

2019 Investment Seminar

October 27, 2019

Toronto, Canada



Session 4A: Maintaining A Pension Plan Long-Term: Hedging the Risks

[SOA Antitrust Compliance Guidelines](#)

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2019 Investment Seminar

MAINTAINING A PENSION PLAN LONG-TERM: HEDGING THE RISKS

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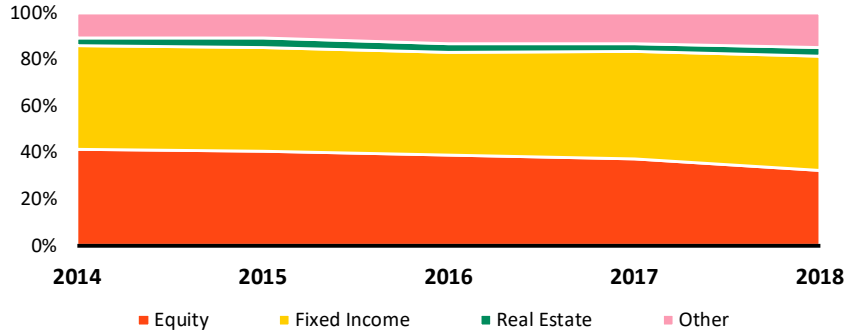
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Introduction

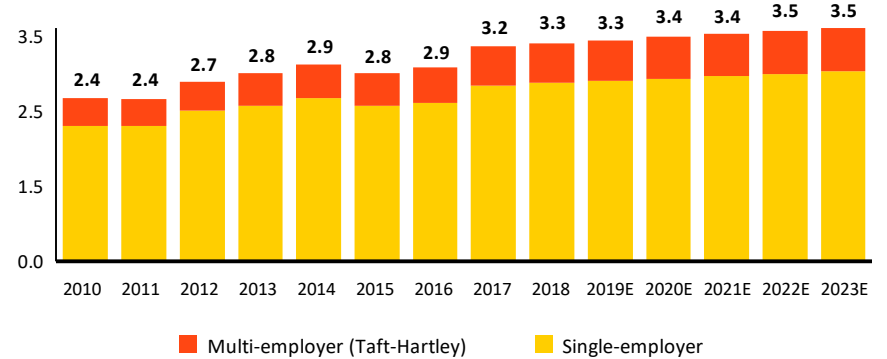


US Corporate DB Pension Asset Ownership

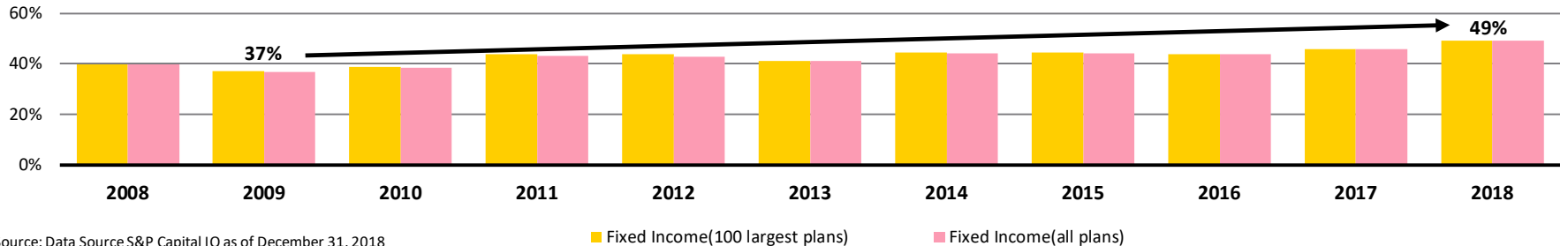
Total Asset Allocation for all plans¹ (%)



Total Corporate DB plans AUM² (\$Trillion)



