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Managing Uncertainty: The Search for a Golden Discount-Rate Rule for Defined-Benefit Pensions

Pension fund sponsors use a discount rate to determine the value of assets they must set aside today to pay for promised benefits in the future. If the rate is too high, the assets are too meagre, and vice versa. Is there an optimum discount-rate rule that strikes the right balance?

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The Study In Brief

This *Commentary* examines how the choice of a pension plan discount rate affects the tradeoff between the risk of holding insufficient assets to pay promised benefits and the cost of acquiring more assets.

The choice of discount rate can have a dramatic effect on the value of a plan's liabilities and, therefore, the assets needed to meet plan obligations.

When assessing the performance of different discount rate rules, it is crucial to recognize the unpredictable nature of pension plan assets and obligations. In a fantasy world of no uncertainty and where the discount rate is equal to the rate of return on pension plan assets, the value of a fully funded plan's projected liabilities equals the value of actual future plan benefit payments. Such a plan will, as a result, be able to pay the pension benefits promised and have no excess assets.

However, in a realistic world of uncertainty, the expected pension payouts, projected at the time when contributions are made, may differ significantly from actual future pension payments due to, for example, unanticipated inflation when pension benefits are indexed. Furthermore, asset returns are unpredictable and often volatile, so yields on plan assets may differ greatly from expected returns. As a consequence, the assets accumulated by the plan can differ markedly from the assets required to meet actual future payments.

A key innovation of our analysis is that, through the use of simulation methods, we observe the performance of a wide range of discount rates under equivalent movements in plan obligations and asset returns. We analyze six discount rate types, or rules, and assess each rule's success in meeting the competing objectives of minimizing the accumulation of excess assets and ensuring a high probability that future benefit obligations are met. The choice of a discount-rate rule depends on the relative importance attached to these two factors. If approximately equal weight is given to achieving these two objectives, the best performing rules are a 10-year moving average of the high-quality corporate bond yield and an inflation forecast supplemented by a constant real interest rate. Both of these rules yield average discount rates below the expected rate of return on assets, but higher than the riskless rate of interest.

Our results indicate there is considerable risk associated with choosing a relatively high pension plan discount rate, such as the expected return on plan assets. However, many pension plan sponsors in Canada prefer this rate, which they argue keeps their pension plans affordable. Current employers and employees have an incentive to keep the discount rate high in order to reduce current contributions, but a higher rate increases the probability that the plan will have insufficient assets to meet obligations. This suggests there is a need for prudent regulation of pension plan discount rates. Public-sector pension plans receive little guidance on the choice of discount rate and, in practice, many such plans use a rate higher than our best performing rules.

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A pension plan provides its members with promised future benefit payments.

The discount rate, an interest rate used to calculate the present value of these projected future benefits, is a key input in the determination of contributions and assets required to cover pension obligations.[1] Using a lower discount rate increases the projected pension liability, so a larger stock of assets is needed to meet expected payments. Because pension plan investment returns and future payouts are uncertain, accumulating a greater stock of assets raises the likelihood that the plan will have sufficient assets to meet its obligations. On the other hand, additional asset accumulation requires increased pension plan contributions from employees and/or employers.

This *Commentary* examines how the choice of a pension plan discount rate affects the tradeoff between the risk of holding insufficient assets to pay promised benefits and the cost of acquiring more assets. Historically low interest rates have motivated reviews in many countries of pension plan discount rates, including by the Canadian Public Sector Accounting Board (PSAB 2017b), the US Governmental Accounting Standards Board (Munnell et al.) and European regulators (PEW 2017, Bank of England 2016).

When assessing the performance of different discount rate rules, it is crucial to recognize the stochastic, or unpredictable, nature of pension plan assets and obligations. In a fantasy world of no uncertainty and where the discount rate is equal to the rate of return on pension plan assets, the value of a fully funded plan's projected liabilities equals the value of actual future plan benefit payments.[2] Such a plan will, as a result, be able to pay the pension benefits promised and have no excess assets.

However, in a realistic world of uncertainty, the expected pension payouts, projected at the time when contributions are made, may differ significantly from actual future pension payments due to, for example, unanticipated inflation when pension benefits are indexed. Furthermore, asset returns are unpredictable and often volatile, so yields on plan assets may differ greatly from expected returns. As a consequence, the assets accumulated by the plan can differ markedly from the assets required to meet actual future payments.

The choice of discount rate can have a dramatic effect on the value of a plan's liabilities and, therefore, the assets needed to meet plan obligations. For example, Simon Fraser University estimates that its accrued pension benefit obligation increases by 56 percent if the discount rate is set equal to the yield on high-quality debt, rather than to the expected return on plan assets. Use of an even lower discount rate, equal to the yield on risk-free debt, increases the obligation by 86 percent (Guthrie 2018). Echoing this point, Alberta's Local Authorities Pension Plan (LAPP) notes: "The cost of being prudent is expensive. Every time we

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1 Given its role in estimating pension-plan liabilities, the discount rate is relevant both for funding purposes (setting contribution rates) and for accounting purposes. While the choice of discount rate affects the estimate of the assets required to meet future pension payments, it does not alter the actual level of future payments.

2 A pension plan is fully funded at a point in time if the plan's assets equal the present discounted value of forecast benefit payments for service accrued up to that point in time, where the present discounted value is calculated using the plan's discount rate.

decrease the discount rate it drives up the value of pension benefits and increases current service costs. For LAPP, a 1 percent decrease in the discount rate raises Plan liability by about $5.8 billion" (LAPP 2018). Because a lower discount rate raises the present value of pension obligations, plan sponsors have an incentive to use a higher discount rate in order to reduce current contribution costs (Lysyk 2018, Robson 2017, Hamilton 2014).

Although the discount rate plays a key role in estimating pension plan obligations, there is no generally agreed-upon method for choosing such a vital rate. Finance theory asserts that pension obligations should be discounted at a rate that reflects the risk associated with the plan's liabilities, rather than the risk of the plan's assets. Following this reasoning, Hamilton (2014) and Andonov, Bauer and Cremers (2017) recommend using the yield on government bonds since pension benefits are a liability that must be paid, similar to the interest on a low-risk bond.[3] Others propose that the discount rate equal the yield on an annuity that could be purchased if the pension plan closed, a rate that is generally lower than the yield on Treasuries (Actuarial Standards Board 2013).

Discount rates proposed by pension plan sponsors and regulators are typically higher than these recommendations – and sometimes much higher. Many public-sector plans in Canada use the expected return on plan assets, viewing this rate as reflective of future cash flows (Thomas 2018). Similarly, the US National Association of State Retirement Administrators (NASRA) argues that the discount rate should be a reasonable estimate of the long-term rate of return on plan assets, a position it notes is supported by the Governmental Accounting Standards Board (NASRA 2010, 2011).

