outcomes. Suppose that the account, along with its expected return, is anticipated to fully offset the defined benefit. The defined benefit liability that would then be calculated is zero. However, in scenarios in which a sufficient rate of return is not achieved, some defined benefit will be due. Intuition suggests that the liability assigned to a promise that might entail payment should not be zero. The discrepancy is a consequence of this approach's reliance upon expected results to the exclusion of other possibilities.

Recognizing that the potential distribution of outcomes for this plan varies by individual and by retirement age, and might include both zero and nonzero values, the actuary might make an adjustment to reflect the expected value of the net benefit rather than the expected value of the input (the unconstrained expected return). This adjustment could take the form of a reduction to the expected return on profit-sharing accounts that approximates this effect, a specified percentage reduction applied to the projected account balance, a specified percentage load to liabilities, or some alternative.

No valuation approach can predict the future. A liability cannot be expected to align perfectly with an outcome that is not yet known. Yet this poses a fair question: How might an entire set of future scenarios be reflected in a liability? Traditional methods, in accordance with the Employee Retirement Income Security Act of 1974 (ERISA), Financial Accounting Standards Board (FASB) or Governmental Accounting Standards Board (GASB), do this by considering the various scenarios in the assumption-setting process, as discussed in the examples above, but then using the single set of assumptions to determine the liability.

Other techniques could also be considered (or invented). Approaches that could be considered to value uncertain payouts include:

- **Stochastic (or Monte Carlo) analysis.**[5] Elements of this approach are already used by pension actuaries in some analyses, but it has not typically been used for valuations in accordance with ERISA, FASB, or GASB. The examples use this approach, in part because actuaries gravitate toward stochastic analyses because they are flexible and produce a range of results. Unlike the next three examples below, which produce market-consistent results, stochastic models produce expected value results but can also provide useful information for market value calculations.
- **Matching portfolio.** This would seek traded securities to serve as proxies for uncertain benefit payments. The observed prices of these securities could then inform the benefit liability. A matching portfolio would be used in market-consistent valuations. The approach can present challenges because capital markets are not complete; market prices for every possible outcome cannot be inferred from observable securities. For

[5] In some fields, the term "stochastic" has been used to describe analysis in a continuous context while "Monte Carlo" has been used for discrete approaches. This practice note uses the terms interchangeably, as is our understanding of typical convention in the pension practice.

example, pension valuations include expected payouts for many years into the future. Fixed-income securities do not yet exist with long enough durations.

- **Closed-form formulas.** These include, for example, the Black-Scholes-Merton formula for pricing equity options. Such formulas can provide elegant solutions in some circumstances, but they do have limitations. This type of closed-form formula provides market-consistent values, which may not represent the valuation approach selected for the situation at hand. Few common benefit formulas can be expressed in a manner for which closed-form expressions are known. In addition, in order to reduce them to a single formula, these approaches may have significant embedded simplifications that could result in calculations that may understate or overstate the liabilities.
- **Lattice pricing models.** These are also used for the valuation of derivative securities, such as options and futures. Although similar to Monte Carlo approaches, lattice models offer less flexibility but greater computational efficiency. Rather than using individual scenarios, lattice pricing models reflect volatility with scenarios that diverge and reconverge at discrete time intervals. They are valuable when the volatility of only a very small number of variables is relevant. The potential application of a lattice pricing model to a pension plan is beyond the scope of this discussion.

Even when these approaches are not used directly to value benefits, they may still be used to develop assumptions that are applied to the traditional valuation model.

For illustrative purposes, the examples in Appendix A of this practice note have been developed using a Monte Carlo approach implemented in a relatively simple spreadsheet. This is not intended to suggest that this method would be the best approach in all situations. However, it is a flexible approach that is readily accessible to most actuaries and that can reveal useful information about the behavior of the liability of a variety of different plan designs across a wide range of economic environments.

Considerations in Selecting a Valuation Approach

Various elements of different alternative valuation approaches will bear upon their utility for valuing defined benefit pension plans. These include:

- **The purpose of the measurement** (discussed below).
- **Use in different valuation paradigms.** Depending on the context, actuaries might use expected returns or current interest rates to discount future benefit payments. Market-consistent valuations are also of interest.[6]
- **Accommodation of different benefit designs.** Benefit formulas, especially those with difficult-to-value-provisions, can take many forms, and some may be better computational fits than others for a particular valuation technique.
- **Technological requirements.** Some approaches may require significant computational power and specialized software.
- **Expertise.** Actuaries may have experience more relevant to the application of some techniques than of others.

[6] Appendix B discusses these three valuation paradigms, both in general terms and with regard to the simplifications that they typically include.

Purpose of Measurement

An actuary may be asked to measure pension liabilities in a number of different contexts, such as:

a) Prescribed by law funding requirements

b) Plan sponsor funding policy (independent of legal requirements)

c) Financial reporting requirements

d) Management reporting

e) Pricing of plan provisions or potential plan changes

f) Determination of some concept of "value," such as for trading, bargaining, or research purposes

g) Risk assessment or risk management

h) Projections of future values

i) Some combination of these purposes

Funding and financial reporting calculations are generally based on a single measure of liability (along with a measure of normal cost). These measurements are repeated at set intervals (generally annually) with each remeasurement providing an opportunity to adjust for deviations between expectations and actual experience. The same basic approach is often used both for traditional plans, as well as for those with difficult-to-value features. The previous section discusses approaches to measuring the potential cost of difficult-to-value features. Even if the increase (or reduction) in cost associated with these features is reflected in the valuation, such a feature may also increase the volatility of potential results or skew the distribution of possible outcomes in one direction. For example, in a floor-offset plan, strong positive returns can drive the net benefit to $0 for some plan participants. Additional positive returns beyond this point benefit the participant (in the form of increases in the value of the offset account) rather than the plan sponsor. Thus, the potential cost to the sponsor of poor asset performance may not be balanced out by the potential benefit of favorable experience. Even if the actuary captures this by, for example, lowering the expected return applied to project offset accounts, the range of potential outcomes may still look different than would be the case for a typical plan. For example, a floor-offset plan with gross obligations (before reflecting the offset) of $100 million but a net liability (after reflecting the offset) of $50 million will likely experience roughly twice as much year-over-year volatility as a "typical" plan with $50 million in liabilities. For funding valuations, this would be discussed in the risk disclosures under ASOP No. 51. The effect of higher volatility could also be discussed in relation to other measurements as discussed below.

Other measurements provide the opportunity for a measurement of liabilities, funded status, or other key measures that consider the distribution of possible outcomes. For example, for purposes of evaluating investment policy or changes in plan design, it may be appropriate to look at multiple measures, such as a distribution of possible future outcomes generated through a stochastic analysis, or a measure such as Value at Risk (VAR).[7] A comparison of these measures for different policy options may be useful in formulating a policy decision. The profile of this distribution will likely look different when these difficult-to-value features are involved than would be the case for a more traditional pension plan, especially where pension benefits vary

[7] This statistic estimates the amount of loss for a specific time horizon at a given probability (for example at the 5% percentile over one year).

asymmetrically in response to the economic environment. With a traditional plan, it is often possible to generate an asset portfolio that substantially limits future funded status volatility (typically through fixed-income investments with scheduled payouts that match those of the pension plan). Where pension benefits vary asymmetrically in response to changes in the economic environment, it may be more difficult to construct a portfolio that minimizes funded status volatility and therefore it may be more difficult to de-risk in the future. The plan sponsor may want to understand these characteristics at the time that plan design decisions are being made.

ASOP Considerations

Actuaries are often asked to calculate the cost, or liability, associated with a particular benefit or program. Although the one who asks might be expecting the answer to be expressed as a single number, a single number rarely tells the full story. Pursuant to ASOP No. 4, "when selecting alternative valuation procedures for such plan provisions, the actuary should use professional judgment based on the purpose of the measurement and other relevant factors and should disclose the valuation procedures used" (sections 3.5.3 and 4.1.f of the ASOP). In some contexts, such as determining annual funding requirements for private-sector plans, the method for calculating the liability may be narrowly prescribed. In these situations, the actuary will follow the prescribed approach to come up with the appropriate result. However, actuarial practice and guidance in the ASOPs can help in putting this single-point representation of a complex system in proper context. In accordance with section 4.1.3 of ASOP No. 41, the actuary's report should include appropriate disclosures, including a description of any constraints or limitations on the use or applicability of the findings.

Section 3.5.3 of ASOP No. 4 recognizes that some difficult-to-value benefits may require the use of alternative valuation procedures such as those discussed in this paper. Revisions adopted in December 2021 included the requirement of section 3.11 that a Low-Default-Risk Obligation Measure (LDROM) be calculated. Difficult-to-value benefits may present challenges when calculating the LDROM, and the standard provides actuary some flexibility. It states that for the "purpose of this obligation measure, the actuary should consider reflecting the impact, if any, of investing plan assets in low-default-risk fixed income securities on the pattern of benefits expected to be paid in the future, such as in a variable annuity plan." Some actuaries may conclude that the measurement need not be based on investments different from the actual plan investments. While using an alternative investment mix might not impact the measurement for benefits under many designs, it might for gain-sharing plans. The specifics of the gain-sharing plan design and actuarial judgment will likely be important factors. ASOP No. 4 does not define a specific purpose or meaning for LDROM, but it requires the actuary to provide commentary on its significance.

ASOP No. 51 requires that certain calculations, such as funding valuations, include an assessment of risks. Liabilities for plans with difficult-to-value features may have asymmetries that increase the risk of asset-liability mismatch or may have other characteristics that might be covered in the ASOP No. 51 risk assessment. In that case, the quantitative approaches discussed in ASOP No. 51—such as scenario testing, sensitivity testing, stress testing, or stochastic modeling—may provide useful insights.

ASOP No. 56 will generally apply to the models used to value these plan provisions. To the extent that the actuary does not use the alternative valuation procedures described in this practice note—perhaps due to perceived constraints in the applicable funding or accounting rules, as discussed further in the next sections—it may trigger some of the disclosures discussed in section 4.1 of the standard. Even where alternative valuation techniques are used, some of these disclosures will likely still be appropriate. Some areas where an actuary might need to be alert to potential additional disclosures under ASOP No. 56 could include:

- **Material inconsistencies in assumptions.** For example, prescribed discount rates might be inconsistent with the assumed asset returns used in projecting plan cash flows for a variable annuity or floor offset plan where the benefit depends on asset returns.
- **Material limitations and known weaknesses.** For example, the use of a single deterministic scenario for valuation purposes may not provide the most appropriate information about the potential cost of any embedded options in the plan design.
- **Reliance on models developed by others.** For example, actuaries may look to nonstandard models developed by other actuaries or others to assist in valuing these features. These models may incorporate or depend on economic scenario generators or capital market simulator models developed by yet another entity.
- **Reliance on experts.** For example, valuation of some of these difficult-to-value features for certain purpose may require a more sophisticated set of capital market assumptions than the actuary uses in normal practice, in which case the actuary may look to outside experts for help in setting these assumptions.

Accounting

Private sector

Pension accounting standards typically do not address the issues raised by these difficult-to-value features.

Under Accounting Standards Codification (ASC) 715 (which covers accounting for plan sponsors subject to U.S. GAAP), the discount rate reflects "the rates at which the pension benefits could be effectively settled."[8] The statement goes on to say, "the objective of selecting assumed discount rates using [rates of return on high-quality corporate bonds] is to measure a single amount that, if invested at the measurement date … would provide the necessary future cash flows to pay the pension benefits when due."

Some read this language to suggest that the resulting benefit obligation measure should also be consistent with a liability settlement measure and that other assumptions should be chosen accordingly. However, the standard also specifies that "each significant assumption used shall reflect the best estimate solely with respect to that individual assumption."[9] Based on this language, the plan sponsor may conclude that the settlement concept applies solely with respect to the discount rate and that all other assumptions are selected independently of how the discount rate is set and without regard to the settlement objective (a "best estimate" approach).

Due to the lack of clarity, a variety of approaches may be used in practice. Some practitioners may believe that it is appropriate to reflect a single best-estimate assumption that may not take account of the potential value of the difficult-to-value feature. Others will attempt to capture the value of the feature and may consider adjusting liabilities in some manner to reflect the expected value or some type of market measurement.

For plans that adjust benefits more directly in line with changes in assets values, such as variable annuity and market return cash balance plans, applying the settlement concept might

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[8] ASC 715-30-35-43.

[9] ASC 715-30-35-42.

suggest either using the expected return on assets as the discount rate, or using the prescribed discount rate as the assumed return on assets for purposes of benefit adjustments. There are differences in opinion regarding whether this approach technically complies with the requirements of the accounting standards, or whether it is more appropriate to follow the best estimate approach and accordingly to set other assumptions independently of how the discount rate is set. This issue is discussed in detail in the *Variable Annuity Plans* practice note.

When these plans incorporate difficult-to-value features, such as caps or floors on annual or cumulative benefit adjustments, the plan sponsor may conclude that the settlement approach described above remains appropriate but could incorporate some adjustment to the resulting value to capture the potential increase or decrease in value resulting from these features. Even under a best estimate approach, similar adjustments could be applied to the extent that the best estimate assumption does not otherwise directly capture the cost of the difficult-to-value features.

International Accounting Standard (IAS) 19 (applicable to most non-U.S. plan sponsors' financial statements) requires the discount rate to be based on high-quality corporate bonds aligned with the timing of the benefit payments.[10] There is no specific reference in IAS 19 to the settlement concept. Assumptions other than the discount rate are required to be "best estimates of the variables that will determine the ultimate cost of providing [the] benefits."[11] Many actuaries read the explicit guidance toward corporate bonds and the best-estimate language as suggesting a "best estimate" approach, rather than a settlement approach. However, other actuaries point to the phrase "variables that will determine the ultimate cost of providing that benefit" to justify a settlement approach. As with ASC 715, it may be useful to make additional adjustments to capture the value of difficult-to-value plan features.

Public sector

Public sector (GASB) accounting rules require actuarial calculations follow relevant ASOPs. They do not typically address the issues raised by these difficult-to-value features, apart from some non-specific guidance to consider their effect.[12]

Funding

Private sector single-employer plans

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[10] IAS 19 Revised 2011, paragraphs 83 and 85.

[11] IAS 19 Revised 2011, paragraph 76.

[12] For example, Appendix B (Basis for Conclusions) of GASB 69 address certain gain-sharing plans in the following language: "Automatic postemployment benefit changes, including automatic COLAs and automatic supplemental payments (for example, "thirteenth checks" and automatic gain-sharing features), are explicitly part of the terms of the pension plan and, therefore, constitute part of the employment exchange each period. Because automatic postemployment benefit changes are part of the employment exchange, the Board concluded that they are an integral part of an employer's present obligation to its employees to provide pensions. Therefore, the effects of such automatic benefit changes should be included in the projection of benefit payments for accounting and financial reporting purposes."

The rules under IRC Section 430 raise many of the similar issues discussed above under ASC 715 accounting. As with ASC 715, the funding discount rate is tied to yields on high-quality corporate bonds. Unlike ASC 715, however, the mortality assumption is also prescribed. For the remaining assumptions, Section 430(h)(1) specifies that they "must be reasonable (taking into account the experience of the plan and reasonable expectations)". In addition, these assumptions must, "in combination, offer the plan's enrolled actuary's best estimate of anticipated experience under the plan based on information determined as of the valuation date."

Some actuaries may take a narrow view of this requirement, arguing for the use of a single best estimate scenario that may not capture the potential cost of difficult-to-value plan features. For example, under a floor-offset plan, a given participant might be projected to have their DB benefit fully offset by the value of the offset account under best estimate assumption and therefore calculate a funding target of $0 for that participant, despite the fact that there might be a non-de minimis likelihood that deviations in asset returns and interest rates could result in a non-$0 DB benefit. However, one might question whether such an assumption is expected to have "no significant bias," as required by ASOP No. 27, and therefore whether it would be regarded as a best estimate.

Other actuaries might conclude that it is more in keeping with the requirements of the funding rules and ASOP No. 27 to adjust assumptions or to apply a load to liabilities to capture the potential for the floor benefit to apply, particularly if the effect on liabilities is likely to be significant.

As with ASC 715, there are also differing views on whether the expected return on assets used to adjust benefits for a variable plan or market return cash balance plan should be adjusted in some manner to be consistent with the discount rate (an issue that is also discussed in the *Variable Annuity Plans* practice note).

Multiemployer plans

The multiemployer plan funding rules under Code Section 431 contain language around assumption setting that is similar to that used for single-employer funding. One key difference, however, is that the discount rate is not prescribed, but rather represents the actuary's expectation for the return on plan assets. This flexibility permits the actuary greater latitude to set the discount rate in a manner that is consistent with other assumptions. Nevertheless, the same questions arise as to whether the best estimate assumptions should be adjusted in some manner to capture the potential value of these difficult-to-value features.

Public sector

Public sector funding rules vary by jurisdiction and are generally less prescriptive and therefore may allow for a wider range of approaches. In practice, it is common to make some adjustment for the potential cost of difficult-to-value features such as gain-sharing provisions.

Appendix A—A potential framework for evaluating difficult-to-value designs

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This practice note has identified different types of difficult-to-value designs that an actuary might encounter, as well as a few different theoretical frameworks that might be applied in valuing these designs. Although there are many possible valuation approaches, this appendix will focus on how the Monte Carlo model may be adapted to the standard valuation approaches with which many actuaries are familiar.