Higher allocation to Fixed income over time

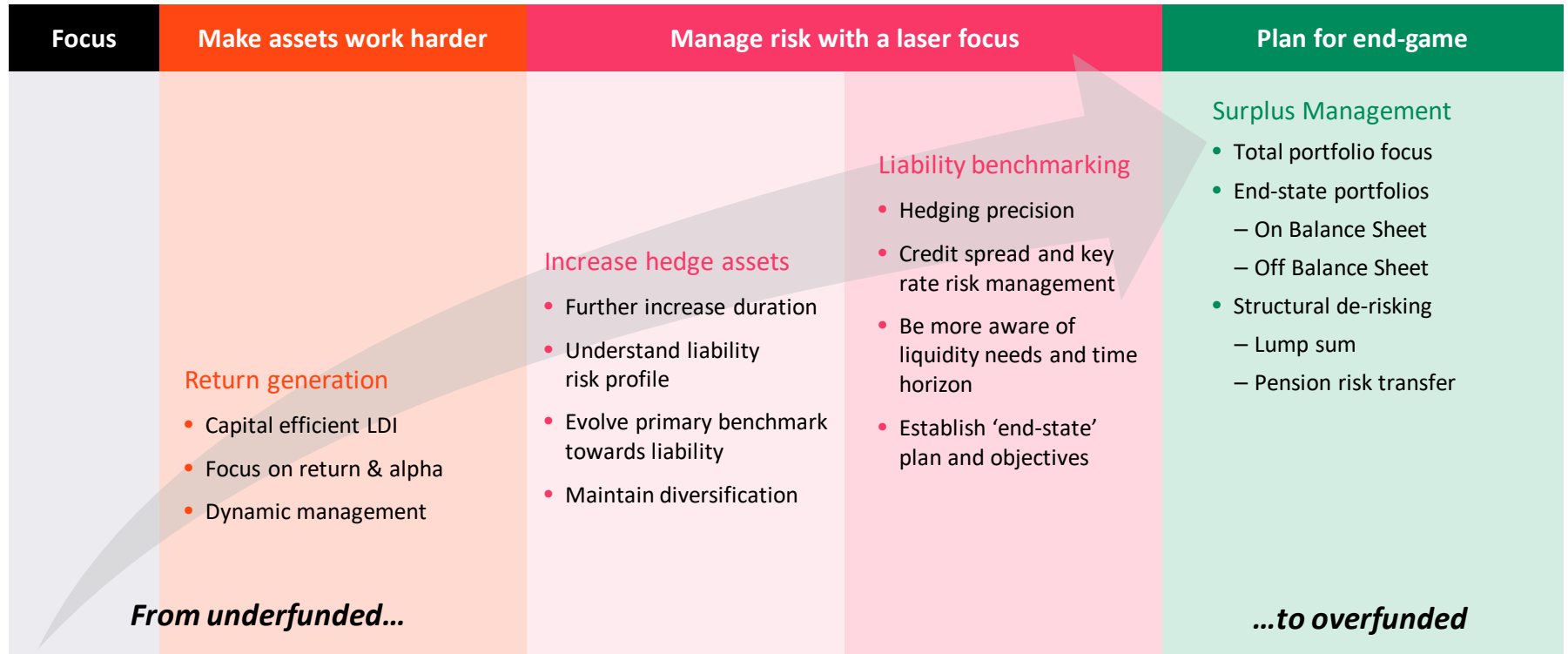


Source: Data Source S&P Capital IQ as of December 31, 2018

1 Universe of data consists of DB plans from S&P500 sponsored companies;

2 Cerulli 2018, Assets include single- and multi-employer plans. For illustrative purposes only

Corporate DB Pension De-Risking Journey



Funded status remains the most significant driver of strategy

TODAY'S FOCUS: THE PLAN

- US single-employer plan or Canadian corporate plan
- Liability focus is on the accounting (ASC 715/CICA 3460/IAS 19) liability
- Liability discount curve is high-quality, i.e., “Aa”
- Plan is well-funded on accounting basis
- Plan sponsor objective is to maintain the plan on balance sheet (no plan termination or partial lift-outs)

TODAY'S FOCUS: PLAN SPONSOR OBJECTIVES

- Ensure that benefit payments can be paid on time
- Hedge liability risks
 - Investment-related risks: discount rate
 - Non investment-related risks: assumption changes and plan experience
- Cover future accruals and ongoing plan costs
 - Usually requires a combination of investment returns and contributions
 - Plan costs include PBGC fixed-rated premiums, plan administration, investment management, actuarial, consulting, custody, etc.

