# Actuarial Valuation of DC Plans: An Introduction

Dimitry Mindlin, ASA, MAAA, Ph.D.
President
*CDI Advisors LLC*
dmindlin@cdiadvisors.com

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*ABSTRACT*

*As defined contribution plans become the dominant source of retirement income, plan participants should benefit from a systematic actuarial approach to measuring the outcomes of defined contribution plans.*

Defined contribution (DC) plans are rapidly becoming one of the primary sources of income in retirement. What started as a relatively minor supplement to defined benefit (DB) plans and the Social Security system has now become a major sector of the retirement industry. Given that participation in DB plans is decreasing and the ability of the Social Security system to provide adequate retirement income is in question, DC plans are expected to play an increasingly important role in providing retirement income to their participants.

Yet several key areas of DC plan management are still in the early stages of their development. In particular, the evaluation of DC plan outcomes and the design of optimal policy portfolios require major improvements to existing practices. These areas should attract a lot of attention in the near future.

Most plan participants and sponsors don't have good understanding of the retirement income funded by their DC plans. Reliable and consistent information about expected DC plan outcomes would allow plan participants and sponsors to make informed decisions regarding plan design, contribution rates, asset allocation, and other aspects of their retirement programs. It would also provide early warnings to plan participants when their expected outcomes fall short of their expected needs in retirement.

DB plans provide a good example in this context. For decades, actuaries have performed regular valuations of DB plans that assess the financial health of these plans and calculated contributions to fund their benefits. The DB plan valuation methodology is transparent: a number of textbooks and other publications present a detailed description of the methodology and actuarial standards of practice guide the practitioners who perform the valuations. While DB plan valuations are far from perfect, the advantages of regular valuations that utilize a well-known clearly enunciated methodology are broadly recognized.

I'd like introduce the concept of a DC plan valuation methodology that's similar to a DB plan valuation in many respects (and dissimilar in some others). It would be a first step toward a robust and transparent valuation model, incorporating innovations in retirement income products, asset allocation, and plan design, that DC plan participants need.

**Measuring DC Plan Outcomes**

There's no shortage of advice in the area of measuring DC plan outcomes (e.g., sustainable spending, replacement ratios, retirement account values). Numerous reports and marketing materials present recommendations for DC plan participants and sponsors. The websites of major financial institutions offer retirement "calculators" that estimate DC plan outcomes. Overall, information in this area is readily available.

For the most part, however, this information is inadequate for prudent retirement plan management. The biggest problem for the vast majority of retirement calculators is that they ignore risk. These calculators are deterministic by design and utilize riskless "expected" economic variables (e.g., investment returns and inflation) and generate riskless "expected" outcome estimates.

Deterministic calculators essentially ignore the fact that expected returns come with substantial risks. After all, DC plan participants generally endeavor to fund their retirements via investing in risky assets. Yet deterministic calculators pay no attention to the volatilities of DC plan outcomes and conceal their upside and downside. In particular, aggressive investments that have high expected returns appear much more attractive than their conservative counterparts.

Some calculators do take into account the risks of retirement investing (we call them retirement risk calculators). The goal of retirement risk calculators is to provide stochastic valuations of DC plan outcomes. Normally, the closed-form distributions of DC plan outcomes aren't available, so we have to estimate them. A relatively straightforward way to generate such estimates is to use Monte-Carlo simulations. But simulation-based models possess major flaws.

In particular, simulation-based models depend on a particular software platform and sample size, require an extensive computational infrastructure to perform a multitude of calculations that ensure statistically credible results, and don't provide theoretical insights into the relationships between the key components of the retirement funding problem. Moreover, simulation-based models don't work well for valuations—different calculators may generate different valuations even if they use the same assumptions.

In recent years, there have been substantial advances in the development of simulation-free retirement risk calculators. These calculators generate reliable estimates of the distributions of DC plan outcomes without performing Monte-Carlo simulations. Given basic participant data (e.g., age, retirement age, salary, saving rate, retirement account balance), these calculators seamlessly connect the accumulation and decumulation phases of the life-cycle and generate reliable estimates of the distributions of DC plan outcomes.

Simulation-free calculators are fast, don't require an extensive computational infrastructure, and provide theoretical insights into the distributions of DC plan outcomes. It should be emphasized that, unlike simulation-based calculators, simulation-free calculators generate the same valuations as long as the same assumptions are used. Overall, simulation-free calculators have become an attractive alternative to simulation-based calculators and should provide a solid foundation for the valuations of DC plan outcomes.