While Canadian public-sector pension plans are not required to use a particular discount rate to determine the present value of pension liabilities, the International Public Sector Accounting Standards Board (2016, p. 22) recommends a discount rate determined by market yields on government bonds or high-quality corporate bonds. Also, International Accounting Standard 19 stipulates that the discount rate be based on market yields for high-quality corporate bonds (International Financial Reporting Standards Foundation 2015, p. 16).

In contrast to the absence of discount-rate requirements for public-sector pension plans, private-sector accounting standards generally require that the discount rate be selected by reference to market yields of high-quality corporate debt instruments (Canadian Institute of Actuaries 2018, p 5).[4] A similar standard applies to US private-sector, single-employer plans (US Government Accountability Office 2014). High-quality corporate bond yields are usually higher than government bond yields, but lower than the average return on pension plan portfolios.

The Canadian Public Sector Accounting Board (2017a, p. 5) notes that the current low interest-rate environment has meant that the expected

3 Novy-Marx (2015) argues that the appropriate discount rate for a pension fund's liabilities is the expected rate of return on a portfolio of traded assets with cash flows that most closely approximate the fund's expected future benefit payments. This portfolio is sometimes called the optimal "hedge portfolio." Andonov, Bauer and Cremers (2017) claim that the appropriate US rate is the nearly default-free, zero-coupon US Treasury rate because, due to individual state constitutional guarantees of pension obligations, states have a lower probability of defaulting on their pension obligations than municipal governments have of defaulting on municipal bonds. Therefore, the rate should be lower than the municipal bond rate.

4 The Canadian Institute of Actuaries (2018) states that "high quality" in Canada has generally been interpreted as referring to market yields on corporate bonds rated AA or higher, as is the practice in most other countries where similar accounting standards apply. The European Union's Solvency II Directive International Accounting Standard 19 requires a discount rate for a defined-benefit pension scheme that is based on high-quality corporate bond yields for which there is a deep market (Bank of England 2016).

return on plan assets often exceeds the yield on high-quality bonds. As a result, concerns have been raised that, by using the higher expected return on plan assets, public-sector pension plans can report a more favourable financial position than otherwise-comparable private-sector plans. Meanwhile, Robson and Laurin (2018) argue that if a more appropriate discount rate is used to value the obligations of federal public-sector employee pension plans, the government's net public debt would rise by a substantial $96 billion at the end of 2016/17, from $632 billion to $728 billion.[5] Similarly, while US public-sector pension plans acknowledge that their liabilities exceed assets by approximately US$1 trillion, the use of a discount rate equal to the return on Treasury bonds, which is lower than the rate employed by many US public sector plans, causes the shortfall to jump to a staggering US$3 trillion (Gale and Krupkin 2016, Rauh 2017).

To capture the stochastic (uncertain) environment faced by pension plan administrators, we employ Monte Carlo simulation techniques.[6] We assume a plan faces uncertainty with respect to four variables that affect future pension payments and asset returns: inflation, wages, bond yields and equity returns. For different discount rate-setting rules, we use simulation methods to determine the probability that a pension plan that is fully funded will have sufficient assets to meet its actual obligations, as well as the extent to which it accumulates excess or insufficient assets.

A key innovation of our analysis is that, through the use of simulations, it is possible to observe the performance of a wide range of discount rates under equivalent movements in plan obligations and asset returns. We analyze six discount rate types, or rules, and assess each rule's success in meeting the competing objectives of minimizing the accumulation of excess assets and ensuring a high probability that future benefit obligations are met. The rules we analyze include the finance-theory recommended yield on Treasury bonds and the generally much higher expected return on the pension plan's investment portfolio.

A significant result of our analysis is that all the discount-rate rules that generate a high probability of meeting future benefit payments also lead, on average, to the accumulation of significant excess assets. While median excess assets are zero when the discount rate is equal to the expected return on plan assets, there is just a 50 percent probability that the plan will have sufficient assets to meet promised pension payouts. Further, assets fall below 80 percent of obligations in approximately one-third of all cases.

We find, however, that some discount-rate rules perform better than others. With the better-performing rules, the discount rate is not constant – it varies with changes in economic variables such as the Treasury bond yield and the inflation rate. As well, if equal weight is placed on the competing objectives of minimizing the accumulation of excess assets and ensuring a high probability that future benefit obligations will be met, one of the best-performing rules is a proxy for the discount rate recommended by international accounting standards; i.e., the yield on high-quality corporate debt instruments.

5 The impact at the provincial level may also be considerable. For its International Financial Reporting Statement, the Ontario Teachers' Pension Plan applies a 3.25 percent discount rate, a rate based on the market yield of high-quality debt instruments. However, for its financial statements, the province of Ontario, a joint sponsor of the plan, uses a 6 percent discount rate, based on the expected return on plan assets. The difference in discount rates transformed the reported plan deficit under the 3.25 percent discount rate to an $11 billion surplus in Ontario's 2017 financial statement for its 50 percent share of the plan (Lysyk 2018).

6 Landon and Smith (2018) provide more detail on the results reported in this *Commentary*, as well as on the Monte Carlo methodology, the data and findings.

In the next section we describe the methodology, the discount-rate rules, the data and the pension plan we analyze. In Section 3 we present our results, and in Section 4 we discuss the key policy implications.

2. Methodology

This section outlines the methodology we use to assess different discount rate-setting rules. In section 2.1 we present the discount-rate rules and in section 2.2 we describe the characteristics of the pension plan used in the analysis. A critical element of the pension planning process is that it involves uncertainty with respect to liabilities and returns on plan assets, and we discuss the Monte Carlo simulation methods used to capture this uncertainty in Section 2.3. US data are employed in our analysis, but we view our results as applicable to other countries, such as Canada, which have similar bond and equity markets and which experience comparable inflation and wage growth dynamics.

2.1 Discount-rate rules

We examine the following discount rate-setting rules, which were chosen to reflect a wide spectrum of rates and are representative of rules commonly used by pension plans. [7]

A. Variable Discount-Rate rules:

i) *Average pension plan portfolio return*: Rolling 10- and 20-year geometric averages of past returns on the pension fund's asset portfolio are employed as a proxy for the expected plan return. Canadian and US public-sector employee pension plans often use a discount rate equal to the expected return on plan assets.[8]

ii) *Treasury bond yield*: The 10-year US Treasury bond yield is an approximation for the risk-free return. The use of this discount rate is recommended by some financial economists due to the low risk associated with pension liabilities (Novy-Marx 2015, Munnell et al. 2010). We also consider discount rates equal to the five-, 10- and 20-year moving averages of the 10-year Treasury yield to determine whether it is beneficial to remove some of the volatility from yields.[9]

iii) *Corporate bond yield*: The Canadian Institute of Actuaries (2018) notes that the use of a high-quality corporate bond rate is consistent with accounting standards for private-sector employers in Canada. Similarly, US private-sector employers are required to use a discount rate equal to a high-quality corporate bond yield (US Government Accountability Office 2014). We