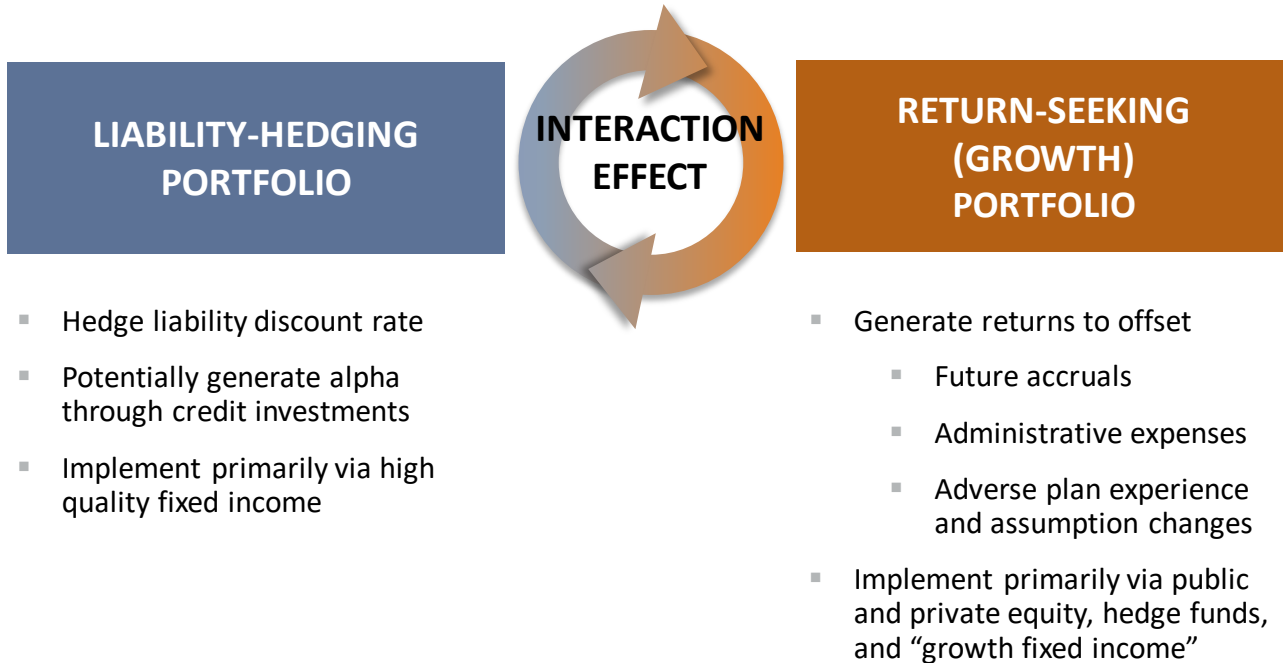
TODAY'S AGENDA

- Total portfolio construction
- Liability hedging:
 - discount rate
 - capital efficiency
 - cashflow matching
 - moment-matching
- Benchmarking considerations
- Liability hedging: longevity risk

Total portfolio construction



COMMON PENSION INVESTING FRAMEWORK



- The correlation between these two portfolio should not be neglected
- Portfolio construction and implementation should be thoughtful for **both**