**DC Plan Valuations vs. DB Plan Valuations**

In a typical DB plan valuation, the plan's benefits are given and a key result of the valuation is the contribution required to fund the benefits. For a DC plan valuation, the situation is just the reverse: the contribution rate is given and the challenge is to estimate plan benefits. In this context, a DC plan valuation is a mirror image of a DB plan valuation.

The purpose of a DC plan valuation is to estimate the sustainable retirement income funded by the plan. This income can be measured in real or nominal terms; alternatively, this income can be measured as a percentage of the current income or the last pre-retirement income (a.k.a. the replacement ratio). The value of the retirement account also can be a useful measure of the accumulation phase of the lifecycle.

All these measurements are uncertain due to the presence of risky assets in the funding process. They therefore should be valued as random variables. In contrast, the conventional figures presented in DB plan valuations—liabilities, normal costs, present values of future benefits—are inherently deterministic. On the surface, there appears to be a fundamental dissimilarity between DC and DB valuations.

Beneath the surface, however, this dissimilarity is rather superficial. One of the key factors that make DC and DB plans fundamentally similar is the fact that the vast majority of DB plans and DC plan participants seek to fund their relatively predictable financial commitments by investing in risky assets. By definition, risky assets introduce uncertainties into the funding problem. In the presence of risky assets, a given commitment (a DB plan's benefit stream, for instance) implies uncertainty of the funding cost. A given cost (a DC plan participant's saving rate, for instance) implies uncertainty of commitment (the participant's standard of living in retirement).

Yet conventional DB plan valuations contain only deterministic estimates of the funding cost, even though the funding cost in reality is inherently uncertain. In a 2009 paper I wrote on the case for stochastic present values, I offered the following explanation for this common practice:

> "*This assumption was adopted decades ago when risk management and risk models were in their infancy and computing power was prohibitively expensive and inaccessible to most practitioners. It was unreasonable to inquire about the volatilities of discount rates and corresponding present values in the era when actuarial clerks had to look up the required commutation functions in thick manuals*

> *by hand. Computational convenience was the primary reason for the acceptance of the assumption that discount rates and present values must be deterministic*."[1]

This computational convenience is no longer a major factor. Still, the tradition of deterministic DB plan valuation results endures because a conventional actuarial report is largely a compliance document that's not designed for the analysis of numerous risks that DB plans face. This tradition is an artifact of a bygone era.

The dissimilarity between the stochastic nature of DC plan valuations and the deterministic nature of DB plan valuations, in fact, is due to a deficiency of conventional DB plan valuations. The reality is that DC and DB plan valuations seek to solve the same underlying economic problem. And the results of these valuations should be conceptually similar.

To illustrate this point, think of a DC plan participant that is currently contributing 10 percent of his or her income to a DC plan. The goal is to estimate the distribution of the participant's sustainable retirement income. For any level of retirement income, a DC plan valuation presents the probability of funding this level. In particular, the valuation presents the level of retirement income that has a 50 percent probability of funding.

Now think of a DB plan valuation report that shows the required contribution rate is 10 percent of payroll. Let's assume that the plan's actuary has gone above and beyond the call of duty and, given this contribution rate, has determined that the probability of funding is 50 percent. These results for the DC and DB plans are conceptually similar: given a 10 percent contribution rate, they estimate the median benefit of their respective plans. We have two very similar valuations even though the goals of these valuations are mirror images of each other.

Overall, DB and DC plan valuations look at similar funding problems from different but closely related perspectives:

- *DC plan valuation*: given contributions, estimate commitment;
- *DB plan valuation*: given commitment, estimate contributions.

**Required Assumptions and Data**

The data and data preparation procedures required for a DC plan valuation are similar to their counterparts required for a DB plan valuation. For a DC plan participant, this data includes the

[1] For more details, see Mindlin, D., [2009]. The Case for Stochastic Present Values, *CDI Advisors Research*, CDI Advisors LLC, 2009, at http://www.cdiadvisors.com/papers/CDITheCaseforStochasticPV.pdf.

age, current account value, salary, saving (contribution) rate. Retirement industry practitioners should be familiar with these data requirements.

The demographic assumptions for a DC plan valuation are generally the same as required for a DB plan valuation. Most of the conventional demographic assumptions—the rates of retirement, mortality, turnover, disability, etc.—are required to perform a DC plan valuation. Again, retirement industry practitioners (particularly DB plan valuation actuaries) should be familiar with these assumptions.