Monte Carlo models are flexible and well suited to the techniques discussed in this paper. This section applies a Monte Carlo model to several different illustrative plan designs. By comparing the results of the analysis for difficult-to-value designs to the results of similar analysis for more standard designs, it is possible to derive some conclusions about how difficult-to-value features affect both the expected cost and the risk profile. For example, if adding a particular feature to a standard plan design increases the expected value of a particular cost measure by 5%, the actuary may conclude that that a reasonable costing approach for a plan that contains this feature should result in liabilities that are roughly 5% greater than the cost of a plan without this feature.

Appendix A—A potential framework for evaluating difficult-to-value designs

Model description

The examples used in this appendix are considerably simplified and created only to illustrate the underlying concepts—in particular how difficult-to-value designs compare to more standard designs when it comes to the distribution of costs and benefits—and the potential implications for plan design and costing. However, it is possible to extend this approach to more complex real-world plan designs.

There are six sample plan designs discussed. Each one reflects a simple “pension” consisting of a single future payment scheduled to be paid in exactly five years with no life contingencies. Apart from the baseline designs, the designs modeled fall into the category of competing formulas and/or adjustments based on market outcomes. The same approach could also be applied to formulas that depend on participant choice that varies based on economic conditions. The first sample plan (Traditional Fixed Pension) illustrates a single fixed payment of $1,000. This example is a stand-in for the traditional pension plan, which pays a series of future payments, each of which is generally assumed to be fixed in the traditional valuation model. Although this plan type is not difficult to value, as defined in this practice note, illustrating the application of the simplified model to the traditional pension provides a useful basis of comparison for the more difficult-to-value types of plans that are variations on this design.

The second sample plan (Standard Variable Annuity) is a payment of $1,000 that is adjusted up or down each year to the extent that returns differ from a hurdle rate of 5%. This example is a stand-in for a pure variable annuity plan, which makes a series of such variable payments. Again, this type of plan is not difficult to value, but the model illustrates the properties of this type of design and provides a useful basis of comparison for the more difficult-to-value types of plans that are variations on this design. The three variations analyzed are Variable Annuity with Limits, Variable Annuity with Split Hurdle Rate, and Variable Annuity with Minimum Benefit. In addition, a Gain-Sharing Pension is also analyzed.

The model illustrates a few different approaches to discounting future benefit payments to determine a liability:

- Discount future payments using an expected return on plan assets. This approach produces a single liability value.
- Discount future payments using yields on high-quality fixed-income securities to derive a market-consistent value of the benefit. This can be thought of as a variation on the first approach, where plan assets are invested in a fixed-income investment maturing on the payment date, and where default risk is disregarded. The use of high-quality bond yields is most straightforward when the dollar amount of payments being matched can be predicted with a high degree of certainty, as is generally the case for a traditional fixed pension promise. However, if the pension payment is more variable—particularly where the variation depends at least partially on the return on the invested assets, as is the case with a standard variable annuity design and with many of the difficult-to-value designs discussed this practice note—the theory breaks down because this approach attempts to derive a price

by matching the market value of predictable bonds payments against pension payments that are not so predictable and that therefore may have a very different market price (if such a price is even readily ascertainable).

- Discount the benefit paid in each scenario by the returns earned in that scenario to produce the amount of money that would have been needed at time 0 to precisely cover the projected payment.[13] In essence, this is the question that actuaries are attempting to answer when calculating a liability or present value—what is the amount of money needed today to meet a future promise? Due to the uncertainties inherent in most pension systems and/or investment policies, this amount cannot be known with certainty, and so this approach produces a distribution of present values. An average value from this distribution might be used as a liability measure, and other points from the distribution might be useful for other analyses. As discussed below, considering the distribution of present values will provide some useful insights when it comes to difficult-to-value designs. Specifically, the actuary can look at the change in value that results from adding a difficult-to-value feature across the full distribution, which can be used to establish a load or to validate an appropriate valuation approach for these designs. This approach is particularly suited to this application because the outcomes are all expressed as a present value as of the valuation date.

  Considering the full distribution of outcomes may also be useful when making choices that are not constrained by funding or accounting rules—such as decisions about plan design or investment policy.

It is worth calling out one difference between the results of this third approach and the first approach—the typical expected return-based model. Under the traditional approach, the discounting would ordinarily have been performed with "average" return, and either the arithmetic or geometric mean is usually used.[14] Under the third approach, however, both the determination of benefit amount and the discount factor are performed individually for each scenario. Reflecting the relationship between these factors is essential to valuing the difficult-to-value provisions. This reverses the order of averaging and discounting: In the examples shown, the discounting comes first. And, perhaps counterintuitively, this affects the result. By averaging the discount factor, rather than the rate of return, the "average" return reflected in the calculation is the harmonic mean.[15] The harmonic mean is less than or equal to the geometric mean, so as shown this will create a larger liability than the traditional approach. Although an interesting topic for further development, this practice note is not intended to assert which average should be used to determine the liability. Rather, the technique shown can be used as part of an indirect approach

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[13] For example, if the returns for each of the five years under one trial are 2%, 12%, 7%, 8%, and -1%, the present value for that trial is $1,000 / (1.02 x 1.12 x 1.07 x 1.08 x 0.99).

[14] See *Selecting Investment Return Assumptions: Considerations When Using Arithmetic and Geometric Averages*; American Academy of Actuaries; July 2019.

[15] The harmonic mean is, along with the arithmetic mean and geometric mean, the third of the "Pythagorean means." See https://www.cuemath.com/data/harmonic-mean/ for more information.

to determine a loading factor for a difficult-to-value plan feature, which can then be applied to any of the more traditional approaches. Even if this approach is not directly used to value the entire liability, an adjustment to whichever average is deemed appropriate could be readily determined.

It is also illustrative to compare this approach to the second approach—the market-consistent model. Where the market-consistent model is truly appropriate, it should be possible to cover plan cash flows with theoretical matching bonds whose characteristics are defined by a high-quality bond yield curve. Although the precise bonds necessary to match pension cash flows may not exist, the application of a yield curve defines the expected pricing of these bonds based on market data. If stochastic present values are developed using these theoretical matching bonds, then the distribution of present values should be very narrow. As the examples will show, this is in fact the case for the standard fixed pension. However, for a standard variable annuity design, there will be a wide range of stochastic present values unless the variable annuity benefit adjustment is also calculated assuming investment in these same matching bonds. This divergence illustrates why market-consistent valuation is not necessarily equivalent to using a bond-based discount rate.

<u>Illustrative model</u>

The illustrations are based on two different asset mixes. First is an asset mix and underlying distribution identified as “Mixed Portfolio.” The model generates returns using a lognormal distribution with an annual return of 7% and a standard deviation of 12% (although these parameters can be modified). This equates to a 5-year median geometric return of 6.28%. The model simulates returns for 10,000 5-year scenarios. Later examples will introduce an alternative asset mix based on hypothetical portfolio of fixed-income investments called “Matching Bond.”

For each plan design, the model produces three different sets of stochastic results:

- A distribution of **benefit amounts**, which illustrates how the design being modeled compares to a traditional fixed pension
- A distribution of **present values (PVs)**, which is most useful in assigning a value to the difficult-to-value feature in relation to a standard pension design
- A distribution of **ending funded status**, assuming benefits are fully funded at the start of the projection based on a specified liability measure, which may be helpful in understanding the range of possible future states when considering policy decisions, such as plan design or investment policy

This discussion focuses on the second measure for purposes of deriving a load to valuation liabilities. This measure is particularly suited toward this purpose because the values derived—a stochastic distribution of results calculated as of the valuation date—are measured as of the same date as of which the load is needed. The mean increase in value relative to a more standard plan design is therefore a convenient measure of the additional cost added when producing traditional, single-value, liability measures.

Each set of results is presented by plotting each of the 10,000 outcomes from left to right, ordered from smallest to largest. For different measures and different plan designs, the ordering of the 10,000 outcomes will vary. Thus, when results for multiple plan designs are plotted on the same chart, one should not assume that the same economic scenario was used to generate the results for a given x-coordinate.

The first section presents the distribution of various outcomes for the simplified versions of traditional plan designs and the Mixed Portfolio. Although these results will likely be very familiar to pension actuaries, they will provide a convenient baseline for comparison when the modeling is expanded to consider some of the difficult-to-value designs that are the focus of this practice note.

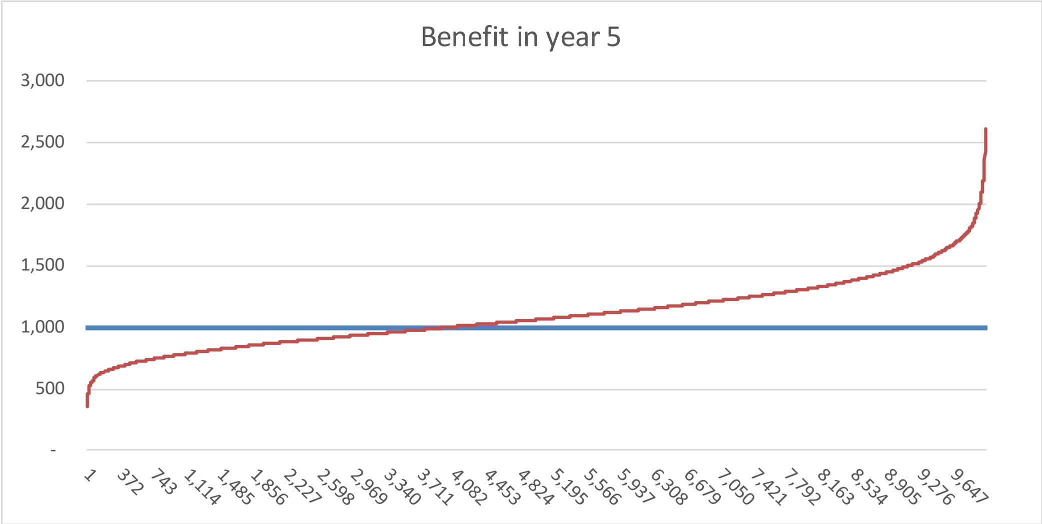
Results for baseline plan designs

The most straightforward result is the distribution of future benefits. For the Standard Fixed Pension, the benefits amounts are the same ($1,000) across each scenario. For the Standard Variable Pension, the amounts vary, with a mean of $1,099 and a standard deviation of $280. The distribution of future benefits is shown below. The x-axis indicates the cumulative number of scenarios, which maxes out at 10,000.

Additional measures, such as the various percentiles of the distribution of outcomes, are shown to the left of each chart. The final line on the left side identifies the investment mix used to generate the results, which is the “Mixed Portfolio” for the examples that follow in the next few sections.

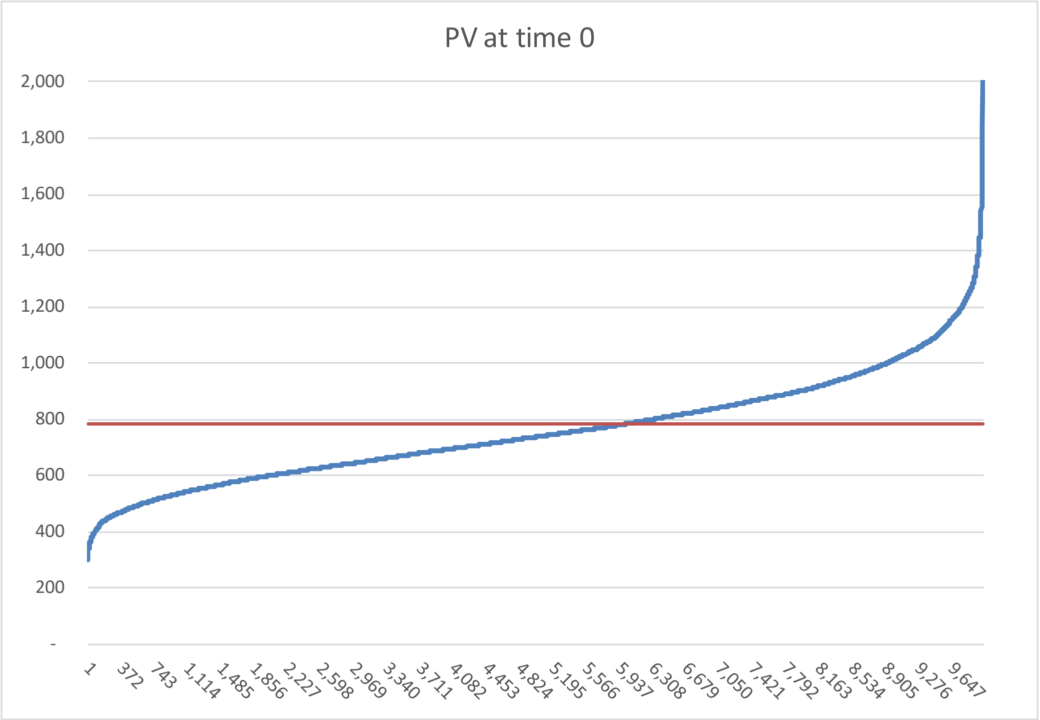
Appendix A—A potential framework for evaluating difficult-to-value designs

	Traditional Fixed	Variable Annuity with 5% Hurdle
Mean Benefit	1,000	1,099
Standard Deviation	-	280
Increase Relative to first scenario		9.9%
Percentiles		
5%	1,000	711
25%	1,000	900
50%	1,000	1,062
75%	1,000	1,258
95%	1,000	1,613
Investment Strategy	Mixed Portfolio	Mixed Portfolio



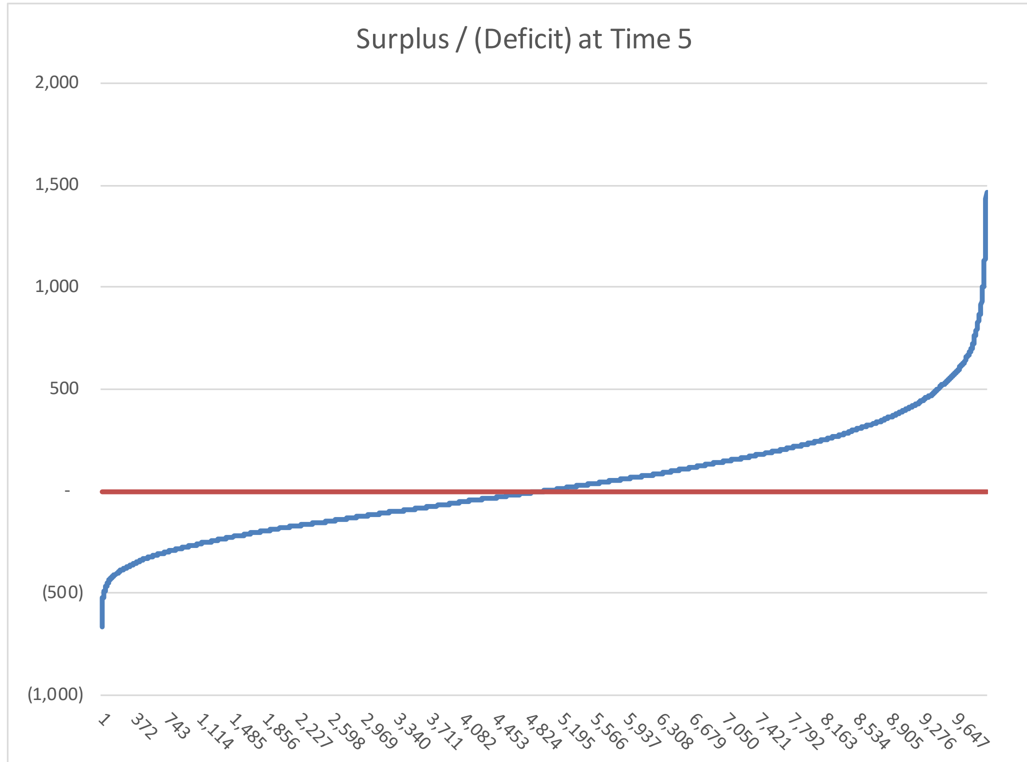
The next result is the distribution of present values across the scenarios. This result provides an indication of the uncertainty around the amount truly needed to provide the promised benefit. For this measure, there is considerable variability for the traditional design, with a mean PV of $759 and a standard deviation of $192. The variable benefit, on the other hand, has a constant PV of $784 across all scenarios.

	Traditional Fixed	Variable Annuity with 5% Hurdle	
Mean PV		759	784
Standard Deviation		192	0
Increase Relative to first scenario			3.3%
Percentiles			
	5%	486	784
	25%	623	784
	50%	737	784
	75%	871	784
	95%	1,101	784
Investment Strategy		Mixed Portfolio	Mixed Portfolio



The final result considers the projected end-state of the system. Assuming benefits are fully funded up-front with a contribution equal to some measure of the liability, a surplus / (deficit) at time 5 (assuming no additional contributions) will result. This result provides an estimate of the volatility of projected funded status. There are several liability measures that might be considered for this purpose. These examples reflect the effect of funding based on a discount rate equal to the median geometric return of 6.28%, a rate equal to the average arithmetic return of 7%, and funding based on the average of the stochastically generated present values. This latter approach equates to a discount rate equal to the harmonic mean of the stochastically generated returns, which is 5.68%. The discounting approach used to generate contributions is identified on the final line to the left of the chart.