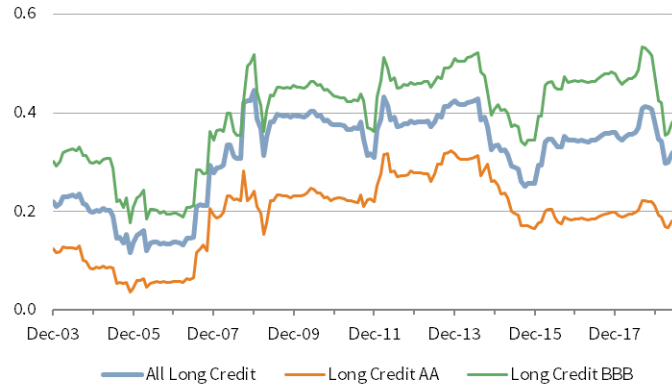
PORTFOLIO CONSTRUCTION: CORRELATION OF EQUITIES AND CREDIT

- Long-term correlation of corporate bond spread returns to equity returns is 0.7 with an average beta of 0.3 (over the last 15 years)
- The beta of Baa corporate bond spread returns to equities is higher than that of Aa, roughly by a factor of 2
- Other growth assets exhibit varying spread betas

ROLLING 3-YEAR CORRELATIONS OF LONG CREDIT SPREAD RETURN AND MSCI ACWI (N) RETURNS



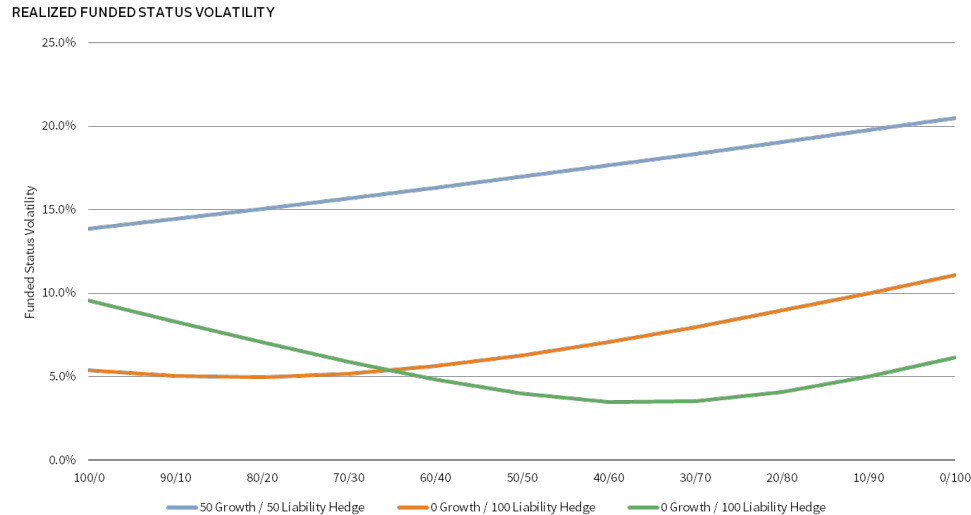
ROLLING 3-YEAR BETA OF CREDIT SPREAD RETURN TO MSCI ACWI (N) RETURNS



Source: Bloomberg and Cambridge Associates, as of 8/31/2019. Credit spread return represents excess return as defined by Bloomberg Barclays; data reflect monthly observations.

PORTFOLIO CONSTRUCTION: OPTIMAL TREASURY VS. CREDIT EXPOSURE

- Given the correlation between credit spread returns, plans with larger allocations to growth assets can minimize funded status volatility by having lower allocations to credit
- Need to weigh lower funded status risk vs. lower carry relative to the liability



PORTFOLIO CONSTRUCTION

- **Typical target return:** Hurdle rate to maintain (or improve) funded status
- **Typical target risk:** Funded status volatility
- **Constraints and considerations:** Target interest rate hedge ratio, target credit spread hedge ratio, liquidity requirements, downside contributions in stress scenarios, time horizon, manager value-add, plan size, etc.

Sample plan hurdle rate	Open	Frozen
Liability discount rate	3.00%	3.00%
Service cost	3.00%	0.00%
Administrative expense	0.75%	0.75%
<u>Benefit drag¹</u>	<u>0.00%</u>	<u>0.00%</u>
Hurdle rate before contribution	6.75%	3.75%
<u>Expected contribution</u>	<u>(2.00%)</u>	<u>(0.00%)</u>
Target return	4.75%	3.75%

Sample plan, as of 8/31/2019. [1] Benefit drag occurs when the plan is underfunded; since the plan is assumed to be fully funded, benefit drag is zero.