The situation with the economic assumptions for a DC plan valuation appears to be somewhat different. Since the results of a DC plan valuation are stochastic, this valuation requires stochastic economic assumptions that include the means, standard deviations, and correlations between several economic variables (e.g., asset class returns, interest rates, inflation). In contrast, a conventional DB plan valuation uses only deterministic expected values of these variables.

But this apparent difference is strikingly deceptive. Most DB plans do use stochastic economic assumptions for the purposes of optimal portfolio selection, financial projections, and others. They just use these assumptions outside of the conventional actuarial reports. In particular, investment consultants that serve DB plans routinely develop and utilize stochastic economic assumptions for their work.

As a result, a DC plan valuation requires no conceptually novel methodology, but can use the well-established methodology that, for decades, has been in the mainstream of the theory and practice of finance in general and DB plan management in particular. The fact that a DC plan valuation requires more comprehensive economic assumptions doesn't make these assumptions hard to incorporate. The fact that a conventional DB plan valuation uses an overly simplistic and outdated economic model shouldn't become an impediment to the adoption of more comprehensive economic assumptions.

Consider the individual economic assumptions required for a DC plan valuation and their counterparts in a DB plan valuation. The assumption for portfolio returns is arguably the most important economic assumption. A DC plan valuation uses the full range of portfolio returns and their relationships with other economic variables. In contrast, a conventional corporate DB plan valuation essentially ignores portfolio returns. A conventional public DB plan valuation normally uses a single deterministic measurement of portfolio returns (for example, the geometric expected return) that can't encompass the full spectrum of portfolio returns. Clearly, a model that incorporates the full range of portfolio returns is more realistic than a model that doesn't.

In a similar way, a DC plan valuation uses the full range of consumer price index (CPI) and salary growth as well as their relationships with portfolio returns. Conventional DB plan valuations instead incorporate deterministic expected values for CPI and salary growth. Again, a model that incorporates the full range of inflation and the hedging properties of the policy portfolio is more realistic and useful than a model that doesn't.

A portfolio rebalancing assumption is another important economic assumption for both DB and DC plan valuations. While often hidden for DB plans, this assumption is nonetheless there. Those DB plans that use a single discount rate (based on portfolio returns or otherwise) make an implicit assumption that their portfolios are regularly rebalanced to the same portfolio. A DC plan valuation, on the other hand, would use an evolving policy portfolio, also known as a glide path.

It's broadly recognized that the portfolios of DC plan participants should evolve as these participants get older. In particular, many believe that younger plan participants should have more aggressive portfolios than their older counterparts. As a result, a DC plan valuation should assume evolving policy portfolios, while a conventional DB plan valuation, in contrast, traditionally assumes stationary policy portfolios.

Yet, just like people, DB plans mature. Over time, the population of a conventional DB plan gets older, the proportion of active plan participants decreases, and the plan increasingly relies on investment returns rather than contributions. The plan's policy portfolio should reflect these trends and evolve with the plan. Therefore, DB plans should assume evolving policy portfolios just as DC plan participants do.

Overall, there are clearly substantial differences between the economic assumptions required for DB and DC plan valuations. All these differences, however, reflect the outdated features of the conventional DB plan valuation model. The era of inaccessible computing power is over. Both DB and DC plan valuations should employ comprehensive economic models.

**The Outcome Valuation**

The goal of any valuation is to produce measurements of the object of the valuation. A measurement is simply a number assigned to an object. Virtually any object allows multiple measurements, and the selection of the right measurements critically depends on the objective of the valuation. This selection is one of the most important steps in designing a useful valuation.

The objective of a DC plan valuation is to measure the sustainable retirement income funded by the plan. There are several measurements that can be useful in evaluating this income. Each has

its pros and cons, so a comprehensive DC plan valuation should present more than one measurement.

One the most popular approaches in measuring the sustainable retirement income is to express it as a percentage of the last pre-retirement income (or, the replacement ratio). The concept of replacement ratio provides an effective connection between the accumulation and decumulation phases of a DC plan participant's life cycle. It also represents a sensible estimate of the standard of living in retirement. There are regularly updated studies out there that present replacement ratio targets for various segments of the population.

Another useful measurement is the retirement income in real terms. This measurement is easy to understand and communicate because of its close relationship to today's standard of living. It also can be expressed as a percentage of current income.