	Traditional Fixed	Variable Annuity with 5% Hurdle
Contribution	737	784
Mean Surplus	34	0
Standard Deviation	263	0
Percentiles		
5%	(330)	0
25%	(153)	0
50%	0	0
75%	184	0
95%	518	0
Investment Strategy	Mixed Portfolio	Mixed Portfolio
Contribution Basis	Median Geo Return	Median Geo Return



For the Traditional Fixed Pension, the only difference between the three approaches is the starting liability, which is the initial contribution. The arithmetic approach has the highest discount rate and therefore the lowest initial funding, while the average PV (harmonic average) approach has the lowest discount rate and highest initial funding. Under the arithmetic approach, the mean surplus is $0, but the median surplus is a deficit of $33. Using the mean geometric return results in slightly higher funding, producing a mean surplus of $34 and a median surplus of $0. Funding the average PV results in a surplus at both the mean ($64) and the median ($29).

For the Standard Variable Annuity design, the liability is $784 regardless of the assumed return used to discount liabilities. Using a higher discount rate results in higher projected benefits, while using a lower discount rate reduces the projected benefit, with the change in projected benefit precisely canceling out the effect of the change in discount rate. Under all scenarios and regardless of funding approach, the projected surplus is precisely $0. While it is mathematically possible to determine funding using an approach that projects benefits at a rate that is independent of the discount rate, such an approach would be guaranteed to produce a mismatch. For example, if the benefit is projected assuming a return of 7% (resulting in a benefit that increases 1.9% per year), but a discount rate of less than 7% is used to discount the resulting payment, then the initial contribution would be higher than $784, which would result in a surplus in all 10,000 scenarios. Later examples that attempt to apply a market-consistent approach, but building in this inconsistency will confirm this result.

Rather than illustrate the effect of three slightly different initial funding regimes on projected surplus, later examples will focus primarily on the result generated by the geometric median return, or, later on, the result generated by using a “market-consistent” funding approach.

Results for alternative plan designs

The remaining four examples consider plan designs that depart from the standard baseline designs by introducing features that produce some variability in both benefit amounts and present value.

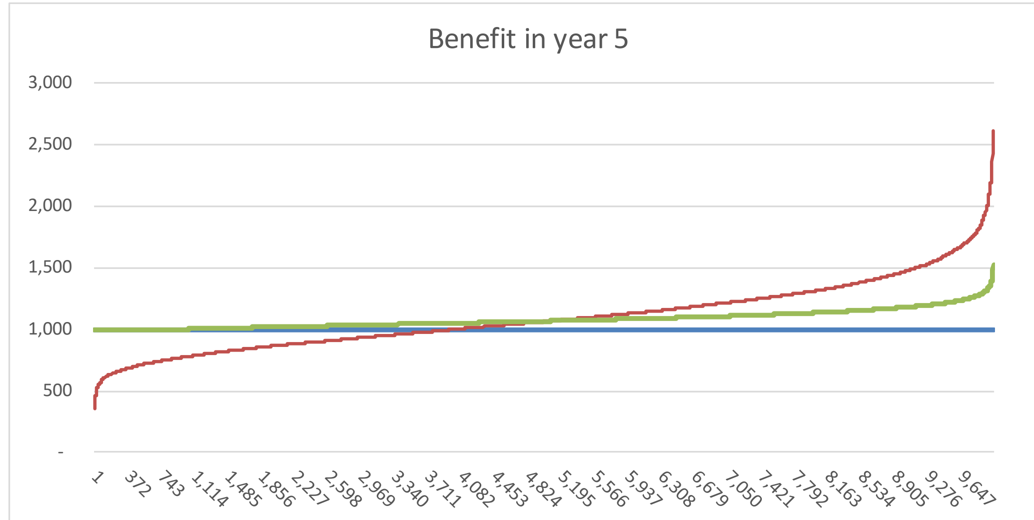
Gain-sharing plan

This example is a gain-sharing plan that provides annual benefit increases in any year in which returns exceed 10%, such that half of the excess is used to increase benefits. This is a highly simplified analog of a feature that appears most commonly in some public-sector pension designs.

This first chart shows how the benefit amount for this design compares to the standard fixed and variable designs.

Appendix A—A potential framework for evaluating difficult-to-value designs

	Traditional Fixed	Variable Annuity with 5% Hurdle	Gain Sharing of 50% above 10%
Mean Benefit	1,000	1,099	1,082
Standard Deviation	-	280	71
Increase Relative to first scenario		9.9%	8.2%
Percentiles			
5%	1,000	711	1,000
25%	1,000	900	1,027
50%	1,000	1,062	1,067
75%	1,000	1,258	1,119
95%	1,000	1,613	1,217
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Mixed Portfolio

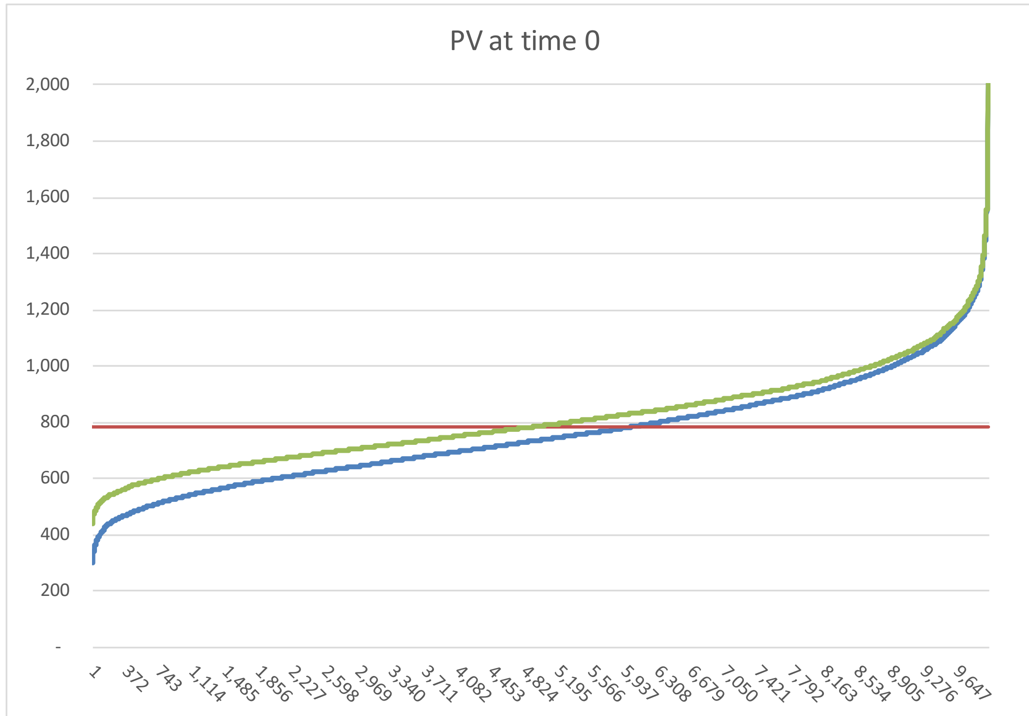


The results reveal a distribution of benefit amounts that has some upward variability in the more favorable return scenarios but is not nearly as variable as the Standard Variable Annuity. Looking at the mean benefit amount of $1,082, one might conclude that the gain-sharing feature adds roughly 8.2% to the cost of the traditional design. However, the results also show that in the more favorable return scenarios, the additional cost is considerably higher (21.7% higher benefit at the 95th percentile). These are the scenarios where return is more favorable, so the higher cost is balanced by higher asset values—precisely the intent of a gain sharing provision.

The next chart compares the distribution of present values.

Appendix A—A potential framework for evaluating difficult-to-value designs

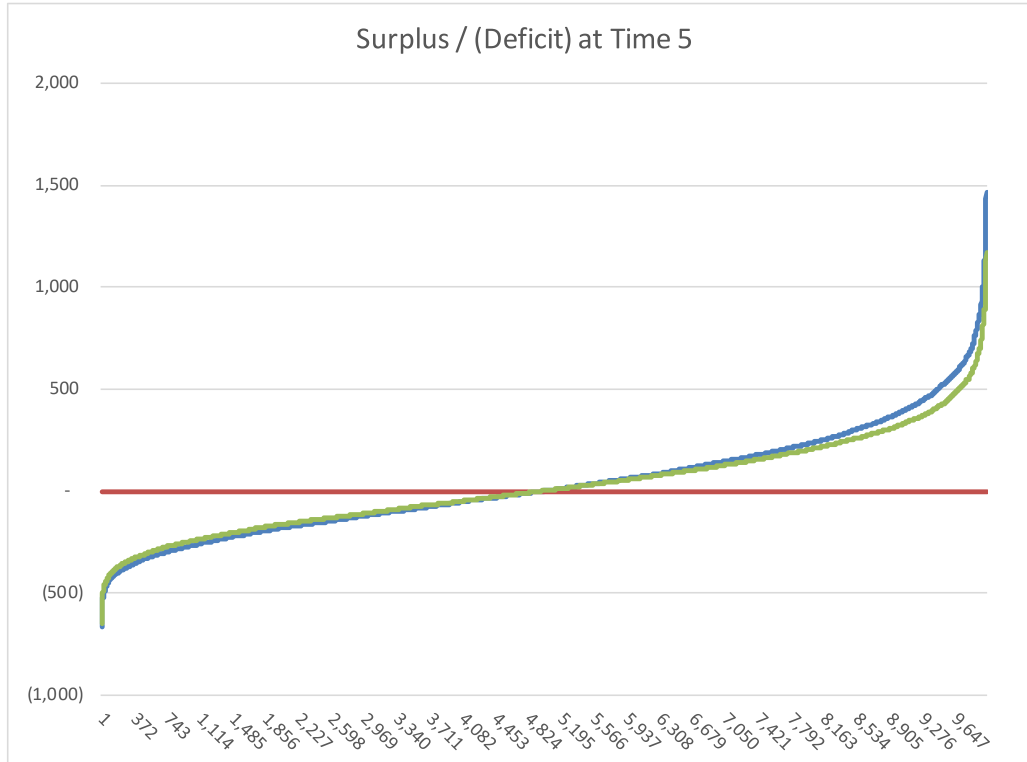
	Traditional Fixed	Variable Annuity with 5% Hurdle	Gain Sharing of 50% above 10%
Mean PV	759	784	811
Standard Deviation	192	0	172
Increase Relative to first scenario		3.3%	6.9%
Percentiles			
5%	486	784	580
25%	623	784	688
50%	737	784	787
75%	871	784	906
95%	1,101	784	1,129
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Mixed Portfolio



These results show a distribution of present values that is somewhat higher than under the traditional design, but with slightly less volatility, as indicated by the lower standard deviation. The mean present value amount is $811, which is only 6.9% higher than the traditional design (despite the average benefit being 8.2% higher). To understand this dynamic, consider that the present values at the low-end of distribution represent scenarios where returns are most favorable and where the gain-sharing provision is most valuable. Under these scenarios, it takes a smaller initial investment to provide the promised benefit. By focusing on the initial value required, the contribution of these scenarios to the overall average is somewhat lower than is generated based on the average ending benefit amount (under which the most favorable scenarios produce the highest amounts and therefore contribute more heavily to the average).

Finally, the effect on projected surplus/(deficit) is shown below. Under this approach, the initial funding for the traditional plan is $737 (1,000 discounted at the geometric average return of 6.28%). For the gain-sharing design, the 6.9% difference in present value noted above is applied as a load to the contribution calculated without the gain-sharing provision, resulting in an initial contribution of $787.

	Traditional Fixed	Variable Annuity with 5% Hurdle	Gain Sharing of 50% above 10%
Contribution	737	784	788
Mean Surplus	34	0	24
Standard Deviation	263	0	227
Percentiles			
5%	(330)	0	(308)
25%	(153)	0	(136)
50%	0	0	1
75%	184	0	162
95%	518	0	424
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Mixed Portfolio
Contribution Basis	Median Geo Return	Median Geo Return	Median Geo Return



These results show that in both cases the plan is projected to be roughly fully funded at the median. The funded status volatility of the gain-sharing design is lower at both extremes. Under the more favorable scenarios, surplus is mitigated because some of the excess is passed on to participants. Under the less favorable scenarios, where little to no gain sharing applies, the underfunding is mitigated somewhat by the fact that the initial contribution is 6.9% higher than would apply to the standard fixed benefit design.

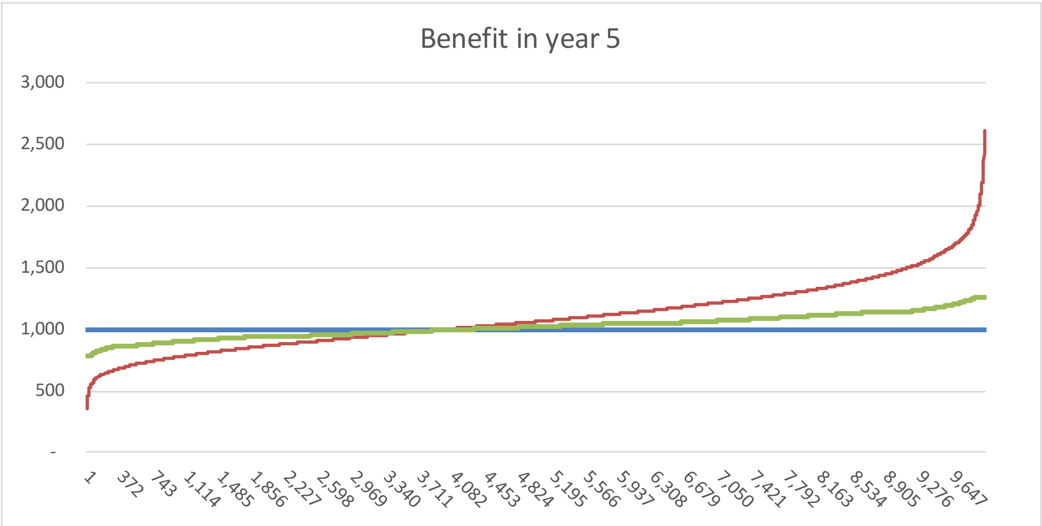
Variations on the Standard Variable Annuity design

The remaining examples consider some variations on the Standard Variable Annuity design. One approach that some plans apply is to modify the Standard Variable Annuity design by applying lower and/or upper limits to the annual benefit adjustment. This reduces the volatility of benefits but introduces some cost volatility. Another option is a “split hurdle rate” where benefits are adjusted downward whenever returns fall below a “low hurdle rate” and are adjusted upward when returns exceed a “high hurdle rate” with no adjustment when returns are between the two rates. Often the amounts not applied to benefit adjustments are instead used to fund (or draw down) a “stabilization reserve,” which is an amount that is notionally set aside to reduce benefit volatility.

The first of these examples is a variation on the variable design where annual returns above 10% or below 0% are disregarded when adjusting benefits.

The chart below shows how this design compares to the standard fixed and variable benefit designs.

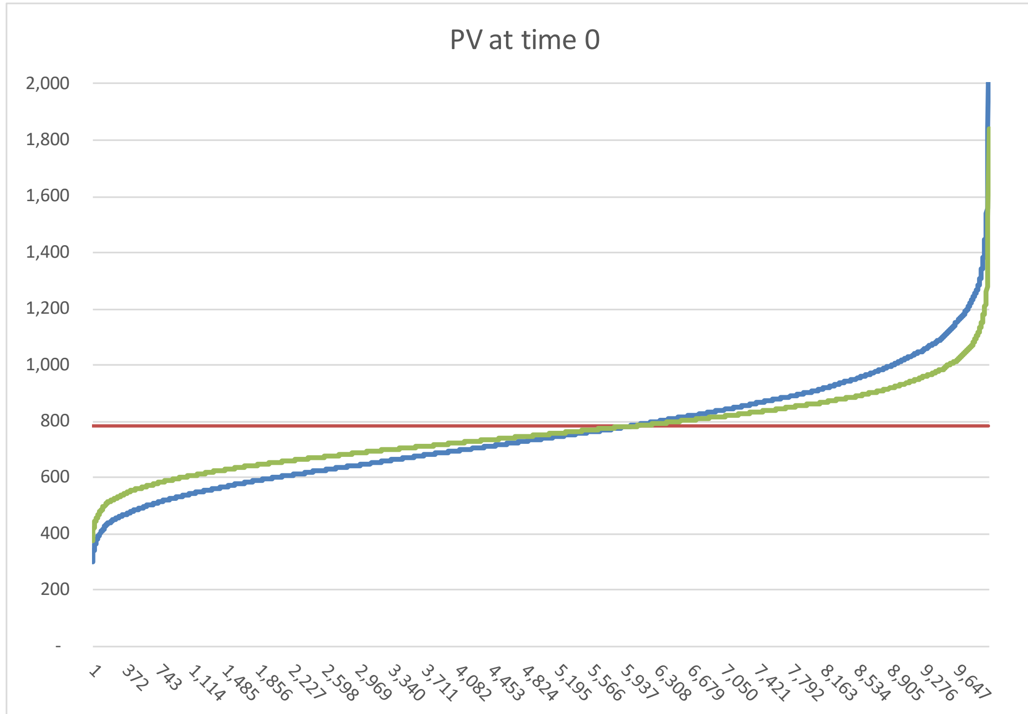
	Traditional Fixed	Variable Annuity with 5% Hurdle	Variable with 10% cap and 0% floor
Mean Benefit	1,000	1,099	1,022
Standard Deviation	-	280	95
Increase Relative to first scenario		9.9%	2.2%
Percentiles			
5%	1,000	711	866
25%	1,000	900	950
50%	1,000	1,062	1,021
75%	1,000	1,258	1,087
95%	1,000	1,613	1,180
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Mixed Portfolio



These results show that the cap and floor returns result in a substantial dampening of benefit volatility. In fact, the benefit distribution for the cap/floor design more closely resembles that of the traditional design than it does a variable annuity design.