7 The discount-rate rules we consider include four of the six alternative discount-rate bases identified by the Canadian Public Sector Accounting Board (PSAB) in its November 2017 invitation to comment on discount rate guidance (PSAB 2017b). That document identifies the following approaches: (1) expected return on plan assets; (2) expected return on an effective hedge portfolio; (3) market yield of high-quality debt instruments; (4) market yield of risk-free debt instruments; (5) entity's cost of borrowing; and (6) effective settlement rate. To this list our analysis adds an inflation forecast plus a constant integer rule and constant discount-rate rules. Our rules (i), (ii), (iii) and (iv) correspond roughly to PSAB bases 1, 4, 3 and 6, respectively. We do not consider PSAB Rules 2 or 5. The expected return on an effective hedge portfolio, Rule 2, may be difficult to implement since it requires finding replicating assets to match the plan's obligation risks. The PSAB notes that most standard setters do not use a discount rate equal to an entity's cost of borrowing, Rule 5, since this rate would mean entities could report a decrease in benefit obligations when their credit rating deteriorates. The PSAB (2017b, pp. 9-10) notes that discount rates 1, 3, 4 and 6 are used by other organizations (such as in the UK and US) that set equivalent discount rate standards.

8 According to the US Governmental Accounting Standards Board (GASB), state and local government employers offering defined-benefit pension plans should use a discount rate that is "based on an estimated long-term investment yield for the plan (GASB 1994, p.6)."

9 Although use of a current-period discount rate can generate greater volatility, an argument for its use is that it provides a better indication of current liabilities.

proxy the corporate bond yield with the 10-year US. Treasury yield plus 1.5 percentage points.[10] We also examine five-, 10- and 20-year moving averages of this corporate bond yield proxy.

iv) *Annuity rate*: The Actuarial Standards Board (2013) argues that the discount rate implicit in annuity prices should be used to determine the value of the assets needed today to fund future pension plan liabilities.[11] The 10-year Treasury yield minus one percentage point is employed as a proxy for the annuity rate since annuity rates are generally lower than the yield on Treasuries.[12] We also consider five-, 10- and 20-year moving averages of the annuity rate.

v) *Inflation forecast plus a constant integer*: We consider an inflation forecast plus two, three, four or five percentage points. This follows the practice of some plan sponsors of calculating the discount rate by adding a real return to an inflation forecast.[13]

B. Constant Discount-Rate rules:

Since several countries stipulate that pension plans use a fixed discount rate, we consider constant integer discount rates ranging from 3 percent to 10 percent and the constant average of the 30-year geometric average portfolio return. An advantage of a constant discount rate is that a variable rate may result in volatile movements in the value of pension fund liabilities, even though the underlying benefit cash flows have not changed (Bucciol and Beetsma 2011, Ponds, Severinson and Yermo 2011, p. 24).[14]

2.2 The Pension Plan

The pension plan we employ in the simulations represents a mature standard defined-benefit pension plan where the ratio of retirees to workers does not change. We posit one worker of each age (ie., from 21 to 80) and workers are employed for 40 years and retired for 20 years. In each year, a worker earns a salary, accumulates pensionable service and contributes to the pension plan. Retirees receive a pension based on the number of years they worked, the salary earned in their final year of work and the salary replacement rate. The replacement rate is .015 percent for each year of work, equivalent to 60 percent of final salary for 40 years of work. Pension benefits are indexed 100 percent to inflation. The pension plan invests 65 percent of

10 The basis for this approximation is that 1.5 percentage points is the average difference between the annual 10-year Treasury yield and the annual yield on high-quality corporate bonds over the 20-year period from 1996-2015 using Moody's Yield on Seasoned Corporate Bonds – All Industries, AAA and the constant maturity 10-year Treasury yield, both taken from the Federal Reserve Board H15 database (downloaded 24 February 2017). Using a proxy allows us to simulate one less yield variable, which is particularly useful given the high correlation of yields.

11 This is consistent with the idea that the appropriate discount rate is one that values pension "liabilities at what an unrelated party would want in exchange for accepting them" (Robson and Laurin 2018, p. 2). See also Hamilton (2014).

12 The spread between annuities and Canadian government bonds is given as 110 basis points for the period July-December 2014, although this is the spread with respect to real return bonds (Canadian Institute of Actuaries 2014, p. 4).

13 The Ontario Teachers' Pension Plan determines the discount rate by separately choosing a real rate of return and an inflation forecast (Ontario Teachers' Pension Plan 2012). A similar methodology is suggested by the Office of the Comptroller of the Province of New Brunswick (2018, p. 41) and the accounting firm Deloitte (Lemire 2018). See also Ménard (2013). A real return within 25 basis points of 3 percent has been assumed by the Ontario Teachers' Pension Plan every year since 2011 (Ontario Teachers' Pension Plan 2018).

14 We also considered: constant discount rates equal to 11, 12 and 13 percent; an inflation forecast augmented with one and 6 percentage points; a 30-year geometric average; and 30-year moving averages of some of the other yields. These results are not reported, as none of these additional discount-rate rules altered the main conclusions.

its assets in equities and the balance in bonds.[15] The plan is fully funded, so the contribution rate is adjusted each year to ensure assets equal projected liabilities, given the plan characteristics and the discount rate employed.[16]

To calculate the plan's projected pension liability for accrued service at a point in time, we determine the pension plan's benefits to be paid to current retirees for the remainder of their lifetimes and to current workers (for their accrued service) once they retire. For each current retiree, the projected pension liability depends on their known final salary and years of work, the replacement rate, the pension indexation rate, the inflation rate since the retiree has retired, an inflation forecast up to the retiree's end of life and the discount rate. For each current worker, the projected pension liability depends on a forecast of the worker's final salary, the number of years the worker has been employed, the replacement rate, the pension indexation rate, an inflation forecast for the years the worker will be retired and the discount rate.

The key differences between our retirees and workers are that all retirees have 40 years of service, the final salaries of retirees are known, as are the inflation rates used to index the pensions of retirees up to the current year. Also, workers and retirees of different ages have different final-year salaries, and workers of different ages have different years of accrued service.[17]

2.3 Incorporating Uncertainty

To determine whether the pension plan assets are adequate to cover promised benefit payments, we employ a Monte Carlo analysis that incorporates randomness in variables over which plan administrators face uncertainty. We focus on four such variables – inflation, wage growth, the Treasury bond yield and the equity yield – due to their inherent volatility and because these variables can have a significant impact on plan assets and liabilities.[18]

Our simulation method allows us to calculate the probability that the plan accumulates sufficient assets to meet actual benefit obligations under the different discount rate scenarios.[19] The method involves three steps. First, we estimate a vector

15 We find that the results are robust to alternative specifications that employ a lower replacement rate, a lower indexation rate and a plan that invests 65 percent in bonds and 35 percent in equities. Aubry, Chen and Munnell (2017) find that the 65/35 ratio of equities to bonds in US state pension plans has remained relatively stable. When the portfolio is invested 100 percent in equities, there is a higher average return on the portfolio and more cases where assets exceed obligations. However, it also produces more cases where assets are less than 80 percent of obligations, due to the greater volatility of the 100 percent equity portfolio. For more detail, see Landon and Smith (2018).