PORTOFOLIO CONSTRUCTION CONSIDERATIONS

Plan size and plan sponsor risk tolerance

Reflects plan size in absolute terms, plan size relative to corporate balance sheet, contribution ability, business sensitivity to market downturns, etc.

Volatility

Driven by plan time horizon, but may be tempered by annual mark-to-market accounting and “trapped surplus” considerations

Liquidity

Reflects plan time horizon, benefit formula (e.g., cash balance), lump sum options

Liability hedge

Should align with benefit formula and actuarial assumptions and methodology (e.g., market-based cash balance plans)

Leverage

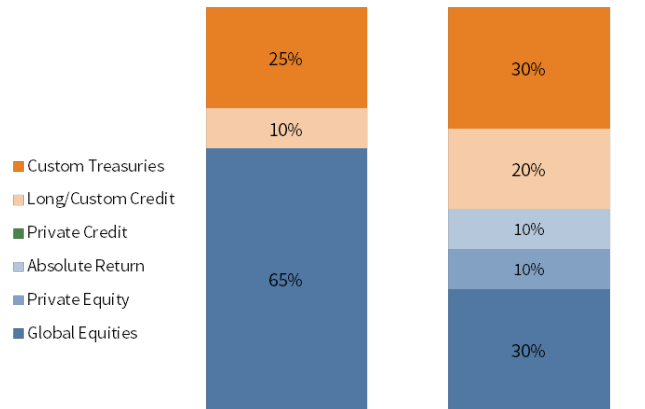
Is often required to achieve an effective hedge (or generate return and can be risk-reducing)

Manager value-add

Is critical in certain asset classes and should not always be ignored

TOTAL PORTFOLIO CONSTRUCTION EXAMPLES

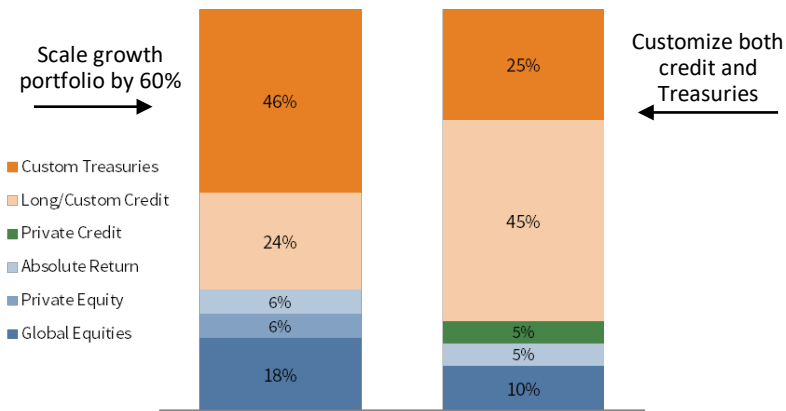
SAMPLE OPEN PLAN



	Simple	Diversified
Expected 10-year return	4.7%	4.7%
Expected funded status vol	12.1%	9.2%
Interest rate hedge ratio	100%	100%
Credit spread hedge ratio	98%	88%

- Diversification reduces funded status risk
- Addition of private equity is countered with Treasuries

SAMPLE FROZEN PLAN



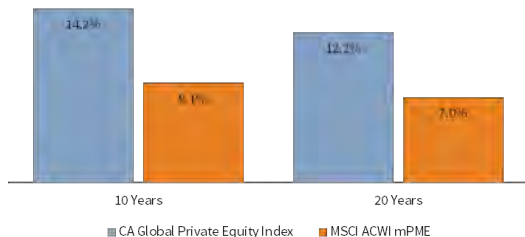
	Scaled from open	Optimal
Expected 10-year return	3.7%	3.7%
Expected funded status vol	6.1%	4.3%
Interest rate hedge ratio	100%	100%
Credit spread hedge ratio	76%	103%