As shown below, while the present value of benefits is uniform across all scenarios for the standard variable annuity design, the addition of volatility-dampening features introduces some cost volatility.

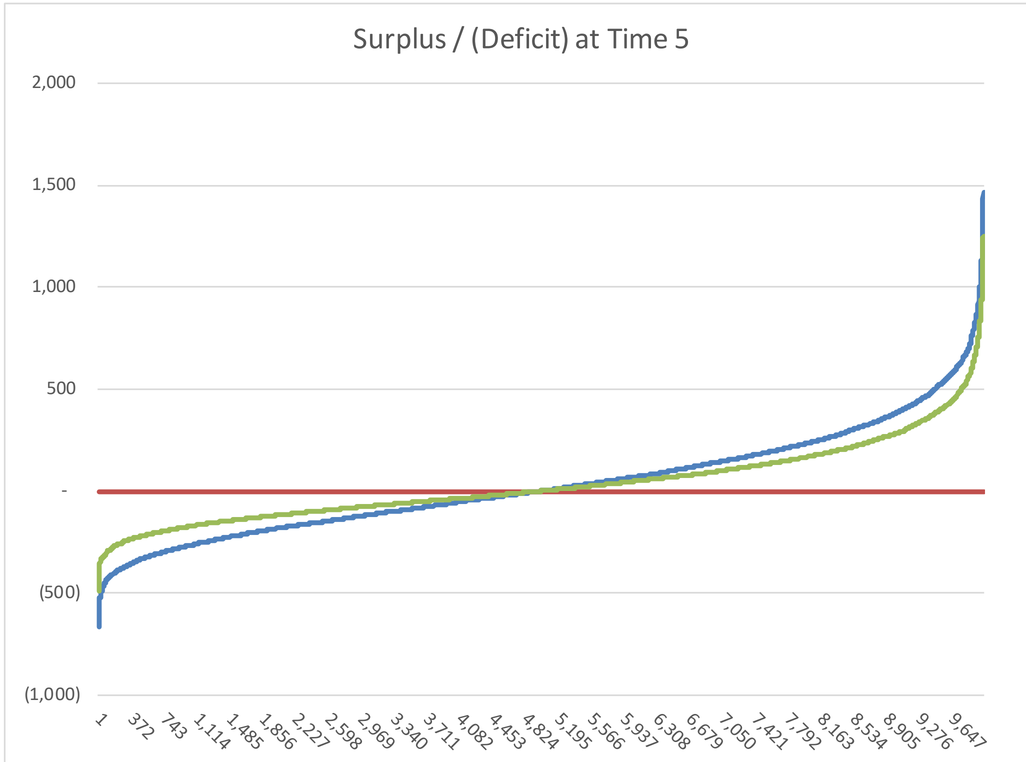
	Traditional Fixed	Variable Annuity with 5% Hurdle	Variable with 10% cap and 0% floor
Mean PV	759	784	760
Standard Deviation	192	0	133
Increase Relative to first scenario		3.3%	0.1%
Percentiles			
5%	486	784	559
25%	623	784	671
50%	737	784	752
75%	871	784	837
95%	1,101	784	990
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Mixed Portfolio



Again, the cap/floor design introduces considerable cost volatility that more closely resembles the traditional fixed benefit design than it does the variable design. This result suggests that it may be appropriate to value this design as a fixed benefit, but with an appropriate adjustment for the cost of the variable features, rather than as a variable design with adjustment, because the modeling illustrates greater similarities with the fixed design. In this case, due to the symmetry of the limits, the load would be minimal (0.1%).

The projected surplus / (deficit) of the sample plan, is shown below.

	Traditional Fixed	Variable Annuity with 5% Hurdle	Variable with 10% cap and 0% floor
Contribution	737	784	752
Mean Surplus	34	0	33
Standard Deviation	263	0	193
Percentiles			
5%	(330)	0	(219)
25%	(153)	0	(97)
50%	0	0	0
75%	184	0	129
95%	518	0	395
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Mixed Portfolio
Contribution Basis	Median Geo Return	Median Geo Return	Median Geo Return

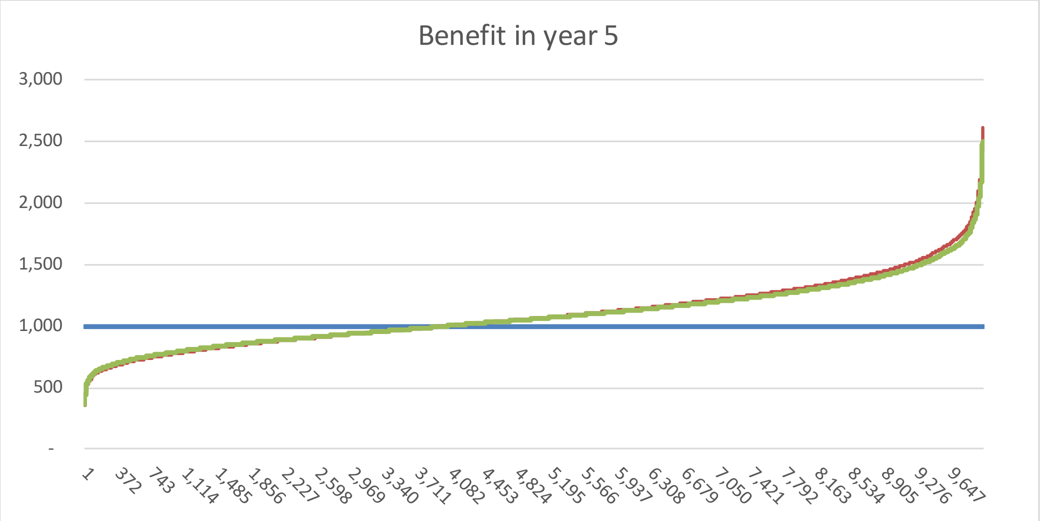


Although not shown, if the 0.1% load derived above is applied to the cost of the fixed design, resulting in a contribution of $738, the mean and median outcomes are somewhat less favorable than would be the case for the traditional design. This reflects the fact that the expected cost of making up shortfalls when the 0% floor limits downward adjustments somewhat outweighs the expected benefit of holding back favorable returns when the 10% cap applies. In this situation, one might look at the resulting distribution of surplus and choose an option that better resembles the distribution for the traditional fixed plan by increasing the contribution to $752. Setting the contribution to $752 results in a median surplus of $0 and a mean surplus of $33, which are comparable to the traditional design. The resulting funding cost is a 2% increase over the cost of the traditional fixed design, rather than the 0.1% load derived by comparing present values. This illustrates that there might still be some judgment involved in settling on the best approach for a given situation. The distribution of results shows that overall surplus volatility is reduced relative to the fixed design, but is much greater than for the variable design.

These results illustrate that the plan sponsor would still assume considerable risk under this type of plan design. Many of the variable designs being implemented currently are intended to reduce the risk to the plan sponsor. Rather than having a strict cap and floor on annual returns, the plan might instead use returns above the 10% cap to fund a “stabilization reserve.” The excess return, instead of being used to immediately improve benefits, would be available to offset downward adjustments for years during which the return falls below 0%. To the extent that the funds in the stabilization reserve are insufficient to protect against downward adjustment, the benefit would be reduced accordingly. This type of mechanism reduces risk to the plan sponsor and would produce a distribution of present values and surplus that is much closer to the standard variable annuity design, rather than the traditional fixed design.

The next variation is a “split” hurdle rate design. Instead of a fixed 5% hurdle rate, the plan uses a low hurdle rate of 4% and a high hurdle rate of 6%. Overall, one might expect the cost of this design to be similar to that of the variable annuity design with a 5% hurdle rate. If returns tend to be slightly higher than 5%, then one might expect the plan to build up a modest surplus over time if the funding cost were set to equal that of the standard variable design with 5% hurdle rate. The distribution of benefits is shown below.

	Traditional Fixed	Variable Annuity with 5% Hurdle	Annuity with 4% low hurdle rate and 6% high hurdle rate
Mean Benefit	1,000	1,099	1,090
Standard Deviation	-	280	259
Increase Relative to first scenario		9.9%	9.0%
Percentiles			
5%	1,000	711	726
25%	1,000	900	907
50%	1,000	1,062	1,058
75%	1,000	1,258	1,238
95%	1,000	1,613	1,564
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Mixed Portfolio

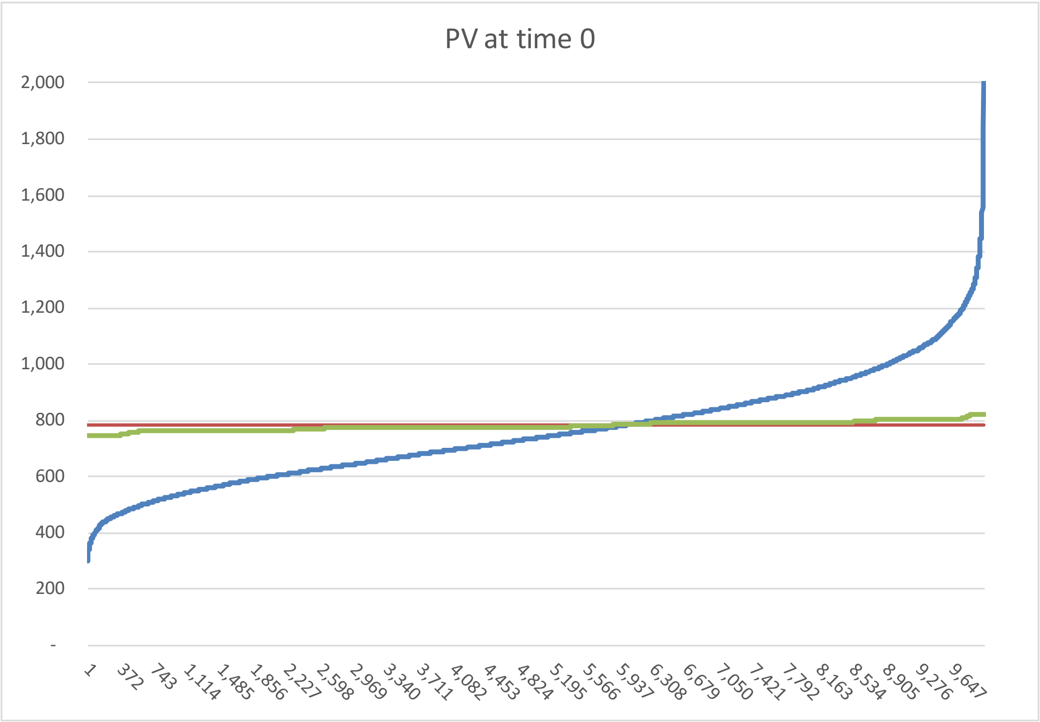


This design is very similar to the standard variable annuity design in terms of the distribution of benefits, with a slightly lower expected benefits (given that expected returns exceed 5%) and a slightly narrower distribution of benefits.

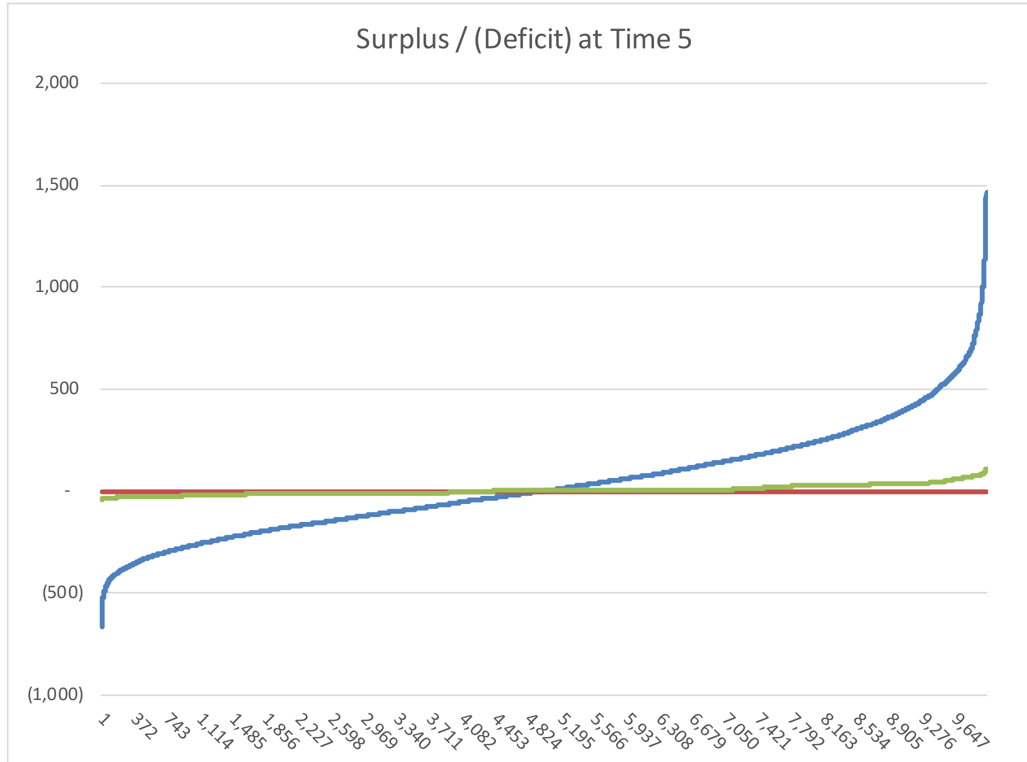
Appendix A—A potential framework for evaluating difficult-to-value designs

The distribution of present values (below) shows a small variation in costs, compared to the standard variable design, which has no variation. Based on these results, an actuary might value this plan in the same manner as a standard variable design, adjusted, as appropriate for cost differences. The results above suggest that this design is about 0.5% lower than the standard variable design.

		Traditional Fixed	Variable Annuity with 5% Hurdle	Variable Annuity with 4% low hurdle rate and 6% high hurdle rate
Mean PV		759	784	780
Standard Deviation		192	0	16
Increase Relative to first scenario			3.3%	2.9%
Percentiles				
	5%	486	784	757
	25%	623	784	770
	50%	737	784	776
	75%	871	784	791
	95%	1,101	784	806
Investment Strategy		Mixed Portfolio	Mixed Portfolio	Mixed Portfolio



	Traditional Fixed	Variable Annuity with 5% Hurdle	Variable Annuity with 4% low hurdle rate and 6% high hurdle rate
Contribution	737	784	780
Mean Surplus	34	0	4
Standard Deviation	263	0	24
Percentiles			
5%	(330)	0	(28)
25%	(153)	0	(13)
50%	0	0	5
75%	184	0	16
95%	518	0	46
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Mixed Portfolio
Contribution Basis	Median Geo Return	Median Geo Return	Median Geo Return

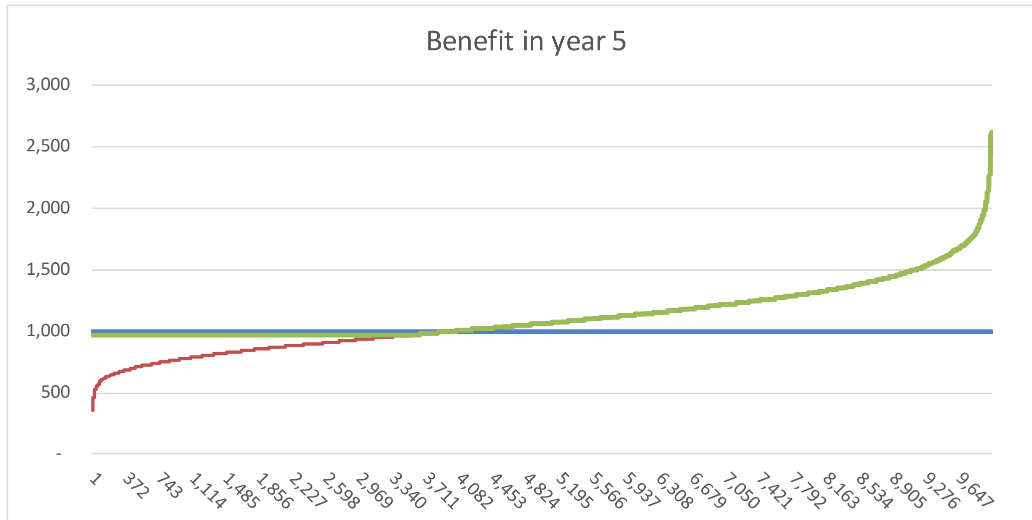


Often the return in excess of the low hurdle rate (up to the high hurdle rate) is set aside in a stabilization reserve, rather than simply remaining in the plan. The stabilization reserve might then be applied to offset downward adjustments that might otherwise occur during years in which returns are less than the low hurdle rate. Under this mechanism, all returns above the 4% low hurdle rate would ultimately be applied to improve participant benefits—either immediately, in the case of returns above the 6% high hurdle rate, or in the future, in the case of funds that are allocated to the stabilization reserve and subsequently used to reduce downward adjustments. Such a design would thus operate very similarly to a standard variable plan with a 4% hurdle rate, rather than 5% hurdle rate, increasing costs accordingly (by roughly 5% in this example).