16 As our focus is on the discount rate, we need to apply a common funding ratio to make the different discount rates comparable. Full funding (a 100 percent funding ratio) provides a neutral comparison point. Some jurisdictions allow or require pension funding ratios to vary from 100 percent. (The Netherlands requires pension plans with a funding ratio under 105 percent to implement a recovery plan and restricts payouts if the ratio is below 130 percent (PEW 2017).) Elder and Wagner (2015) and Munnell (2016) observe that a funding ratio greater than 100 percent can lead to pressure to increase benefits, which would move the funding ratio back toward 100 percent.

17 In our simulations, average annual wage growth is 4.7 percent, while inflation is about one-percentage-point lower. This means the final salary of current workers will be higher, on average, than the final salary of retirees, and that wages will be growing faster than the fully indexed pensions of retirees. (See Table 1, which is discussed in the next subsection.)

18 This implies that the variables that do not change in our analysis include, for example, the number of workers and retirees, years of service and the mortality rate.

19 An alternative type of analysis is to compare the impact of a discount-rate change on pension plan outcomes for an actual pension plan ex-post, as is done for US state and local pension plans by Freeman (2013), Beetsma, Lekniute and Ponds (2014), Elder and Wagner (2015), Boyd and Yin (2016) and Turner et al (2017). However, with this method, the results apply only to the particular pension plan and historical period examined.

Table 1: Data vs. Simulated Values

	Mean (Standard Deviation) of the Data 1954-2016	Values to Which the VAR Estimates Converge[a]	Mean (Standard Deviation) of the Simulated Values[b]
CPI Inflation	.0358 (.0289)	.0370	.0367 (.0279)
Wage Inflation	.0470 (.0204)	.0468	.0465 (.0205)
Yield on 10-yr Treasuries	.0588 (.0276)	.0592	.0589 (.0272)
Return on the S&P 500	.1235 (.1751)	.1171	.1149 (.1641)
Inflation Forecast			.0369 (.0151)
Wage Inflation Forecast			.0467 (.0126)
Portfolio return	.1016(.1169)	.0968	.0983 (.1106)

Notes:
[a] These are the values to which a dynamic VAR simulation converges when all the shocks are set equal to zero.
[b] The means and standard deviations of the simulated values are the means and standard deviations of the 50,000 simulated values for the 100th observation after the beginning of the simulation (to remove any influence of the starting values on the simulation).

Source: Authors' calculations.

autoregressive (VAR) model, using US data from 1956 to 2016 to determine historical patterns in the movements and interactions of the four random variables.[20]

The second step is to use this model's estimates, along with shocks generated by a random number generator, to dynamically simulate 50,000 series for each of the four stochastic variables: Treasury bond yields, equity returns, inflation and wage growth. As shown in Table 1, the estimates produce the desirable result that a dynamic simulation of the VAR, when all shocks are set equal to zero, converges to values that are very close to the means of the data used to estimate the VAR.

The third step is to use the simulated variables from the second step to calculate 50,000 values for the present value of the pension plan's projected liabilities and 50,000 values for the present value of the actual future pension benefit payments. The actual benefit payments are the future payments the plan will make for accrued service up to the current period, discounted by the actual return on the plan's portfolio. The present value of actual future benefits is determined by the characteristics of the defined-benefit plan and the movements in asset returns, wages and inflation. The projected liabilities are the forecasts of future promised pension payments, discounted at the rate set by one of the discount rate-setting rules. Since the pension plan is fully funded, the plan's assets equal this projected liability.

We determine the probability that the fund's assets will be sufficient to cover promised benefits by calculating the proportion of the 50,000 simulations for which accumulated assets are

20 Our vector autoregressive (VAR) model has an equation for each of the four variables, and the explanatory variables in each equation include the lags of all four variables. The advantage of this type of model is that it allows the data to determine the structure of the relationships among the variables.

adequate to meet actual future pension benefits.[21] Effectively, for each simulation, we determine whether the plan has sufficient assets at a point in time to meet promised benefits for service accrued up to that time.[22] Differences between actual inflation and forecast inflation, actual wage growth and forecast wage growth and between the portfolio's actual return and the discount rate will determine how the assets required to meet future pension payments differ from the plan's accumulated assets.[23]

3. Comparison of the Discount-Rate Rules

Using the methodology described above, in this section we assess the different discount rate-setting rules. Section 3.1 presents the metrics for comparison, Section 3.2 gives the simulation results and Section 3.3 uses a loss-function method to rank the rules.

3.1 Metrics for comparison

Using the methodology described in Section 2.3 for each discount rate-setting rule and each of the 50,000 simulations, we compare the assets accumulated by the fully funded pension plan at a point in time to the present value of actual future pension benefit payments for service accrued up to that same point in time. We use the following metrics to compare rules:

i) the median percentage by which accumulated assets exceed the assets required to meet promised pension benefit payments;
ii) the percentage of the 50,000 simulations for which assets are less than promised pension benefit payments;
iii) the percentage of the 50,000 simulations for which assets are less than 80 percent of promised pension benefit payments; and
iv) the percentage of the 50,000 simulations for which assets are greater than 120 percent of promised pension benefit payments.

The first two metrics indicate whether the pension plan accumulates excess or insufficient assets and, if so, by how much. The third and fourth metrics provide an indication of how frequently the pension fund misses the required level of assets by a large amount (more than 20 percent). For all four metrics, the preferred value is zero, since zero values mean the plan is able to meet its future pension obligations but does not collect contributions and accumulate assets in excess of those required.

3.2 Comparison of the Discount-Rate Rules

The Certain Case: To help understand the results under uncertainty, it is useful to first consider our

21 This calculation is similar to that of a "going concern" valuation since the pension plan does not close. However, it differs fundamentally from the standard "going concern" and "solvency" valuations which calculate liabilities based on a discount rate and a forecast of future benefit payments, but do not (and cannot) compare these to the present value of actual future benefit payments.

22 Payments for the plan's obligations accrue for 59 years since only then can one be confident that the workers who have accrued service in the plan have died. For example, a worker with one year of service today will work for 39 more years and then receive a pension for 20 years based on his/her one year of accrued service and salary in the 40th year of work. We assume that current workers receive a pension based on the final salary they would earn if they continued working, not their salary at present because this more accurately reflects the pension promised to workers and, therefore, better reflects the plan's benefit obligations.