Yet another useful measurement of the accumulation phase is the value of the plan assets at retirement. This measurement arguably is the easiest for grasping the magnitude of retirement savings. But it can be somewhat misleading: A seemingly substantial amount of assets at retirement may provide a relatively modest sustainable lifetime income in retirement.

The next step is to determine the proper segmentation of plan participants, grouping them according to certain criteria for the purposes of valuation. Obviously, the simplest segmentation is to put all plan participants in one group and use average age, account value, and savings rates to evaluate the plan's outcomes. On another extreme, a valuation can be performed for each plan participant individually.

The right segmentation should be something in between. There are several ways to group plan participants including, but not limited to, age, service, occupation, account balance, saving rates, various combinations thereof, and other factors. The optimal segmentation should depend on the plan's specific conditions.

Assuming that a proper segmentation has been determined, let's look at the valuation results for a group of plan participants. The demographics data for the group is presented in Table 1.

**Table 1**

| Demographic Data | |
|---|---|
| Age | 37 |
| Retirement Age | 67 |
| Years in Retirement | 25 |
| Salary ($000) | 50.0 |
| Assets ($000) | 25.0 |

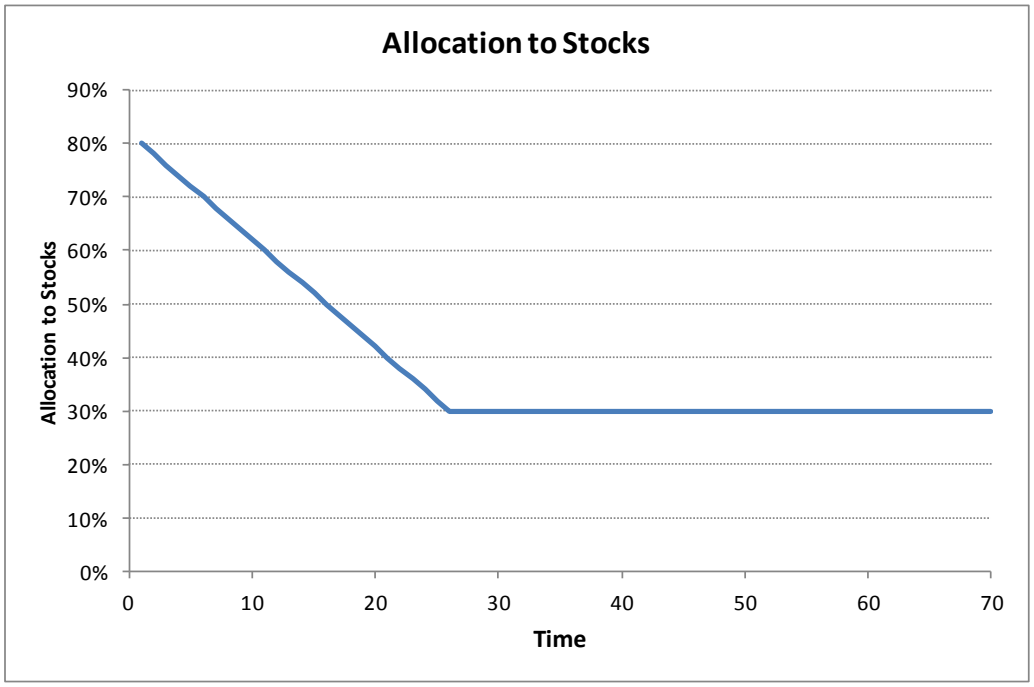
On the "asset" side, let us assume for simplicity that the plan offers two investment options: stocks and bonds. The economic assumptions are summarized in *Table 2*.

**Table 2**

| Capital Market Assumptions | | | |
|---|---|---|---|
| *Mean/St Dev* | | | |
| | Geometric Mean | St Dev | Arithmetic Mean |
| Stocks | 7.00% | 16.00% | 8.16% |
| Bonds | 4.00% | 5.00% | 4.12% |
| Salary Growth | 4.00% | 1.00% | 4.005% |
| CPI | 3.00% | 1.00% | 3.005% |
| *Correlations* | | | |
| | Bonds | Salary Growth | CPI |
| Stocks | 0.2 | 0.0 | 0.0 |
| Bonds | 1 | -0.3 | -0.3 |
| Salary Growth | | 1 | 0.7 |
| CPI | | | 1 |

Also, let us assume that the group will use a simplified glide path that has the starting allocation to stocks of 80%, decreases this allocation linearly to 30% in 30 years, and keeps it at 30% for the rest of the group's lifetime (see *Figure 1*).