Appendix A—A potential framework for evaluating difficult-to-value designs

Many of the difficult-to-value designs considered in this practice note have features that are not symmetric and which make them more difficult to compare to a standard type of design. While it is reasonably straightforward to use Monte Carlo techniques to estimate the additional cost added by the variable feature, it can be more challenging to decide which valuation model (traditional fixed or variable) is the better analog. Consider a variable design with a 5% hurdle rate, but with a minimum benefit of $975—just slightly below the starting benefit level of $1,000. One would expect this minimum to be triggered in a significant portion of the scenarios. The distribution of benefits for this design is shown below.

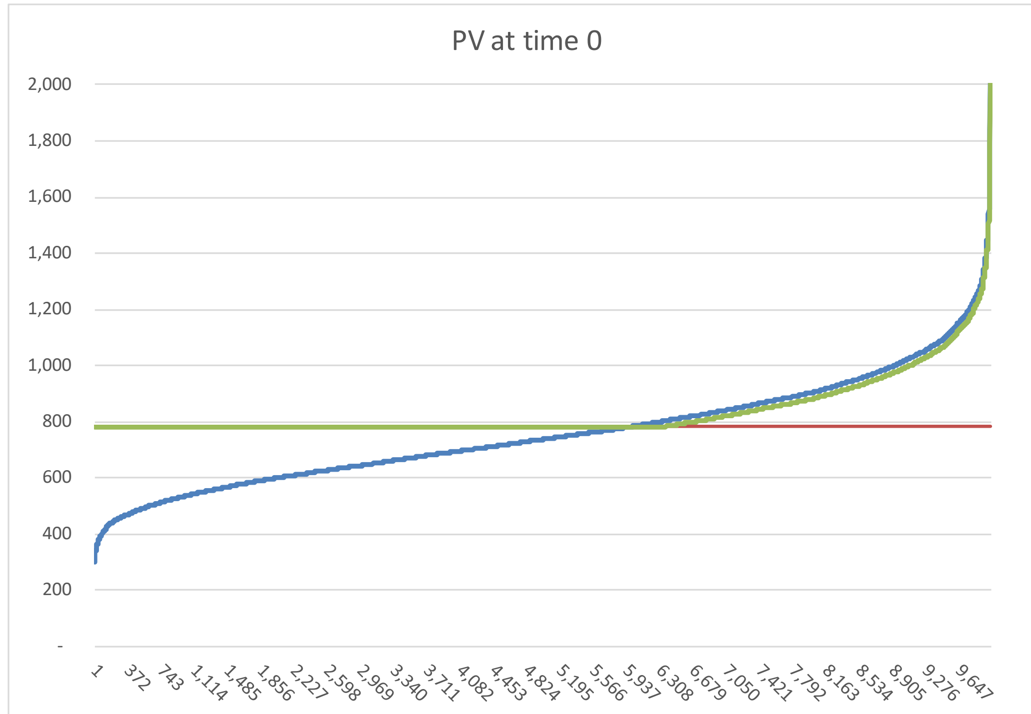
	Traditional Fixed	Variable Annuity with 5% Hurdle	Variable Annuity with 5% Hurdle and $975 floor
Mean Benefit	1,000	1,099	1,151
Standard Deviation	-	280	226
Increase Relative to first scenario		9.9%	15.1%
Percentiles			
5%	1,000	711	975
25%	1,000	900	975
50%	1,000	1,062	1,062
75%	1,000	1,258	1,258
95%	1,000	1,613	1,613
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Mixed Portfolio



The distribution of benefits looks exactly like the standard variable design in the more favorable scenarios, but is fixed in the less favorable scenarios—thus it appears to be a hybrid of the two standard designs with which it is compared.

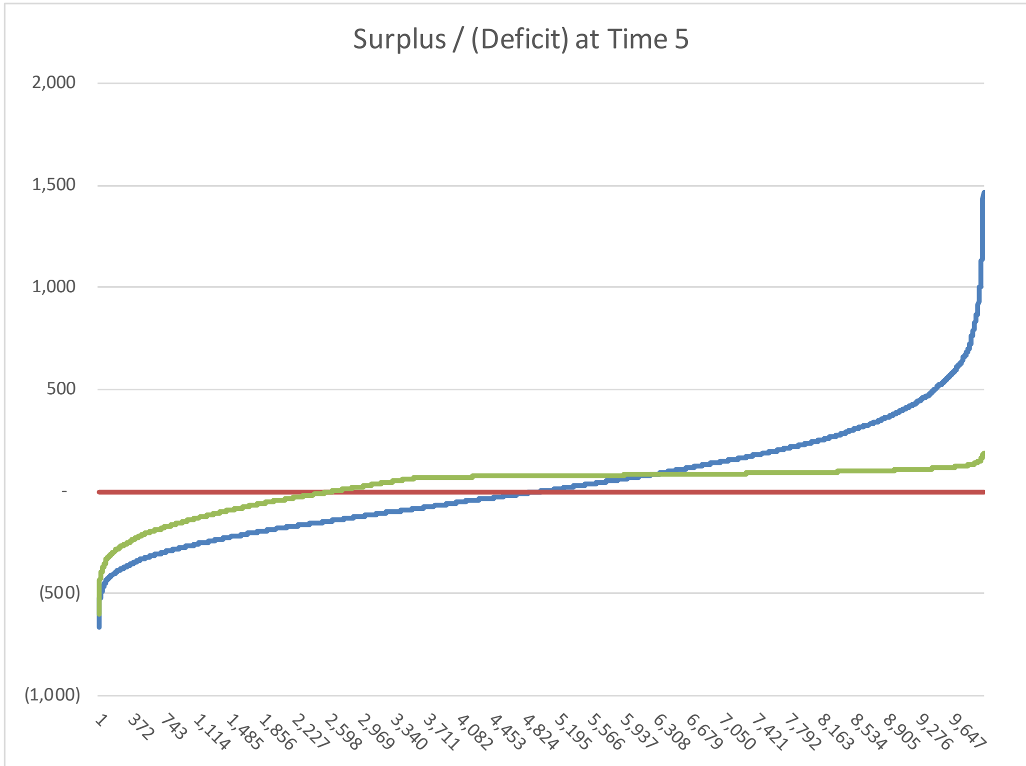
The distribution of present values is shown below

	Traditional Fixed	Variable Annuity with 5% Hurdle	Variable Annuity with 5% Hurdle and $975 floor
Mean PV	759	784	839
Standard Deviation	192	0	111
Increase Relative to first scenario		3.3%	10.5%
Percentiles			
5%	486	784	784
25%	623	784	784
50%	737	784	784
75%	871	784	849
95%	1,101	784	1,074
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Mixed Portfolio



Again, this design precisely matches the variable design for the more favorable scenarios but is significantly more costly in the less favorable scenarios, resulting in a skewed distribution of costs. Overall, it appears to be 10.5% more expensive than the standard fixed annuity and 7.0% more expensive than the standard variable design. If the plan is funded with an initial contribution of $839 (7% more than the standard variable annuity cost of $784), the resulting cost distribution is shown below.

	Traditional Fixed	Variable Annuity with 5% Hurdle	Variable Annuity with 5% Hurdle and $975 floor
Contribution	737	784	839
Mean Surplus	34	0	26
Standard Deviation	263	0	108
Percentiles			
5%	(330)	0	(213)
25%	(153)	0	(12)
50%	0	0	75
75%	184	0	89
95%	518	0	114
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Mixed Portfolio
Contribution Basis	Median Geo Return	Median Geo Return	Median Geo Return



Overall, these results show a slight expected surplus at the mean and an even higher expected surplus at the median. In fact, most scenarios will produce a surplus, but the upside potential is very limited since all of the upside (other than that which results from making a contribution that is higher than what the standard variable design costs) is passed along to participants. The downside, however, can be more significant.

Market-consistent valuation

Up to this point, the examples have assumed investment in a mixed portfolio that produces volatile returns, and contributions calculated based on a discount rate tied to the expected return on that portfolio. This section revisits these sample designs, considering the implications of using a discount rate tied to yields on fixed-income securities. Discount rates for single-employer funding and accounting rules are tied to yields on high-quality bonds because these are indicative of the market cost of an obligation to make fixed payments—which is roughly characteristic of the design of most traditional pension plans. In theory, a traditional fixed pension plan could purchase a series of bonds to match the expected pension payments, with the price of that portfolio representing a market-based measure of the liabilities. A yield curve derived from high-quality bonds is a stand-in for the pricing of the actual portfolio. There are some caveats—for example, the high-quality corporate bonds generally used to derive yields are not entirely risk-free, but standard valuation approaches effectively treat them as such by using the yields on these bonds. Also, the single-employer funding rules under the Pension Protection Act of 2006 (PPA) now contain interest rate smoothing mechanisms that depart significantly from market yields.

Although this section is labeled “market-consistent” valuation, as the examples will illustrate, applying bond yields to a system that is not readily matched by bond cash flows does not produce a market-consistent value. It might be more accurate simply to characterize this as bond yield-based valuation once the examples depart from the traditional fixed design.

In the simple examples considered here, there is a single payment at time 5. Therefore, the 5-year spot yield, which represents the theoretical pricing on a zero-coupon bond that would precisely cover that single payment, is the relevant discount rate. If the plan buys that bond and holds it to maturity, then it will be able to cover that payment with 100% certainty (given the assumption of no default and no other contingencies). Although change in market yields in the interim might change the measure of the obligation and the value of the bond, a plan that invests in this bond will remain fully funded throughout the 5-year period.

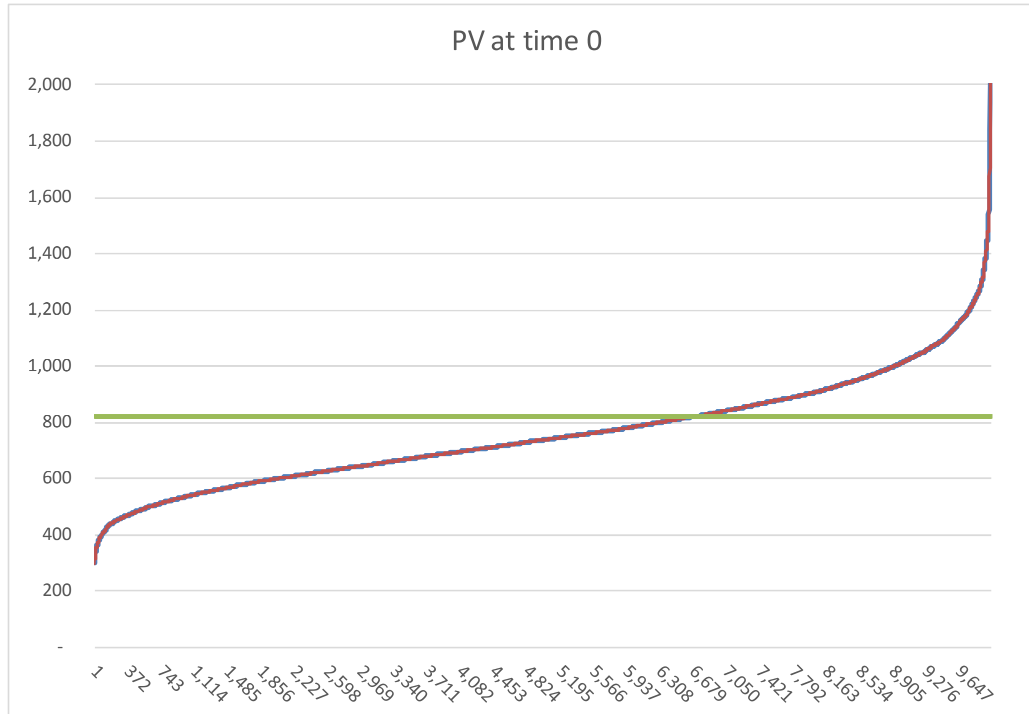
The example assumes that the 5-year spot yield is 4% at time 0. For the simplified model, yields at subsequent measurement dates on this bond (which will shorten in duration as the time to payment shortens) are modeled based on prior year yield less 0.2%, with a standard deviation of 0.8% (to illustrate how a typical upward sloping yield curve might change over time). Although yields and returns on this bond will vary year by year, the 5-year geometric average return will be 4% regardless of what happens to interest rates in the interim. The chart below looks at Standard Fixed Pension, the traditional fixed payment plan, under three combinations of asset mix and discount rate regimes:

1) Investment in a mixed portfolio, with funding based on the geometric average return of 6.28% (illustrative of the funding rules that applied prior to the PPA and which are still commonly used for multiemployer and public-sector plans)
2) Investment in a mixed portfolio, with funding based on the bond yield of 4% (illustrative of the application of the PPA rules—before interest rate smoothing—for a plan investing in a mixed portfolio)
3) Investment in the 4% bond and funding based on the 4% bond yield (illustrative of the results for a plan invested in a matching portfolio under any of these funding regimes)

Standard designs

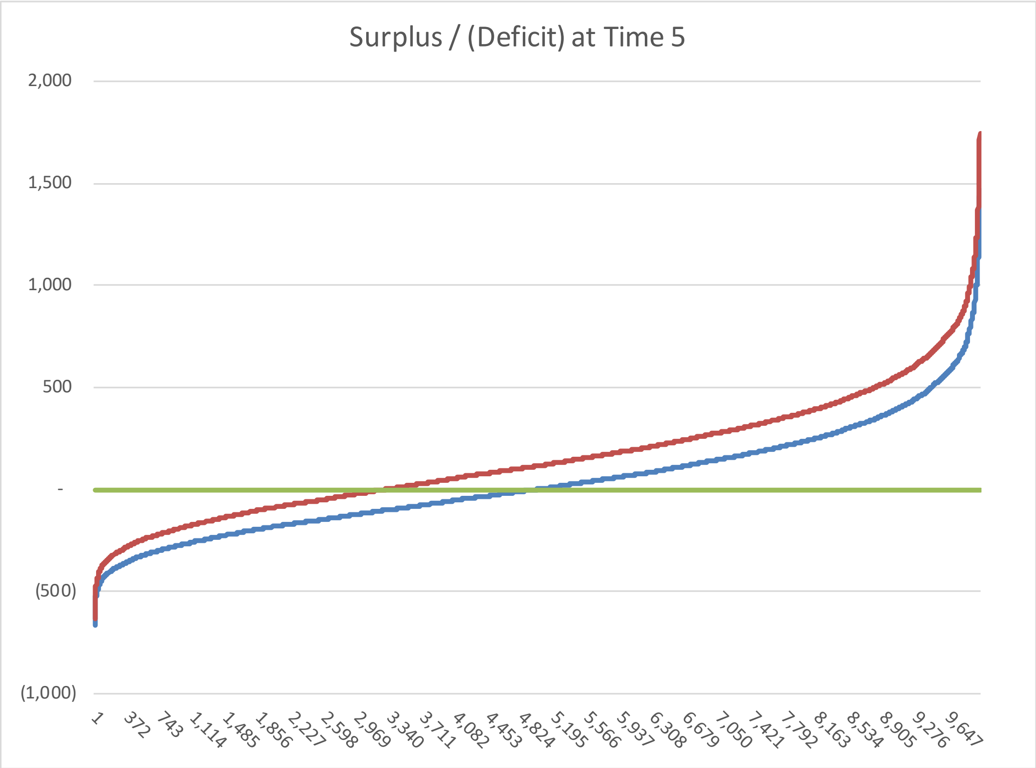
The first design considered is the Traditional Fixed Pension. The chart below shows the stochastically generated present value (the benefit distribution chart is omitted for this plan design because there is no volatility). This present value depends solely on the investment mix and not on the funding strategy. The bond, if held to maturity, returns 4% over the 5-year period (even though year-by-year returns vary), resulting in the same present value of $822, over all scenarios. As expected, this is higher than the mean and median present values for the mixed portfolio and is approximately the 67th percentile value generated by the mixed portfolio.