23 For a particular simulation example, suppose the inflation rate, bond yields and equity returns are as forecast, but that the wage growth rate is higher than forecast. Due to the higher-than-anticipated wage growth, actual future pension payments are higher than forecast and, as a result, the plan has insufficient assets to meet its obligations. Similarly, if the inflation and wage growth rates are as anticipated, but the portfolio return is lower than the discount rate, the plan will have accumulated insufficient assets to cover accrued benefit obligations.

model with no uncertainty or randomness – that is, when inflation, wage growth and the return on the pension plan's asset portfolio are all constant and known. In this case, if the discount rate equals the return on the portfolio, the plan always has enough assets to meet its promised pension benefit payments and no excess assets are accumulated. If the discount rate is set below the return on assets, as the plan is fully funded, assets will be accumulated in excess of those required to meet future obligations. The greater the deviation between the discount rate and the return on the portfolio, the larger the difference between the assets accumulated and the assets required to meet pension obligations.

Seemingly small deviations between the discount rate and the return on assets can lead to large funding imbalances due to the long time span between the accrual of pensionable service and the payment of pension benefits. For example, the use of an 8 percent discount rate, rather than 9.7 percent (the average annual rate of return on our pension plan's asset portfolio), leads to higher contribution rates and the accumulation of 23 percent more assets than required to meet actual benefit payments.

The Case with Uncertainty: With uncertainty, the liabilities projected by the pension plan at a point in time can differ from actual future pension payments due to differences between forecast and actual future inflation rates, between forecast and actual future wages and between the discount rate and actual future returns on the fund's portfolio. The values of the four metrics for each of the discount-rate rules are presented in Columns 2 to 5 of Table 2.

A discount rate commonly used by public-sector pension plans is the projected return on the plan's portfolio, a rate we proxy with a moving average of past returns. A desirable aspect of this discount rate, which we call the average pension plan portfolio return, is that median excess assets are approximately zero. However, as would be expected, in half the cases the plan accumulates fewer assets than required to cover actual benefit obligations (Table 2.A, Column 3, Rows 1 – 2). This follows because, with the discount rate set equal to the average return, the actual return will be below the average in approximately half the cases. For the probability that the plan will have sufficient assets to cover future obligations to be greater than 50 percent, the discount rate must be set at a level that is less than the average portfolio return rate.

Given that the requirement to pay future pensions is typically a secure obligation, financial economists argue that the yield on a risk-free asset is the appropriate rate to discount future pension liabilities. Our simulations show that use of a discount rate equal to the 10-year Treasury bond yield, or a moving average of this yield, generates a high probability of 90 percent or greater that the pension plan will accumulate sufficient assets to meet future obligations. On the other hand, because Treasury yields tend to be lower than the plan's return on assets, median excess asset accumulation is high with this discount rate, equivalent to more than 50 percent of obligations (Table 2, Columns 2 and 3, Rows 3-6). Similarly, with the even lower discount rate that proxies the annuity rate, the plan has a greater than 95 percent probability of accumulating sufficient assets to meet pension payment obligations, but generates very high median excess assets of over 80 percent of obligations (Table 2, Columns 2 and 3, Rows 11-14).[24]

There are no discount-rate rules for which median excess assets are low, say under 20 percent (Table 2, Column 2), and the percentage of cases

24 Other studies also find that the volatility of pension plan liabilities and asset returns imply that plans require significant assets to have a high probability of meeting obligations. For example, Elder and Wagner (2015) find, using data from Pennsylvania's two largest public pension plans, that the plans would need assets equal to 181 percent of the present value of liabilities to have a 90 percent chance of holding sufficient assets to pay all future liabilities.

Table 2: Simulation Results

Discount Rate Rule	Discount Rate Average (standard deviation)	Median Assets in Excess of Obligations (percentage)	Percentage of Cases Assets < Obligations	Percentage of Cases Assets < 80% of Obligations	Percentage of Cases Assets > 120% of Obligations
	(1)	(2)	(3)	(4)	(5)
A. Variable Discount Rate Rules					
i) Average portfolio return rule					
1. 10-yr geometric average portfolio return	9.25 (3.50)	-0.6	50.5	32.5	35.0
2. 20-yr geometric average portfolio return	9.21 (2.58)	-0.5	50.5	31.0	33.7
ii) 10-year Treasury bond (TB) yield rule					
3. TB yield	5.92 (2.74)	55.1	10.0	2.7	77.2
4. 5-yr MA TB yield	5.92 (2.58)	55.1	8.0	1.8	79.7
5. 10-yr MA TB yield	5.92 (2.41)	54.8	7.3	1.5	80.7
6. 20-yr MA TB yield	5.92 (2.09)	54.4	8.7	2.1	79.2
iii) Corporate bond yield rule					
7. TB yield + 1.5%	7.42 (2.74)	24.7	24.6	8.6	54.8
8. 5-yr MA TB yield + 1.5%	7.42 (2.58)	24.8	22.8	7.1	55.2
9. 10-yr MA TB yield + 1.5%	7.42 (2.41)	24.4	22.3	6.8	55.1
10. 20-yr MA TB yield + 1.5%	7.42 (2.09)	24.1	24.1	8.2	54.7
iv) Annuity rule					
11. TB yield – 1%	4.92 (2.74)	82.4	4.7	1.0	87.8
12. 5-yr MA TB yield – 1%	4.92 (2.58)	82.5	3.1	0.6	90.4
13. 10-yr MA TB yield – 1%	4.92 (2.41)	82.0	2.6	0.4	91.5
14. 20-yr MA TB yield – 1%	4.92 (2.09)	81.6	3.4	0.7	90.2

Notes:
"TB yield" is the yield on 10-year U.S. Treasury bonds.
MA denotes "moving average".
Source: Authors' calculations.

Table 2: Continued

Discount Rate Rule	Discount Rate Average (standard deviation)	Median Assets in Excess of Obligations (percentage)	Percentage of Cases Assets < Obligations	Percentage of Cases Assets < 80% of Obligations	Percentage of Cases Assets > 120% of Obligations
	(1)	(2)	(3)	(4)	(5)
v) Inflation forecast plus a constant integer rule					
15. Inflation forecast + 2%	5.71 (1.53)	59.3	6.2	1.4	83.3
16. Inflation forecast + 3%	6.71 (1.53)	36.9	14.5	4.0	67.6
17. Inflation forecast + 4%	7.71 (1.53)	19.1	27.5	9.3	48.9
18. Inflation forecast + 5%	8.71 (1.53)	4.7	43.5	18.1	31.4
B. Constant Discount Rate Rules					
3%	3 (0)	159.6	1.9	0.6	95.5
4%	4 (0)	114.3	4.3	1.4	90.7
5%	5 (0)	79.8	8.6	3.1	83.0
6%	6 (0)	53.0	15.3	6.2	72.4
7%	7 (0)	32.0	24.5	10.9	59.5
8%	8 (0)	15.2	35.8	17.7	45.5
9%	9 (0)	1.6	48.3	26.6	32.4
10%	10 (0)	-9.4	61.1	36.9	21.3
Average of 30-year geometric average portfolio return	9.2 (0)	-0.8	50.8	28.6	29.9

Notes:
"TB yield" is the yield on 10-year U.S. Treasury bonds.
MA denotes "moving average".
Source: Authors' calculations.

for which assets are less than obligations is small, say under 10 percent (Column 3). Therefore, to have a relatively high likelihood of meeting future pension obligations (a small value in Column 3), a plan must, on average, use a discount rate that leads to large median excess assets. For example, of all the rules, the 20-year moving average of the Treasury bond yield generates the smallest level of median excess assets while ensuring that the plan has at least a 90 percent probability of holding sufficient assets, but this rule still has considerable median excess assets of 54.4 percent. The inflation forecast plus 3 percent rule yields the minimum level of excess assets while maintaining at least an 80 percent probability that assets will be sufficient to cover promised pension payments. However, even in this case median excess assets equal 36.9 percent of pension obligations.