**Figure 1**




The results of the valuation for the saving rate of 9% are presented in *Table 3*.

**Table 3**

| Valuation Results<br>*Saving Rate 9%* | | | | |
|---|---|---|---|---|
| | Replacement Ratio | Sustainable Spending Real ($000) | Assets at Retirement Nominal ($000) | Assets at Retirement Real ($000) |
| Mean | 24.1% | 16.1 | 751 | 310 |
| St Dev | 9.0% | 6.0 | 235 | 99 |
| | | | | |
| 5th %tile | 12.5% | 8.3 | 433 | 176 |
| 25th %tile | 17.7% | 11.8 | 583 | 239 |
| 50th %tile | 22.6% | 15.1 | 716 | 295 |
| 75th %tile | 28.9% | 19.3 | 881 | 364 |
| 95th %tile | 40.9% | 27.4 | 1,185 | 494 |

As we see, the median replacement ratio is 22.6%, and the replacement ratio may be as low as 12.5% under unfavorable market conditions. The median asset value at retirement (real) is $295,000, and the asset value may be as low as $176,000 under unfavorable market conditions.

But the real value of an outcome valuation methodology transpires when there is a need for additional valuations that utilize alternative assumptions. Let us assume, for example, that it is desirable to increase the median replacement ratio. Then it would be informative to evaluate the impact of the contribution increase of 1% bringing it up to 10%. The results of the valuation for the saving rate of 10% are summarized in *Table 4*.

**Table 4**

| Valuation Results<br>*Saving Rate 10%* | | | | |
|---|---|---|---|---|
| | Replacement Ratio | Sustainable Spending Real ($000) | Assets at Retirement Nominal ($000) | Assets at Retirement Real ($000) |
| Mean | 26.3% | 17.5 | 816 | 337 |
| St Dev | 9.7% | 6.5 | 253 | 107 |
| | | | | |
| 5th %tile | 13.7% | 9.1 | 474 | 193 |
| 25th %tile | 19.4% | 12.9 | 636 | 261 |
| 50th %tile | 24.6% | 16.5 | 780 | 321 |
| 75th %tile | 31.3% | 21.0 | 956 | 396 |
| 95th %tile | 44.3% | 29.7 | 1,283 | 534 |

The median replacement ratio is 24.6% now. The next step may be to inquire about the required saving rate to get the median replacement ratio over 30%. As shown in *Table 5*, this saving rate is 13%.

**Table 5**

| Valuation Results<br>*Saving Rate 13%* | | | | |
|---|---|---|---|---|
| | Replacement Ratio | Sustainable Spending Real ($000) | Assets at Retirement Nominal ($000) | Assets at Retirement Real ($000) |
| Mean | 32.6% | 21.8 | 1,013 | 418 |
| St Dev | 11.8% | 7.9 | 305 | 129 |
| | | | | |
| 5th %tile | 17.2% | 11.5 | 598 | 244 |
| 25th %tile | 24.2% | 16.2 | 796 | 326 |
| 50th %tile | 30.7% | 20.5 | 970 | 400 |
| 75th %tile | 38.8% | 25.9 | 1,184 | 490 |
| 95th %tile | 54.5% | 36.5 | 1,575 | 656 |

There may be other aspects of this funding problem that require additional valuations. It would be informative, for example, to evaluate alternative glide paths and/or additional investment alternatives and retirement income products. These issues, however, are outside the scope of this article.

**Providing a Valuable Service**

The challenge of evaluating the sufficiency of retirement savings and income is as important as it is long-standing. It's well-known that many people don't save enough to retire comfortably. Anything that facilitates better saving and investment programs is valuable. In particular, reliable information provided by an unbiased source would be helpful to DC plan participants and sponsors. If this information properly reflects the realities of retirement investing—the presence of risky assets and uncertain outcomes, for instance—it becomes essential.

The importance of such an evaluation is rapidly increasing in light of the growing realization that DC plans should transition from a conventional portfolio-centric approach to more broadly defined outcome management. Various aspects of retirement programs should be evaluated based on their impact on the program's ultimate objective—to provide sustainable retirement income. Reliable measurements of retirement outcomes should be an integral component of any DC plan management.

I'd like to encourage actuaries and other practitioners in the retirement industry to further explore this opportunity to provide a valuable and much-needed service to DC plan participants and sponsors.

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