	Traditional Fixed	Traditional Fixed	Traditional Fixed
Mean PV	759	759	822
Standard Deviation	192	192	0
Increase Relative to first scenario		0.0%	8.3%
Percentiles			
5%	486	486	822
25%	623	623	822
50%	737	737	822
75%	871	871	822
95%	1,101	1,101	822
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Matching Bond



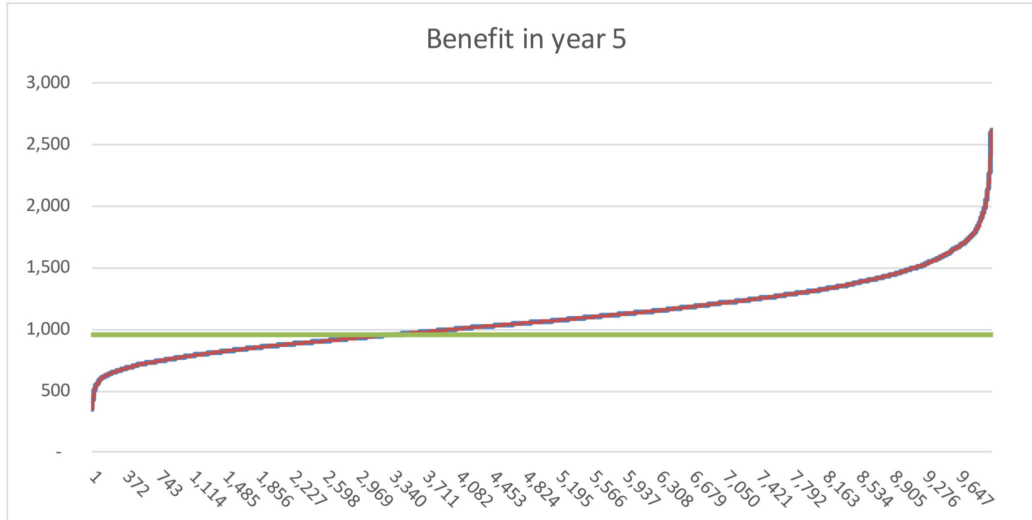
The distribution of surplus (below) shows no volatility for the matching bond investment. For the mixed portfolio, if contributions are based on 4% discount rate, instead of 6.28%, the contribution is higher and so the projected funded status is higher, but the distribution of funded status is otherwise similar.

	Traditional Fixed	Traditional Fixed	Traditional Fixed
Contribution	737	822	822
Mean Surplus	34	153	0
Standard Deviation	263	293	0
Percentiles			
5%	(330)	(254)	-
25%	(153)	(56)	-
50%	0	115	-
75%	184	319	-
95%	518	692	-
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Matching Bond
Contribution Basis	Median Geo Return	Bond-based discount rate	Bond-based discount rate



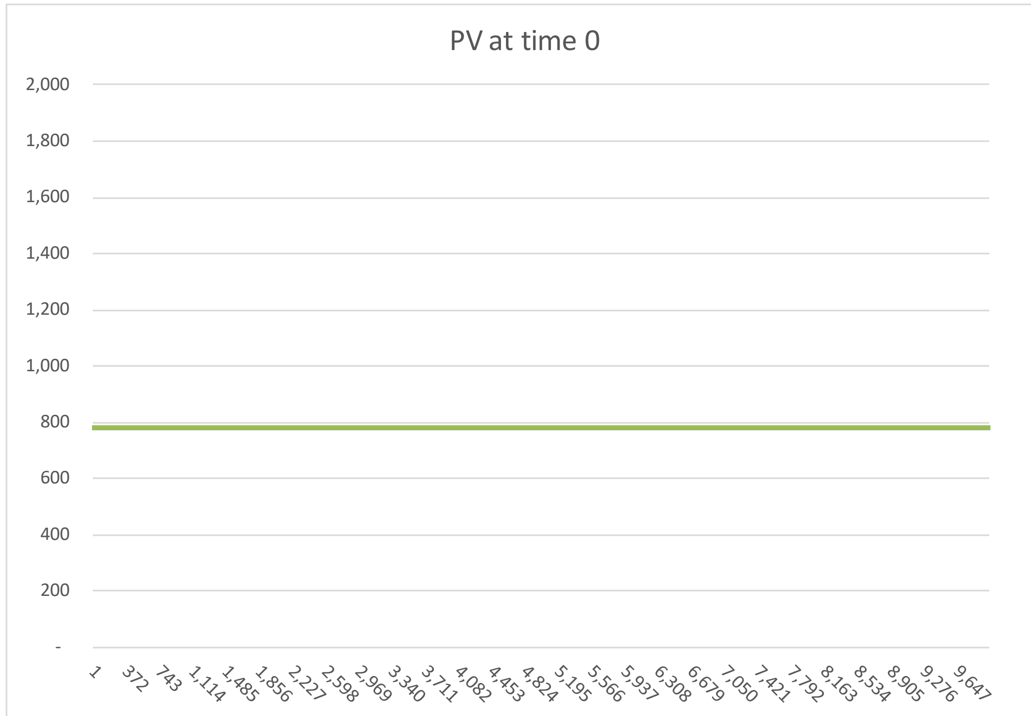
Similar analysis can be done for the Standard Variable Annuity design. The change in investment strategy would have a significant effect on benefits, locking in a return that is below the hurdle rate, resulting in a benefit across all scenarios that falls short of the nominal $1,000 starting amount, but which would eliminate all volatility.

	Variable Annuity with 5% Hurdle	Variable Annuity with 5% Hurdle	Variable Annuity with 5% Hurdle
Mean Benefit	1,099	1,099	953
Standard Deviation	280	280	0
Increase Relative to first scenario		0.0%	-13.3%
Percentiles			
5%	711	711	953
25%	900	900	953
50%	1,062	1,062	953
75%	1,258	1,258	953
95%	1,613	1,613	953
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Matching Bond



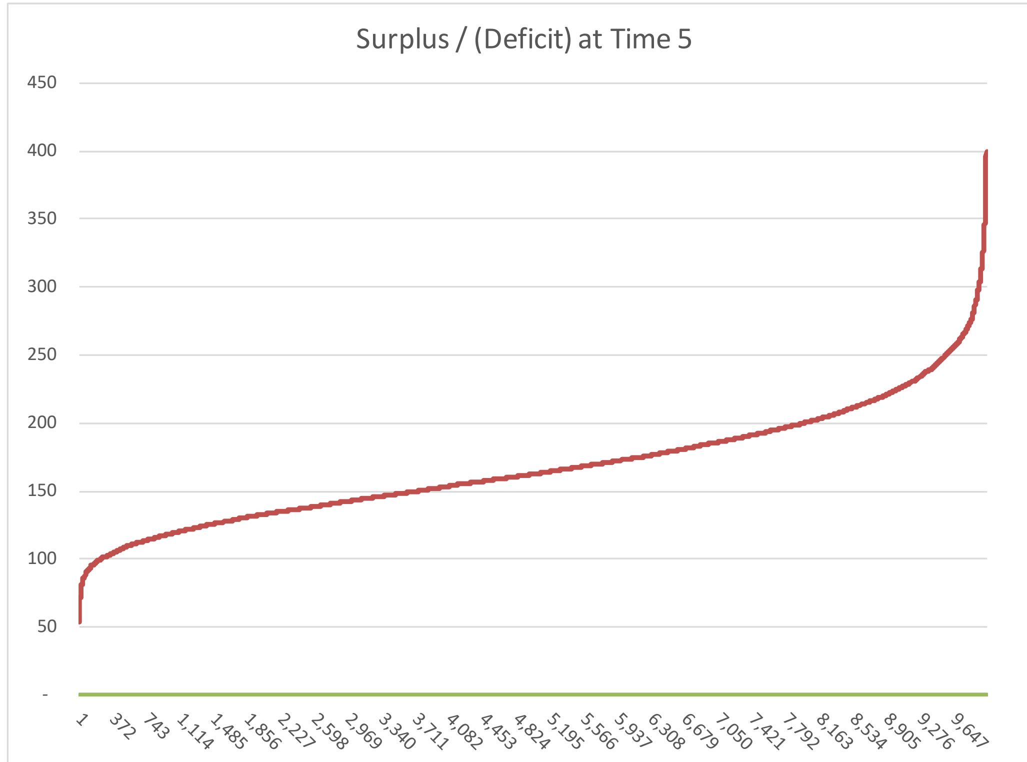
The stochastic present value (below) is the same ($784), regardless of how assets are invested, and across all scenarios. This result reinforces that fact that *any* portfolio is a matching portfolio and that the argument for using bonds to set the discount rate or reduce risk does not apply to this type of design.

	Variable Annuity with 5% Hurdle	Variable Annuity with 5% Hurdle	Variable Annuity with 5% Hurdle
Mean PV	784	784	784
Standard Deviation	0	0	0
Increase Relative to first scenario		0.0%	0.0%
Percentiles			
5%	784	784	784
25%	784	784	784
50%	784	784	784
75%	784	784	784
95%	784	784	784
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Matching Bond



The projected surplus is $0, as long as funding is based on this present value of $784. If, however, funding is based on the median projected benefit reflecting the mixed portfolio, but discounted to the valuation date at the bond-based discount rate ($903), then the plan will have a positive surplus across all scenarios, illustrating the fundamental flaw of this approach. To avoid this outcome, the projected benefit would have to be based on returns that are consistent with the rate being used to discount the benefit, even if plan assets are actually invested in a different manner.

	Variable Annuity with 5% Hurdle	Variable Annuity with 5% Hurdle	Variable Annuity with 5% Hurdle
Contribution	784	903	784
Mean Surplus	0	168	0
Standard Deviation	0	43	0
Percentiles			
5%	0	109	0
25%	0	138	0
50%	0	162	0
75%	0	192	0
95%	0	247	0
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Matching Bond
Contribution Basis	Median Geo Return	Bond-based discount rate	Bond-based discount rate

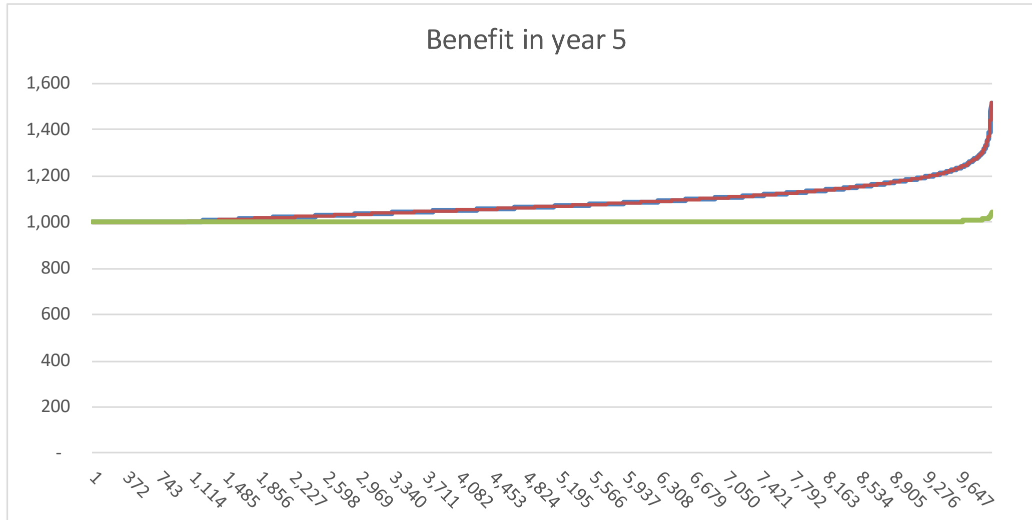


Difficult-to-value design variations

Gain-sharing design

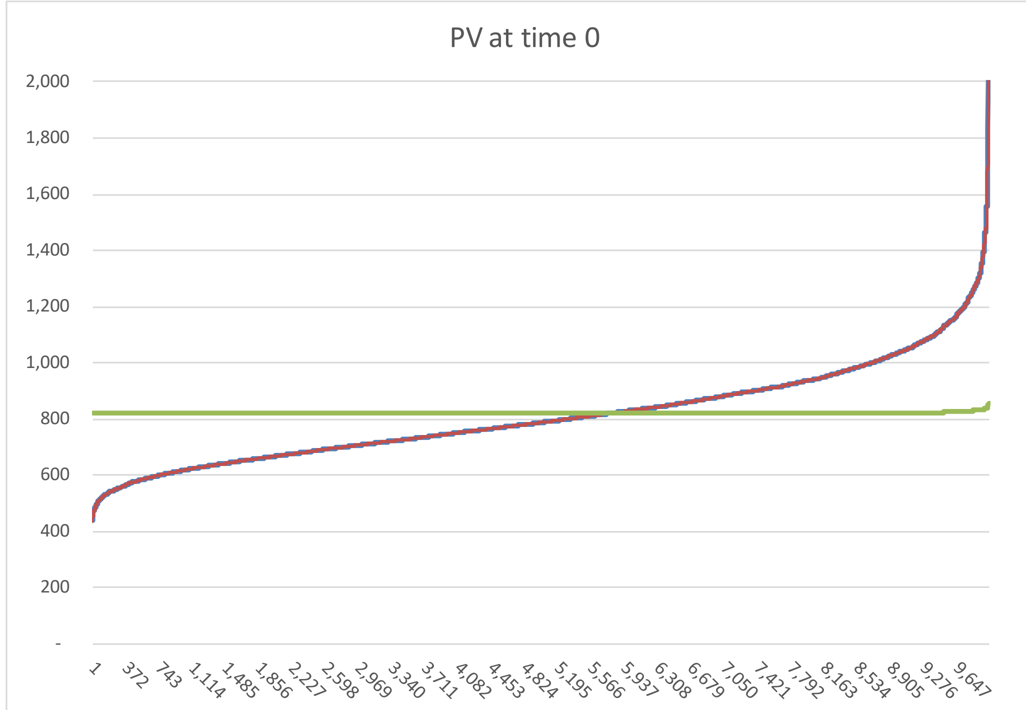
The remaining analysis considers the other designs that were previously reviewed. The first of these is the gain-sharing plan. The investment strategy has a significant effect on the distribution of benefits. If the investment strategy is changed to a matching bond approach, then the gain-sharing provision is rarely triggered because interest rate fluctuations on a relatively short-duration bond are almost never significant enough to generate a 10% annual return on the value of a bond investment. If this were a traditional pension plan with a gain-sharing provision investing in matching bonds, those bonds would have longer duration and thus would be subject to more substantial changes in value from one year to the next. Thus, one might still expect the gain-sharing provision to apply at times, but still not that often.

	Gain Sharing of 50% above 10%	Gain Sharing of 50% above 10%	Gain Sharing of 50% above 10%
Mean Benefit	1,082	1,082	1,000
Standard Deviation	71	71	2
Increase Relative to first scenario		0.0%	-7.5%
Percentiles			
5%	1,000	1,000	1,000
25%	1,027	1,027	1,000
50%	1,067	1,067	1,000
75%	1,119	1,119	1,000
95%	1,217	1,217	1,003
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Matching Bond



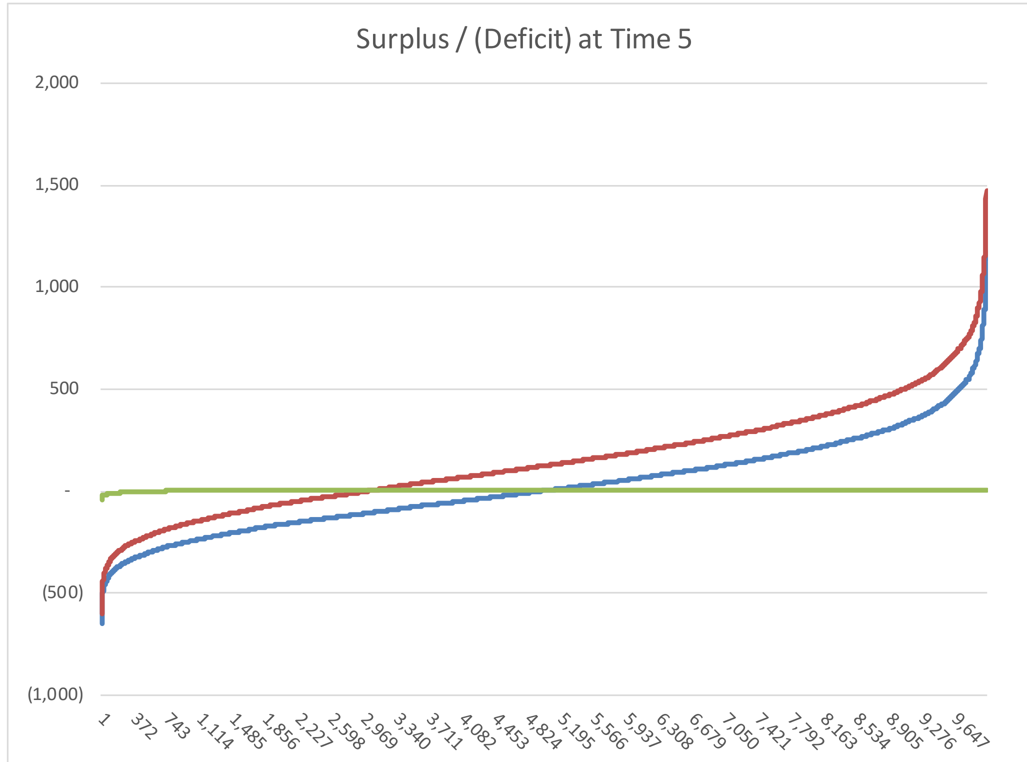
The stochastic present value shows that the matching bond virtually eliminates volatility. This result suggests that, like the traditional pension, investing in matching bonds would be a possible approach to reducing (although not entirely eliminating) risk to the plan sponsor.