Fewer than half the discount-rate-setting rules we examine have a 90 percent or greater probability of accumulating sufficient assets to meet future benefit obligations (or, equivalently, have less than a 10 percent chance that assets are less than obligations (Table 2, Column 3)). To achieve this 90 percent probability, a rule must generate a discount rate that is below 6 percent when the average return on the portfolio is above 9 percent. Therefore, to achieve a high probability of having sufficient assets to meet future pension obligations, a plan must use a discount rate that is significantly lower than its long-run average portfolio return.

Whether a pension fund's assets meet or exceed benefit obligations is likely to be less of an issue for both pension plan sponsors and beneficiaries if any shortfall or excess is small. A notable feature of the discount-rate-setting rules is that they all yield a large number of cases for which there is either a funding shortfall of more than 20 percent (Table 2, Column 4) or assets exceed obligations by more than 20 percent (Table 2, Column 5). For example, in approximately one-third of the cases, the assets accumulated under the two average return rules are less than 80 percent of obligations. In another one-third, the assets are more than 120 percent of obligations (Rows 1 and 2, Columns 4 and 5). Meanwhile, if the discount rate is derived from any of the Treasury bond yield rules, the corporate bond yield rules or the annuity rules, there is a greater than 50-percent probability that assets exceed 120 percent of obligations.

Furthermore, 16 of the 18 variable discount-rate rules have at least a 60 percent probability that assets will either exceed or fall short of obligations by more than 20 percent (Table 2, Part A). The two rules for which this is not the case – the inflation forecast plus 4 percent and 5 percent rules – have a relatively high percentage of cases for which assets are less than 80 percent of obligations (Table 2, Columns 3 and 4, Rows 17 and 18), which may be of greater concern than large excess assets.

The constant discount-rate rules generally do not perform as well as the rules that vary the discount rate with the yield on Treasury bonds or the inflation rate. For example, the 20-year moving average of the annuity-rate rule has similar median excess assets as the constant 5-percent rule (81.6 percent and 79.8 percent, respectively). However, the percentage of cases for which assets are less than obligations is 2.5 times as large with the constant 5 percent rule. Also, the percentage of cases for which assets are less than 80 percent of obligations is four times as large under the 5-percent rule. Similar comparisons hold for other constant and variable rate rules. This suggests there is a benefit to choosing a discount rate that varies with the economic factors that affect pension payouts and asset accumulation.

To understand the intuition for this finding, consider the case in which a downward trend in Treasury yields reduces pension plan portfolio returns. Given this change, the pension fund must accumulate more assets and contributions must increase to meet future obligations. If the discount rate varies with the Treasury yield, a fall in the Treasury yield causes a fall in the discount rate, which prompts a rise in projected liabilities and contribution rates.[25]

For the three classes of rules that involve moving averages (see Table 2, Part A, Rows 3-14), a longer moving average, at least up to 10 or 20 years, smooths the discount rate and generates slightly lower median assets, fewer cases of assets that are insufficient to meet obligations and fewer cases of assets below 80 percent of obligations. Therefore, smoothing movements in the discount rate over 10 or 20 years provides some benefit. Furthermore, because a moving average leads to lower volatility in the discount rate and slower adjustment of contributions, it may reduce the adjustment burden for plan members and sponsoring employers.

25 Freeman (2013) and Abourashchi (2013) also find that when modeling pension fund sustainability it is important to consider co-movements between economic variables that affect the plan and the discount rate.

Table 3: Loss Function Discount-Rate Rule Comparison

Loss Function = ω(median excess assets)^2 + (1-ω)(percentage of cases assets < obligations)^2

ω	Rule with the Smallest Loss	Average Discount Rate	Median Excess Assets	Frequency of Negative Excess Assets
1.0	20-year geometric average portfolio return	9.21	-0.5	50.5
0.9	Inflation forecast + 4%	7.71	4.7	43.5
0.8	10-year MA of corporate bond yield rule	7.42	24.4	22.3
0.7	10-year MA of corporate bond yield rule	7.42	24.4	22.3
0.6	10-year MA of corporate bond yield rule	7.42	24.4	22.3
0.5	Inflation forecast + 3%	6.71	36.9	14.5
0.4	Inflation forecast + 3%	6.71	36.9	14.5
0.3	Inflation forecast + 3%	6.71	36.9	14.5
0.2	10-year MA of TB yield	5.92	54.8	7.3
0.1	10-year MA of TB yield	5.92	54.8	7.3
0.0	Constant 3%	3.00	159.6	1.9

Notes:
"TB yield" denotes the 10-year US Treasury bond yield.
"MA" denotes "moving average."

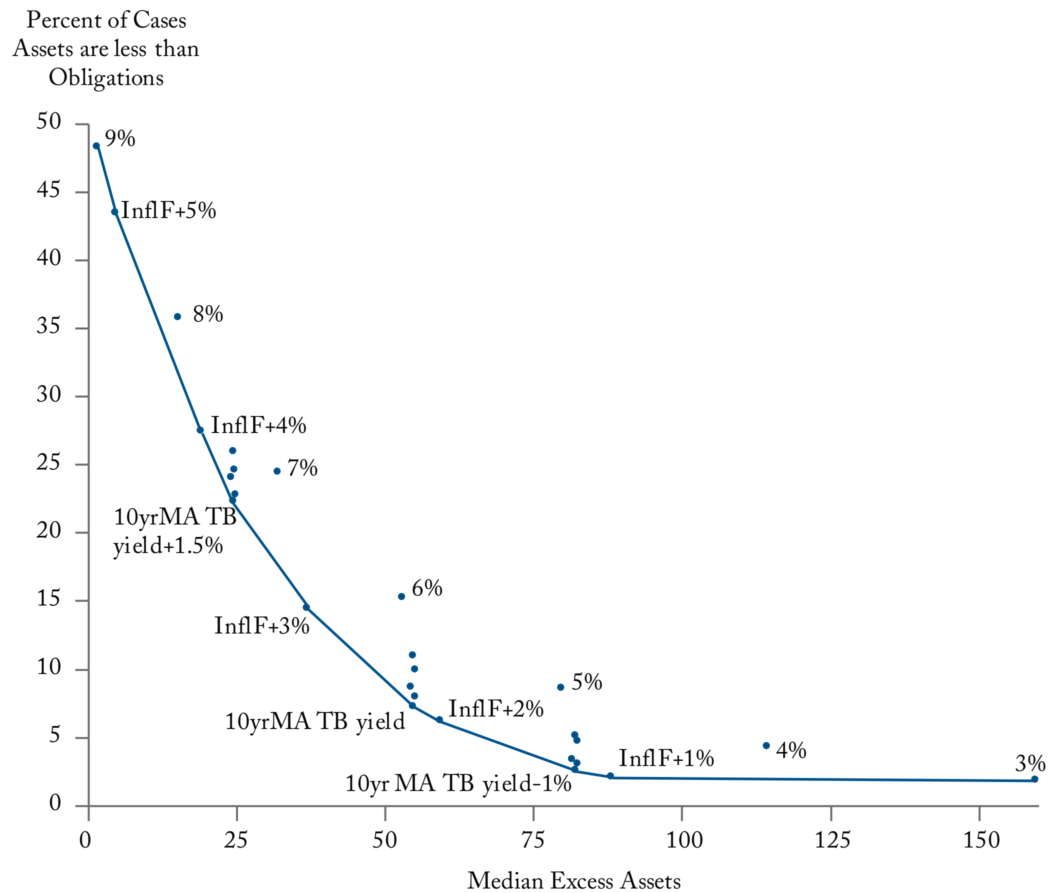
Source: Authors' calculations.

3.3 Ranking the Discount-Rate Rules

A ranking of the discount-rate-setting rules depends on the importance allocated to minimizing the probability that assets are insufficient to meet pension obligations versus minimizing excess asset holdings. A convenient method used to compare outcomes when there are multiple objectives is to employ a loss function. We utilize a quadratic loss function that is the weighted sum of the square of median excess assets and the square of the frequency of negative excess assets (Columns 2 and 3, Table 2). The weights on the two variables in the loss function sum to one, and we vary the weights from zero to one in increments of 0.1, as shown in Table 3, to allow greater or lesser weight to be given to the two objectives. The preferred value of the two variables in the loss function is zero, so the minimum value of the loss function is also zero. This type of loss function, where the two criteria are squared, tends to emphasize the impact of outliers, which is appropriate if large deviations are more of a concern to pension fund sponsors.

If all the weight in the loss function is allocated to minimizing the quantity of excess assets (squared median excess assets receive a weight of one in the loss function), the best discount-rate rule is the 20-year geometric average of the portfolio return since this rule has median excess assets of approximately zero. As more weight is given to the objective of minimizing the percentage of cases in which assets are less than obligations, rules with a lower average discount rate, such as the 10-year moving average of the corporate bond yield rule, are preferred.

Figure 1: Median Excess Assets and Frequency of Negative Excess Assets



Source: Authors' calculations.

This trade-off is evident in Figure 1, which graphs median excess assets against the frequency of negative excess assets. As the optimal point is at the origin, an envelope line has been added to connect the points closest to the origin to highlight the best rules. This line shows that some discount-rate rules are clearly dominated by others. These dominated rules include the constant discount rates from 4 percent to 8 percent and the Treasury bond yield rules, other than the 10-year moving average of the Treasury bond yield rule.

As can be seen from Figure 1 and Table 3, when approximately equal weight is given to the two criteria in the loss function, the inflation forecast plus 3 percent, and the 10-year moving average of the corporate bond yield rule (10yr MA TB yield+1.5%), dominate the other rules. These two rules minimize the loss function for a majority of the preference weight choices and are the best rules except when preferences heavily weight one criterion over the other. The only other rule that minimizes losses for more than one value of the preference weights is the 10-year moving average of the Treasury bond yield, and then only if very little weight is given to the accumulation of excess assets.

For the two rules that most often dominate the others, the inflation forecast plus 3 percent rule and the 10-year moving average of the corporate bond yield rule, the average discount rate is lower, by 2.5 and 1.8 percentage points, respectively, than the expected rate of return on plan assets – the rate used by many Canadian and US public-sector pension plans. On the other hand, these two rules yield average discount rates that are 0.8 and 1.5 percentage points higher, respectively, than the 10-year Treasury bond rate, an approximation to the risk-free yield.[26]

While the inflation forecast plus 3 percent and 10-year moving average of the corporate bond yield rules are the best rules for many loss-function weight combinations, even these rules yield median excess assets of more than 24 percent and at least a 14 percent probability that plan assets will not be sufficient to meet plan obligations. Thus, even the top-ranked rules have high median excess assets, but fail to meet promised benefit obligations in a significant share of cases.

4. Policy Implications

Although the discount rate has a substantial impact on the valuation of pension plan liabilities, there is no generally agreed upon rate used to determine the funding of benefits. Accounting standards stipulate that the market yield on high-quality corporate debt be used to discount private-sector pension liabilities. In contrast, public-sector pension plans receive little guidance on the choice of discount rate and, in practice, many such plans use a rate equal to the expected rate of return on pension plan assets. This expected return is usually higher than the yield on high-quality corporate debt, and both rates are generally higher than the yield on government debt, the discount rate typically advocated by finance theorists.

Given the wide range of discount rates recommended for, or used by, pension plans, we evaluate six types of discount-rate-setting rules to help identify those that provide a high probability a plan will have sufficient assets to meet promised benefit payments while amassing few excess assets. Using simulation methods, we find that none of the discount-rate rules yield both low median excess assets and a high probability that pension plan assets will be adequate to meet future obligations. Rules that yield low levels of excess assets (for example, median excess assets under 20 percent of obligations) – including our proxy for the expected return on plan assets – have a high probability (over 40 percent) that the assets accumulated by the plan will not be adequate to cover future promised benefits. Meanwhile, rules that generate a high likelihood that a plan will have sufficient assets to meet promised obligations (for example, a probability of over 90 percent), such as the 10-year moving average of the Treasury bond yield rule, accumulate a large quantity of assets in excess of obligations (median excess assets of over 54 percent).

Our simulations also show there is a high probability that plan assets will be insufficient or excessive by a large amount with all the discount-rate rules. For example, almost all the rules generate a 60 percent or greater probability that plan assets will either exceed or fall short of obligations by at least 20 percent.

A notable result of our analysis is that the better-performing rules vary with economic factors, such as asset yields and the inflation rate. Compared

26 While they use a different methodology, the findings of Turner, et al. (2017) are consistent with ours in that they recommend a discount rate that is less than the expected rate of return on assets, but greater than the risk free rate.

to constant-rate rules, the variable rules generally exhibit a lower probability that assets will be insufficient to cover obligations for a given level of excess assets. The advantage of rules that adjust the discount rate with economic factors is that they can move the rate in the direction of change of the portfolio return and/or benefit payments. This may be helpful particularly when, as in recent years, falling bond yields have caused portfolio returns to decline.