	Gain Sharing of 50% above 10%	Gain Sharing of 50% above 10%	Gain Sharing of 50% above 10%
Mean PV	811	811	822
Standard Deviation	172	172	2
Increase Relative to first scenario		0.0%	1.4%
Percentiles			
5%	580	580	822
25%	688	688	822
50%	787	787	822
75%	906	906	822
95%	1,129	1,129	824
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Matching Bond



Investing in matching bonds would almost eliminate volatility in the projected funded status. Calculating the funding requirement using a bond-based discount rate, but continuing to invest in the mixed portfolio, raises the question of whether the additional value of the gain-sharing provision should still be estimated based on the mixed portfolio. The chart below assumes that funding for the gain sharing will continue to be set based on a 6.9% load relative to the cost of the traditional fixed benefit (which was $822 using a bond discount rate), resulting in a contribution of $879. As with the variable design, there is an inconsistency between using a bond-based discount rate (which should, in theory, give the cost of the benefit as if the fund were invested in these “safe” investments) but nevertheless calculating the gain-sharing value as if the fund is invested in a different portfolio. As with the variable design, this approach produces a much higher cost than if the projected benefit is estimated reflecting the bond investments. Unlike with the variable design, this approach doesn’t guarantee a surplus because the mixed portfolio is not a matching portfolio, but the higher contributions do make it more likely by shifting the distribution of outcomes upward.

	Gain Sharing of 50% above 10%	Gain Sharing of 50% above 10%	Gain Sharing of 50% above 10%
Contribution	788	879	822
Mean Surplus	24	150	(0)
Standard Deviation	227	259	2
Percentiles			
5%	(308)	(226)	(2)
25%	(136)	(32)	0
50%	1	124	0
75%	162	305	0
95%	424	609	0
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Matching Bond
Contribution Basis	Median Geo Return	Bond-based discount rate	Bond-based discount rate



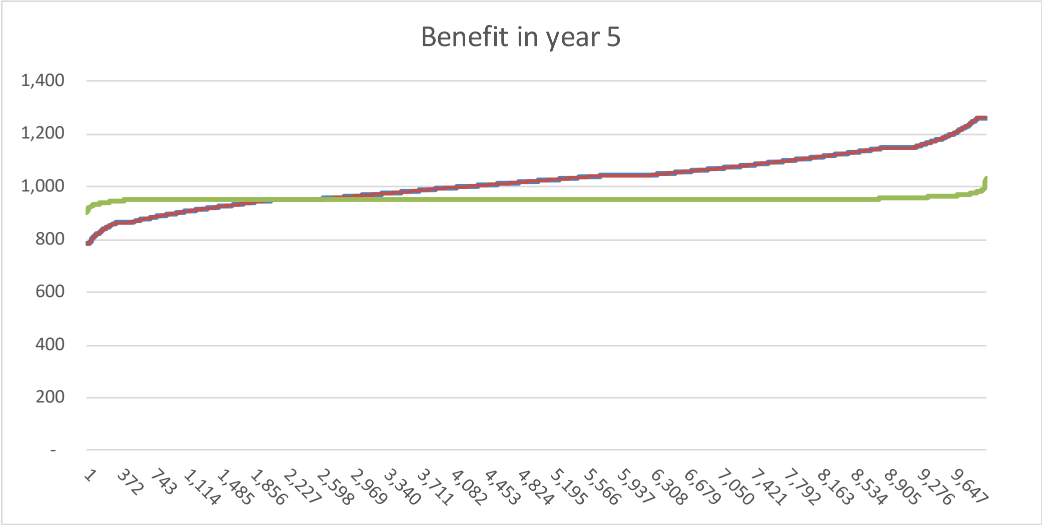
The results above show that investing in matching bonds might be an effective way to reduce investment risk to the sponsor, but at the price of rendering the gain-sharing provision essentially meaningless and increasing the contribution on this basis from $788 to $822.

Variable annuity designs

The next design is the variable annuity with 10% cap and 0% floor on returns. The cap and the floor act to make this design more comparable to a traditional fixed benefit than to a variable benefit. Investing in the matching bonds makes downward adjustments substantially more likely than upward adjustments, making the benefit less valuable to participants under most scenarios, and also further flattens out the distribution of benefits.

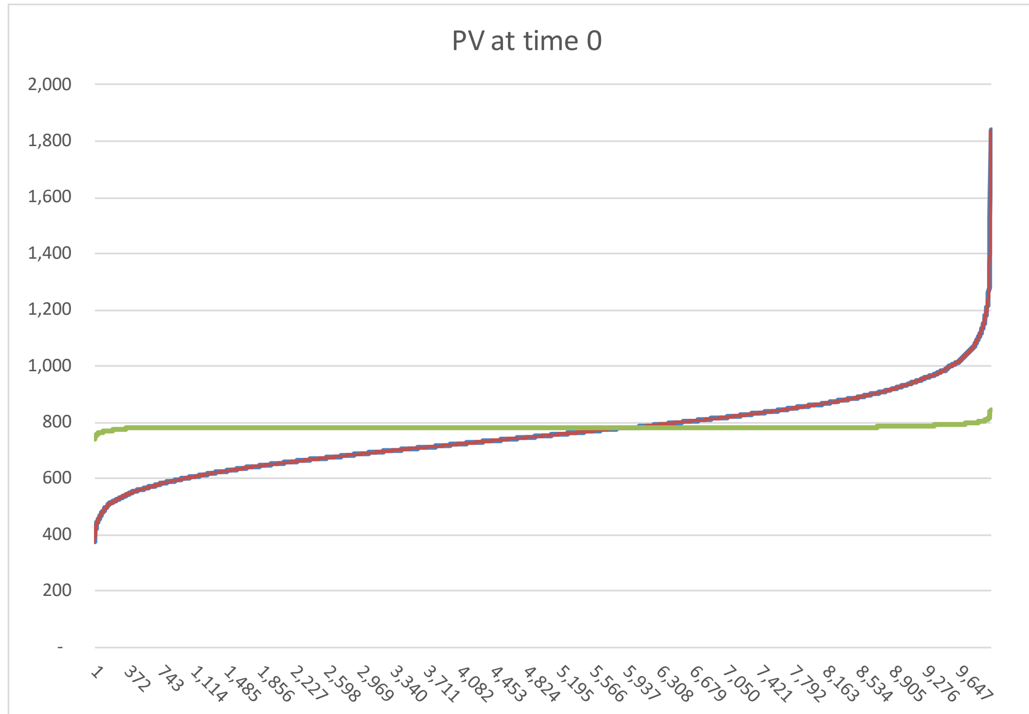
Appendix A—A potential framework for evaluating difficult-to-value designs

	Variable with 10% cap and 0% floor	Variable with 10% cap and 0% floor	Variable with 10% cap and 0% floor
Mean Benefit	1,022	1,022	954
Standard Deviation	95	95	6
Increase Relative to first scenario		0.0%	-6.7%
Percentiles			
5%	866	866	950
25%	950	950	953
50%	1,021	1,021	953
75%	1,087	1,087	953
95%	1,180	1,180	963
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Matching Bond



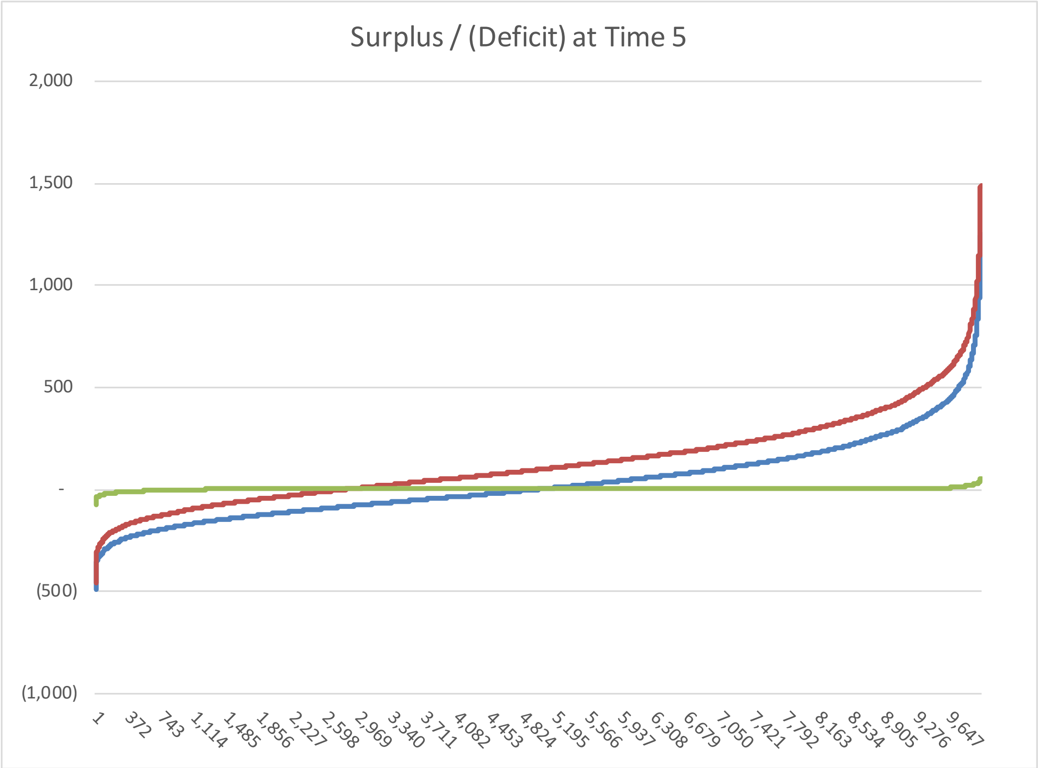
A similar effect can be seen on the stochastic present value, with the present value increasing slightly, on average, and becoming considerably less volatile.

	Variable with 10% cap and 0% floor	Variable with 10% cap and 0% floor	Variable with 10% cap and 0% floor
Mean PV	760	760	784
Standard Deviation	133	133	5
Increase Relative to first scenario		0.0%	3.2%
Percentiles			
5%	559	559	781
25%	671	671	784
50%	752	752	784
75%	837	837	784
95%	990	990	791
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Matching Bond



The effects on projected surplus are shown below. The $823 contribution (for bond-based discount rate but mixed portfolio) is calculated by applying the 0.1% load to the contribution that would apply to the traditional fixed design.

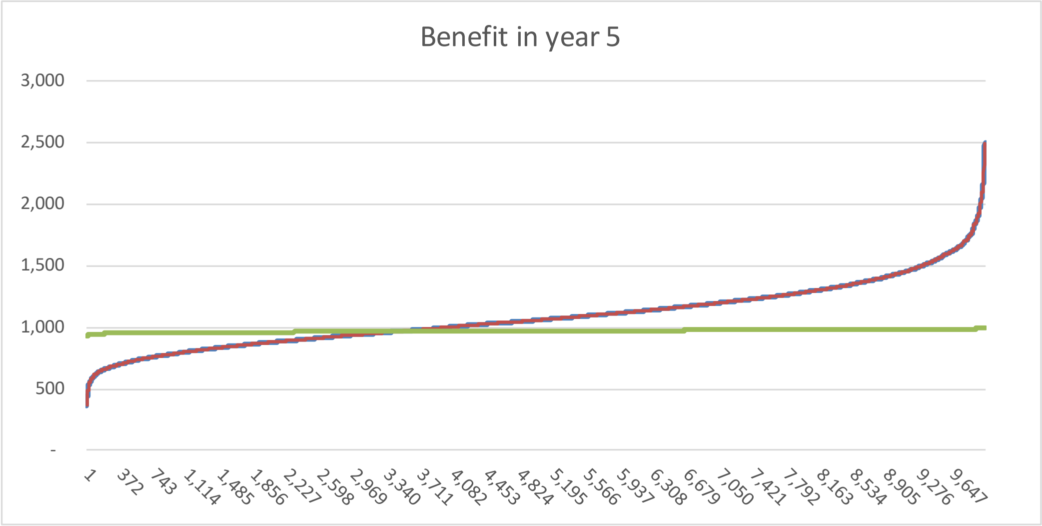
	Variable with 10% cap and 0% floor	Variable with 10% cap and 0% floor	Variable with 10% cap and 0% floor
Contribution	752	823	784
Mean Surplus	33	133	0
Standard Deviation	193	218	6
Percentiles			
5%	(219)	(153)	(9)
25%	(97)	(16)	1
50%	0	97	1
75%	129	243	1
95%	395	541	4
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Matching Bond
Contribution Basis	Median Geo Return	Bond-based discount rate	Bond-based discount rate



The next design is the variable benefit with 4% low hurdle rate and 6% high hurdle rate. As discussed previously, this design is very similar to the pure variable design with the 5% hurdle rate. The benefit distribution under both investment strategies is shown below.

Appendix A—A potential framework for evaluating difficult-to-value designs

	Annuity with 4% low hurdle rate and 6% high hurdle	Annuity with 4% low hurdle rate and 6% high hurdle	Annuity with 4% low hurdle rate and 6% high hurdle rate
Mean Benefit	1,090	1,090	971
Standard Deviation	259	259	9
Increase Relative to first scenario		0.0%	-10.9%
Percentiles			
5%	726	726	955
25%	907	907	964
50%	1,058	1,058	972
75%	1,238	1,238	978
95%	1,564	1,564	982
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Matching Bond

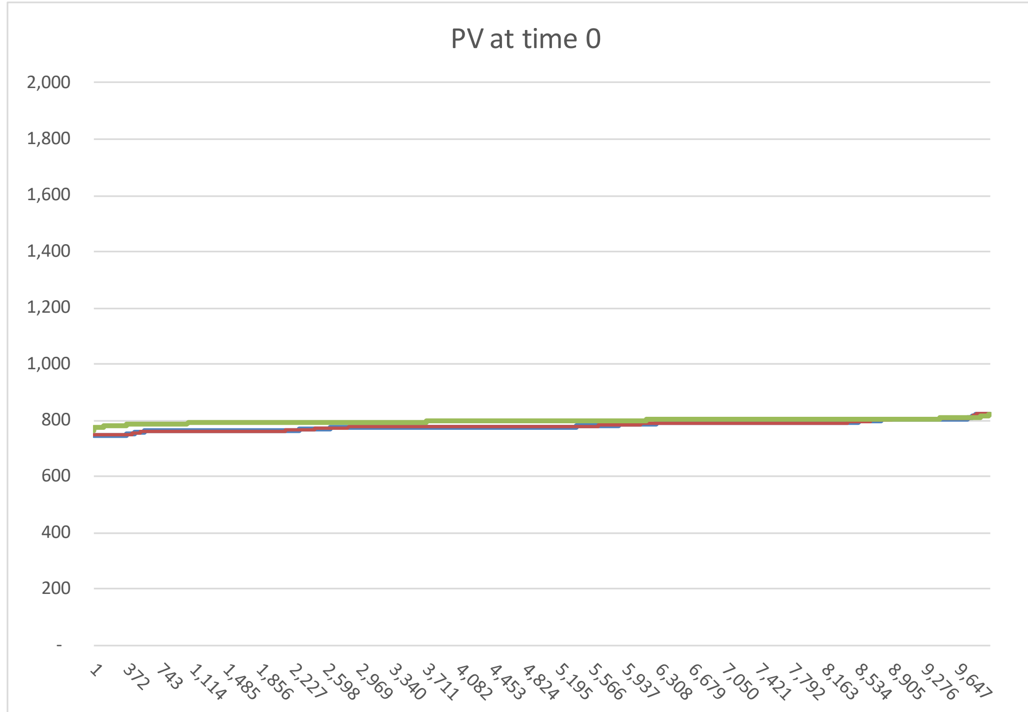


As with the pure variable design, the matching bond greatly reduces benefit volatility, but in this case some volatility remains—even though the geometric average return is 4% across all scenarios, the pattern of returns also matters with this design, resulting in modest variation in benefit levels.

The present value chart below shows very little volatility regardless of asset mix. Investing in the "matching" bond reduces volatility very slightly, but at the cost of a reduction in benefits and a slight increase in cost at all percentiles.

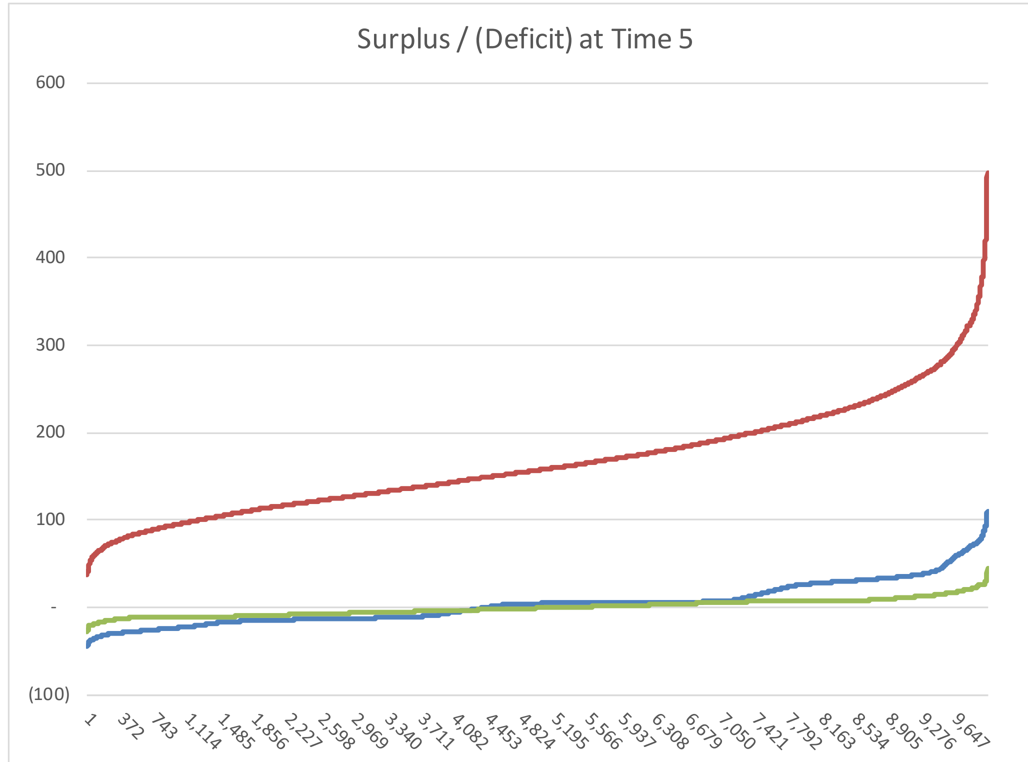
Appendix A—A potential framework for evaluating difficult-to-value designs

	Annuity with 4% low hurdle rate and 6% high hurdle rate	Annuity with 4% low hurdle rate and 6% high hurdle rate	Variable Annuity with 4% low hurdle rate and 6% high hurdle rate
Mean PV	780	780	798
Standard Deviation	16	16	7
Increase Relative to first scenario		0.0%	2.2%
Percentiles			
5%	757	757	785
25%	770	770	792
50%	776	776	799
75%	791	791	804
95%	806	806	807
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Matching Bond



The projected surplus results are very similar to the standard variable annuity. Projecting benefits based on the mixed portfolio but discounting using bond-based rates results in overfunding across all scenarios. This result suggests that it would be more reasonable to have consistency between the rates used to project benefits and those used to discount (as with the standard variable annuity) than to allow those rates to be inconsistent with one another.

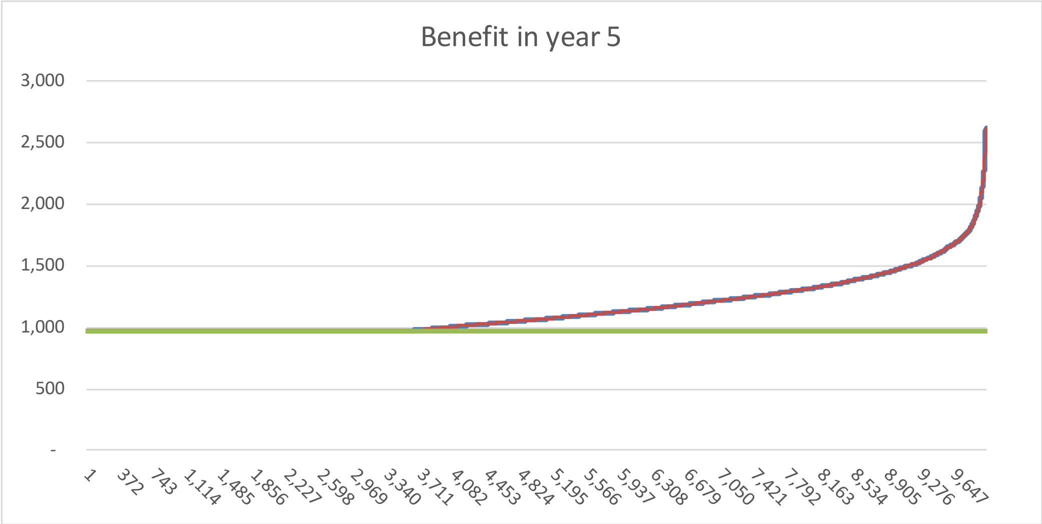
	Annuity with 4% low hurdle rate and 6% high hurdle rate	Annuity with 4% low hurdle rate and 6% high hurdle rate	Variable Annuity with 4% low hurdle rate and 6% high hurdle rate
Contribution	780	896	798
Mean Surplus	4	167	0
Standard Deviation	24	62	9
Percentiles			
5%	(28)	83	(11)
25%	(13)	121	(8)
50%	5	157	(1)
75%	16	202	7
95%	46	281	15
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Matching Bond
Contribution Basis	Median Geo Return	Bond-based discount rate	Bond-based discount rate



The final design considered is the variable benefit with $975 floor. Investing in the “matching” bond results in a return that falls short of the hurdle rate, driving the benefit to the $975 floor across all scenarios. From the participant perspective, this outcome is never better than the benefit provided by the mixed portfolio and substantially lower in the majority of scenarios.

Appendix A—A potential framework for evaluating difficult-to-value designs

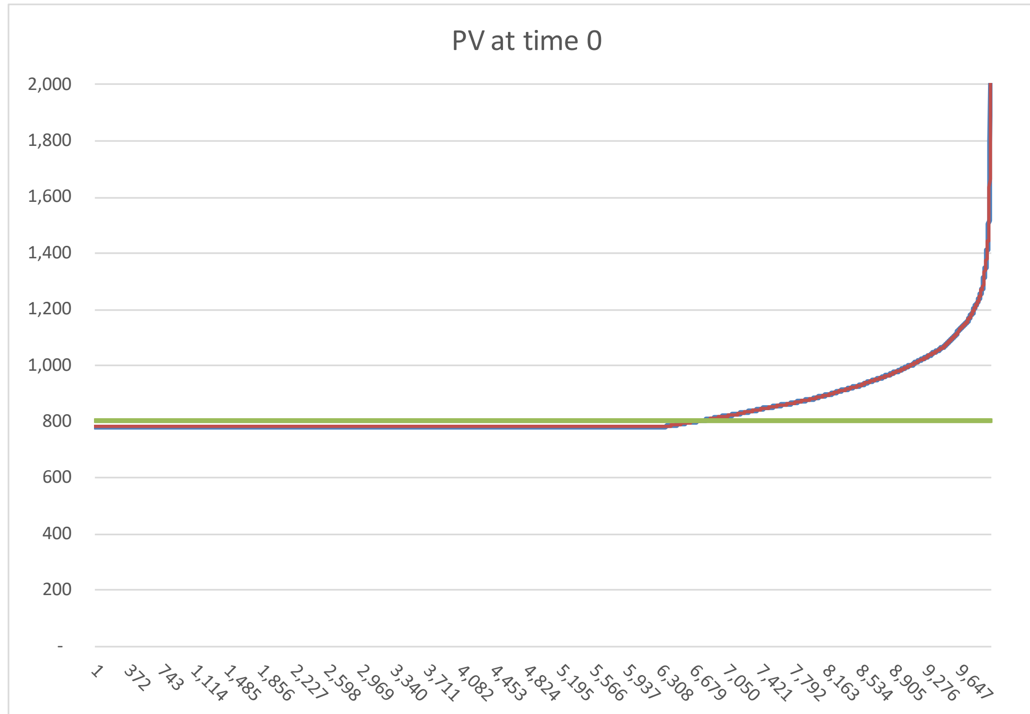
	Variable Annuity with 5% Hurdle and $975 floor	Variable Annuity with 5% Hurdle and $975 floor	Variable Annuity with 5% Hurdle and $975 floor
Mean Benefit	1,151	1,151	975
Standard Deviation	226	226	-
Increase Relative to first scenario		0.0%	-15.3%
Percentiles			
5%	975	975	975
25%	975	975	975
50%	1,062	1,062	975
75%	1,258	1,258	975
95%	1,613	1,613	975
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Matching Bond



The present value chart shows that the bond investment eliminates the volatility in present value. The resulting value is slightly higher across the majority of scenarios, but lower, on average, than the mixed portfolio because it avoids the most costly outcomes.

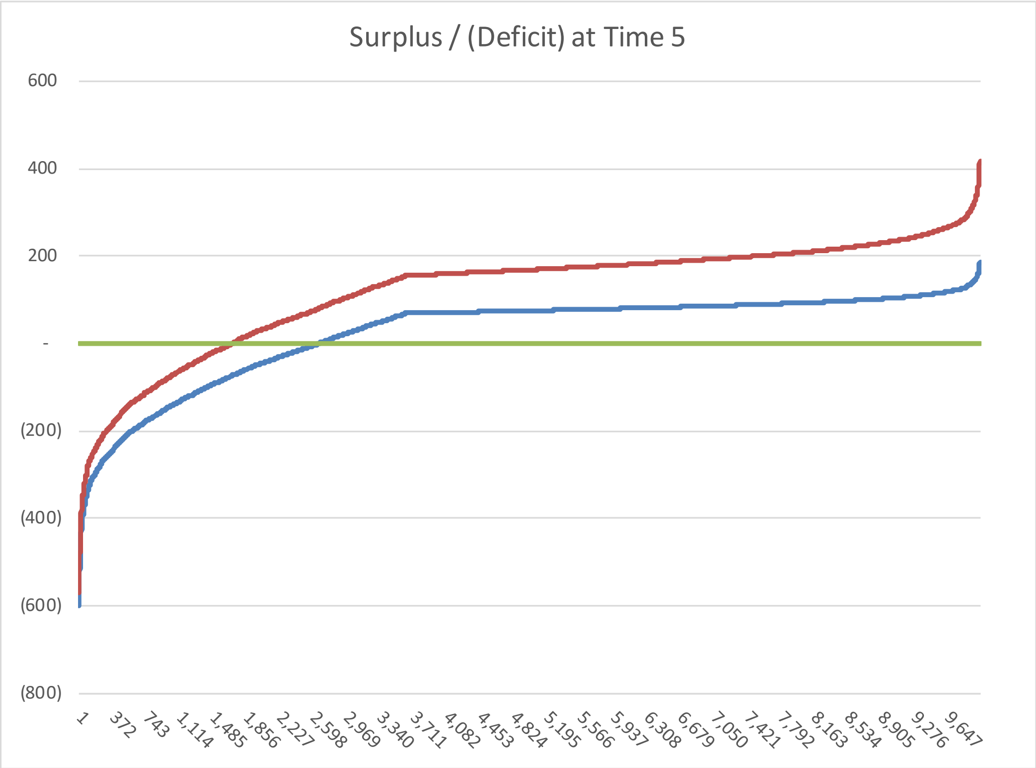
Appendix A—A potential framework for evaluating difficult-to-value designs

	Variable Annuity with 5% Hurdle and $975 floor	Variable Annuity with 5% Hurdle and $975 floor	Variable Annuity with 5% Hurdle and $975 floor
Mean PV	839	839	801
Standard Deviation	111	111	0
Increase Relative to first scenario		0.0%	-4.5%
Percentiles			
5%	784	784	801
25%	784	784	801
50%	784	784	801
75%	849	849	801
95%	1,074	1,074	801
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Matching Bond



The analysis of present value and projected surplus show that the financial risk can be managed through matching bond investments, which is similar to the result for the traditional plan. For this reason, it might be reasonable to value this plan as a traditional fixed benefit but with a load for the additional cost of the variable feature. The contribution for the mixed portfolio is based on the $822 cost for the traditional fixed benefit, loaded for the 10.5% additional cost of the variable feature, resulting in a contribution of $908. Interestingly, the matching bond investment strategy is also the least expensive strategy from an expected value perspective, in addition to having the lowest risk.

	Variable Annuity with 5% Hurdle and $975 floor	Variable Annuity with 5% Hurdle and $975 floor	Variable Annuity with 5% Hurdle and $975 floor
Contribution	839	908	801
Mean Surplus	26	123	0
Standard Deviation	108	128	0
Percentiles			
5%	(213)	(151)	-
25%	(12)	68	-
50%	75	169	-
75%	89	200	-
95%	114	256	-
Investment Strategy	Mixed Portfolio	Mixed Portfolio	Matching Bond
Contribution Basis	Median Geo Return	Bond-based discount rate	Bond-based discount rate



Potential application to actual plans

Clearly the analysis illustrated by these examples is highly simplified. However, some of these techniques may be applied to actual pension plans. While it is likely impractical to produce a distribution of benefits for a real plan with many different participants and a wide range of benefit commencement ages, the other approaches can be applied to more complex systems. In particular, stochastic projection systems can be adapted to produce a present value for a given liability measure for pension plan across all scenarios, similar to the approach illustrated above. As shown above, this approach can be used to estimate the relative cost of a more complicated plan design to a more standard analog, thereby developing a load that can be applied to a more traditional valuation measure. In addition, comparing the distribution of present value or surplus results from a plan with a difficult-to-value feature to similar results for more standard fixed benefit or variable annuity designs can reveal characteristics that might not otherwise be obvious, and can thereby assist the actuary in developing an appropriate valuation technique.

Appendix B: Extending valuation paradigms to include difficult-to-value benefits

Framework

A general framework for the liability assigned to benefits to be paid at time t can be written as follows:

$L_t = \sum_{A_t} p(A_t)\, B(A_t) v(A_t) u(A_t)$, where

A_t represents a possible state of the world at time t

$p(A_t)$ is the (real-world) probability of realizing state A at time t

$B(A_t)$ is the benefit to be paid at time t if state A is realized

$v(A_t)$ is the discount factor applied for deferral to time t if state A is realized

$u(A_t)$ represents a market preference or utility factor for payment in state A_t

This basic framework can represent three different valuation approaches used for pension plans

- **Discounting with expected returns**

  $v(A_t)$ = discount factor based on portfolio return from valuation date to t when state A is realized. This is uniquely defined by the portfolio value at time t and the cash flows between the valuation date and time t. Different interpretations could use geometric or arithmetic over time, but that is outside the scope of this paper.

  $u(A_t)$ = 1

- **Discounting using market interest rates**

  $v(A_t)$ = $v(t)$ = discount factor calculated with the spot rate observed for maturity t on the valuation date

  $u(A_t)$ = 1

- **Market-consistent valuation**

  $p(A_t)$, $v(A_t)$ and $u(A_t)$ are not individually observable or clearly defined, but their product represents an Arrow-Debreu state price. Market-consistent valuations are often performed using a risk-neutral valuation technique. This involves making the following substitutions, which preserve the state price and eliminate market preferences from subsequent calculations.

  $v^*(A_t)$ = discount factor calculated with the spot rate for maturity t for a risk-free bond on the valuation date

  $u^*(A_t)$ = 1

Appendix B: Extending valuation paradigms to include difficult-to-value benefits

$p^*(A_t)$ is the risk-neutral probability of realizing state A at time t. These probabilities are calibrated such that the resulting Arrow-Debreu state prices reconcile with observed security prices.

For the time being, at least, other sections of this document set market-consistent valuation aside and address only the traditional actuarial approaches.

Common simplifications

Typical pension valuations, which are usually of one of the first two types, conventionally make certain simplifications.

- Economic outcomes are represented by a single scenario
- Demographic experience is assumed to be independent of economic experience

If each state of the world A_t is represented as a combination of demographic circumstances D and economic circumstances E, the following expressions result:

$$L_t = \sum_{A_t^{D,E}} p(A_t^{D,E})\, B(A_t^{D,E})\, v(A_t^{D,E})\, u(A_t^{D,E})$$

Incorporating these two simplifications results in this expression for the expected return paradigm:

$$L_t = v(A_t^{\bar{E}}) \sum_{A_t^D} p(A_t^D)\, B(A_t^{D,\bar{E}})$$

And this similar expression for the market interest rate paradigm, which differs only in that the discount factor reflects observed interest rates:

$$L_t = v(t) \sum_{A_t^D} p(A_t^D)\, B(A_t^{D,\bar{E}})$$

These match the fundamental equations currently used in traditional valuation work.

Approaches to consider

The equations before reflecting these simplifications could in theory be applied in valuation work. This would require a structural change to the way in which many valuation systems work.

1. Tables representing decrement probabilities are developed
2. Assumptions corresponding to $A_t^{\bar{E}}$, expected economic outcomes, are developed
3. The valuation system cycles through time and through each participant to develop $A_t^{D,\bar{E}}$, $p(A_t^D)$, and $B(A_t^{D,\bar{E}})$
4. The liabilities attributed to each participant and each future payment date are determined and summed

Appendix B: Extending valuation paradigms to include difficult-to-value benefits

If it is deemed inappropriate to assume independence of economic outcomes and demographic outcomes, partial generalization of this approach could be considered. (This would not allow rigorously reflecting selection bias). In this case, Step 1 could be maintained without modification. Instead of representing all $A_t^{D,E}$ by a single $\underline{A_t^{D,E}}$, the universe of all possible economic outcomes could be represented by finite number of discrete scenarios $\underline{A_t^{D,E_j}}$ where j = 1…n. The expression becomes

$$L_t = \sum_{j=1}^{n} p(A_t^{E_j}) v(A_t^{E_j}) \sum_{A_t^D} p(A_t^D)\, B(A_t^{D,E})$$

The number of economic scenarios considered could be many hundreds or thousands if the valuation were performed within a stochastic structure. It could also be considerably smaller. As the number increases, the result would converge to a limit. A judiciously selected smaller number of scenarios would speed this convergence. This selection of scenarios would itself present interesting challenges, and this would interact with the optionality present in the plan design.

Perhaps even a single economic scenario that would replace the current best-estimate scenario. This would essentially be probability- and benefit-weighted. This would alleviate the need to retool valuation systems.

If the independence of demographic and economic outcomes is not assumed, then $\underline{p(A_t^{E_j})}$ and $p(A_t^D)$ could not be developed separately. Rates of decrement, for example, could vary by economic scenario. This greater generality would require additional modifications to the structure of typical valuation systems.

Other observations

A market-consistent value may not be uniquely defined unless the variability is a transfer of risk from the sponsor to the beneficiary. Otherwise, the values from those perspectives will differ, and a consensus market price would be bounded but not clearly defined.