Furthermore, a rule that adjusts the rate automatically does not require plan sponsors to make a judgment about when there is a need to modify the discount rate. As noted by Saskatchewan's auditor general, governments may resist changes to discount rates when the change increases the liability of government-sponsored pension plans (Ferguson 2018).

With a discount rate equal to the expected return on plan assets, median excess assets are zero, but there is an approximately 50 percent probability that a plan will have insufficient assets to meet its promised pension payouts. This risk can be reduced by using a lower discount rate, but a lower rate will cause accumulated median excess assets to exceed zero. One way to justify a lower discount rate is as a precautionary measure, or insurance, against higher pension payouts or lower asset returns than expected. For example, a discount rate equal to the return on high-quality corporate bonds creates an asset cushion relative to a rate equal to the expected return on the pension plan's asset portfolio. An even lower rate, equal to the Treasury bond rate, provides even more insurance. The cost of this insurance is the accumulation of contributions in excess of those needed on average to meet pension obligations, which implies delayed consumption for pension plan members and may impose a direct cost on firms that sponsor pension plans.[27] The trade-offs we find provide an indication of the magnitude of this insurance cost.

As there is a trade-off between minimizing the accumulation of excess assets and maximizing the likelihood of meeting promised pension payments, the choice of discount-rate rule depends on the value attached to these two factors. Using a loss function that allocates roughly equal weight to each objective, the best performing rules are the 10-year moving average of the corporate bond yield rule and the inflation forecast plus 3 percent rule. These rules have average discount rates that are 1.8 to 2.5 percentage points lower than the expected rate of return on plan assets, which is used as the discount rate by many Canadian and US public-sector pension plans. Also, the rules yield average discount rates 0.8 to 1.5 percentage points higher than the 10-year Treasury bond yield, the approximately risk-free rate.

However, even with the best discount-rate rules, it is necessary on average to hold significant assets to achieve a high probability that plan assets will be adequate to meet future obligations. For example, with the 10-year moving average of the corporate bond yield rule, the probability that assets are less than obligations is 22 percent, while the rule generates median excess assets of 24 percent.

Our results indicate there is considerable risk associated with choosing a relatively high pension

27 Some observers argue government-sponsored plans can use a higher discount rate because they are less likely to go bankrupt. Our focus is on whether a plan has sufficient funds to pay benefits, not on possible government responses (such as a bailout) if a plan has a funding shortfall.

plan discount rate, such as the expected return on plan assets.[28] However, many pension plan sponsors in Canada prefer this rate, which they argue keeps their pension plans affordable (Thomas 2018). Current employers and employees have an incentive to keep the discount rate high in order to reduce current contributions, but a higher rate increases the probability that the plan will have insufficient assets to meet obligations. This suggests there is a need for prudent regulation of pension plan discount rates.[29] Robson (2017) argues that a reason for the lack of regulation in Canada is that "governments yield to the same temptations as do other sponsors of defined-benefit pensions. Ottawa's own plans have assets way short of their liabilities. Most governments give the green light to other employers whose assumptions understate the cost of their pension promises."

Lower asset accumulation, due to using a higher discount rate, may increase the likelihood that a pension plan member does not receive the benefits promised. Possible methods to deal with this *ex-post* are: (1) a cut to pension benefits; (2) an increase in the pension contributions of current employees and/or employers; or (3) a bailout by taxpayers.[30] One way to deal with the risk ex-ante, other than by use of a rule that generates a lower discount rate, is establishment of a hybrid plan to share risk (such as risk associated with inflation and portfolio returns).[31] Our results show that use of a lower discount rate implies higher contributions than required on average, but this is a cost employees might be willing to bear in order to make future pension benefits more secure. On the other hand, a hybrid system might be preferred if the contributions needed to ensure a very high probability of meeting obligations are viewed as too great.

Conclusions

Pension plan investment returns and future required benefit payouts are uncertain. Through the use of stochastic simulation methods, this *Commentary*

28 A practical issue related to using the expected return on plan assets as the discount rate is that there is no standard method used to calculate this rate. As a consequence, there may be more opportunity for the rate to be influenced by management bias (Barr 2018, p. 60). Also, as noted by the Office of the Auditor General of Canada (Barr, 2018, p. 59) and the Provincial Auditor of Saskatchewan (Ferguson 2018, p. 66), when the discount rate differs across pension plans, this impedes comparability of plans that are otherwise similar. Finally, a factor that makes the task of determining the expected rate of return on plan assets quite challenging is that asset returns exhibit considerable volatility. For example, the standard deviation of our proxy for the expected return on the pension plan portfolio, the *10-year geometric average portfolio return*, is 3.50 percent (Table 2). Given the average portfolio return of 9.25 percent, 68 percent of observations are between 5.25 percent and 12.75 percent, so a substantial 32 percent of cases fall above or below this range.

29 The Ontario government's new PfAD (Provision for Adverse Deviations) regulations impose some discipline on the choice of discount rate by linking contributions to the benchmark Government of Canada long bond yield (Ontario 2018), although the link is more complicated than the discount rate rules examined here. In Canada, examples where poor regulatory oversight was a contributor to firms reneging on pension promises to employees include Sears Canada, Nortel, and Stelco, according to McKiernan (2017). Melnitzer (2018) notes that the US pension regulator, the Pension Benefit Guaranty Trust Corp., has more power than Canadian regulators to ensure private pension benefits are paid. For example, as Sears in the US experienced mounting financial troubles and its pension deficit grew, the Pension Benefit Guaranty Corp. ring-fenced 140 Sears properties until a payment of $407 million was paid into its pension fund.

30 If the value of pension benefits received is not funded by contributions (or is more than funded) over an employee's working lifetime, this violates intergenerational equity, a key pension funding principle proposed by the US *Society of Actuaries* (2014).

31 Steele, Mazerolle and Bartlett (2014) and Munnell (2016) note that sponsors should recognize the risk inherent in their pension plans and recommend that plans establish risk sharing provisions. Given the risks associated with defined-benefit plans, sponsors may want to explicitly spell out how plan deficits and surpluses are to be resolved across plan participants.

provides insight into the risks for pension funds associated with the choice of a discount rate. There is a trade-off between minimizing the accumulation of potential excess assets and maximizing the likelihood that assets will be sufficient to meet pension benefit payments. Therefore, the choice of a discount-rate rule depends on the relative importance attached to these two factors. If approximately equal weight is given to achieving these two objectives, the best performing rules are a 10-year moving average of the high-quality corporate bond yield and an inflation forecast supplemented by the real interest rate (proxied by a constant 3 percent). Both of these rules yield average discount rates below the expected rate of return on assets, but higher than the riskless rate of interest. In practice, the choice of discount-rate rule can have a dramatic impact on those who bear the plan's risk; i.e., plan members, employers and, for public pension plans, the taxpayer.

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Notes:

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