- Simply scaling the growth portfolio to achieve lower target return is inefficient
- Customizing the L-H portfolio is critical

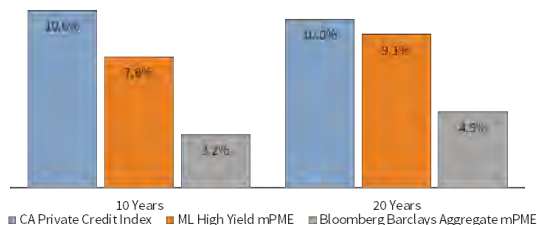
LIQUIDITY OPPORTUNITY: PRIVATE INVESTMENTS CAN DRIVE RETURNS

- Private investments can be an important driver of returns through an **illiquidity premium** and **potential manager value-add**
 - Historical value-add over public market equivalents is attractive
 - Forward-looking value add is ~2% (Horizon Survey of Capital Market Assumptions, 2019)
 - The dispersion of manager returns is very wide

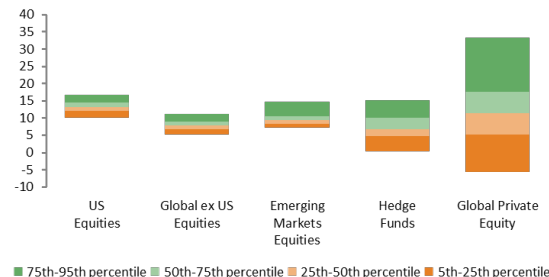
GLOBAL PRIVATE EQUITY VS. PUBLIC MARKET EQUIVALENT
AS OF MARCH 31, 2019



PRIVATE CREDIT VS. PUBLIC MARKET EQUIVALENT
AS OF MARCH 31, 2019



DISPERSION OF 10-YEAR MANAGER RETURNS (%)
AS OF DEC, 2018

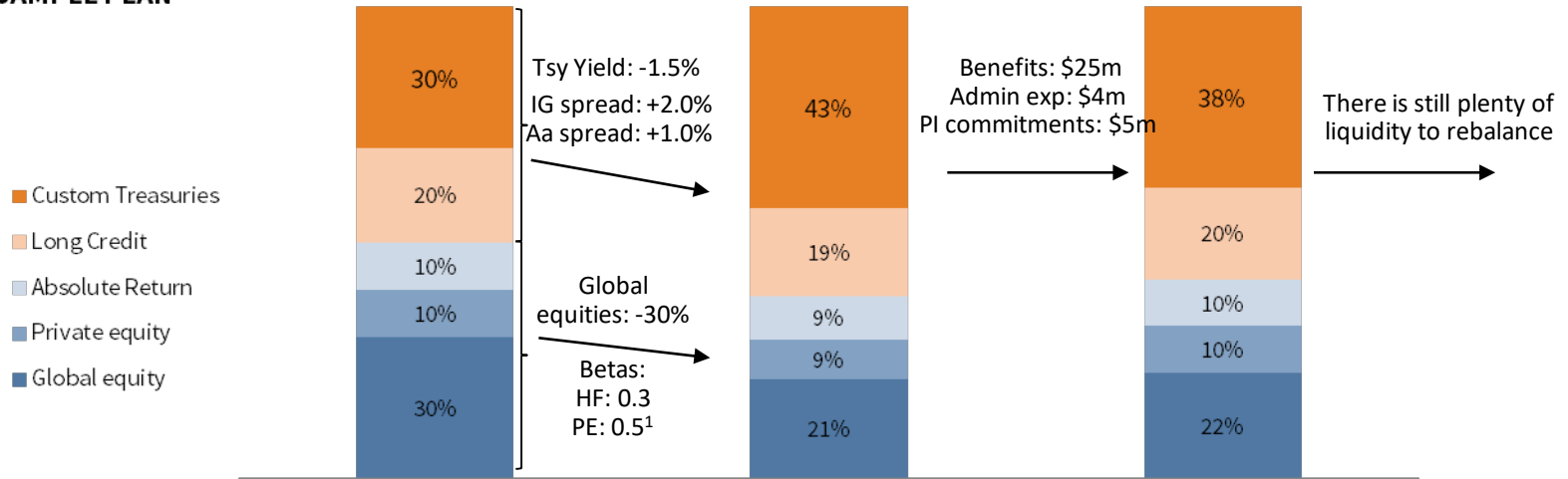


First two charts source: Cambridge Associates LLC and MSCI Inc. MSCI data provided "as is" and without any expressed or implied warranties. Cambridge Associates mPME methodology replicates private investment performance under public market conditions and allows for an appropriate comparison of private and public market returns. The mPME analysis evaluates what return would have been earned had the dollars invested in private investments been invested in the public market index instead. Based on all global private equity (buyout, private equity energy, growth equity, and subordinated capital funds) funds (for private equity chart) and all private credit (credit opportunities, subordinated capital, and senior debt) (for private credit chart) tracked by Cambridge Associates that were active during the time periods analyzed. Returns for private investments are based on quarterly end-to-end internal rates of return, which are net of fees, expenses, and carried interest; analysis includes funds from vintage years 1999–2013. Total return data for the MSCI ACWI are net of dividend taxes for the 10-year period and gross of dividend taxes for the 20-year period.

Third chart source: Cambridge Associates. Returns for bond, equity, and hedge fund managers are average annual compound returns (AACRs) for the ten years ended December 31, 2018, and only managers with performance available for the entire period are included. Returns for private investment managers are horizon internal rates of return (IRRs) calculated since inception to September 30, 2018. Time-weighted returns (AACRs) and money-weighted returns (IRRs) are not directly comparable. Cambridge Associates LLC's (CA) bond, equity, and hedge fund manager universe statistics are derived from CA's proprietary Investment Manager Database. Managers that do not report in US dollars, exclude cash reserves from reported total returns, or have less than \$50 million in product assets are excluded. Performance of bond and public equity managers is generally reported gross of investment management fees. Hedge fund managers generally report performance net of investment management fees and performance fees. CA derives its private benchmarks from the financial information contained in its proprietary database of private investment funds. The pooled returns represent the net end-to-end rates of return calculated on the aggregate of all cash flows and market values as reported to Cambridge Associates by the funds' general partners in their quarterly and annual audited financial reports. These returns are net of management fees, expenses, and performance fees that take the form of a carried interest.

LIQUIDITY RISK: LIQUIDITY NEEDS ARE OFTEN OVERESTIMATED

SAMPLE PLAN



	Initial	Stress test return	After stress test	Cash flows	After stress test and cash flows
Assets	500	-0.1%	500	(29)	482
Liabilities	500	+6.0%	530	(25)	505
Funded status	100%		94%		93%

Sample plan, 12 year duration, sample stress scenario. For illustrative purposes only. [1] Private equity beta reflects the fact that most private equity investments are not marked to market as frequently and to the same extent as public investments resulting in "sticky" market values.

LEVERAGE

- While presenting certain risks, leverage used to hedge interest rate risk (in total or across the curve) is **risk-reducing relative to liabilities**
- One approach to evaluating leverage is to determine how much interest rates would have to rise before liability-hedging assets would be exhausted
 - For example, for a portfolio duration of 30 years, where the duration of Treasuries is 40 years and the duration of credit is 14 years:
 - Interest rates would have to rise at least 250 bp to exhaust the Treasury securities, i.e., all the Treasuries would have to be sold to post collateral for the derivatives
 - Interest rates would have to rise at least 333 bp to exhaust the entire portfolio, assuming no credit spread changes and corporate bonds can be sold efficiently to post collateral
- In reality, any significant changes in interest rates would result in portfolio re-evaluation and potential rebalancing, likely adding physical assets if funded status improves

Liability hedging: discount rate

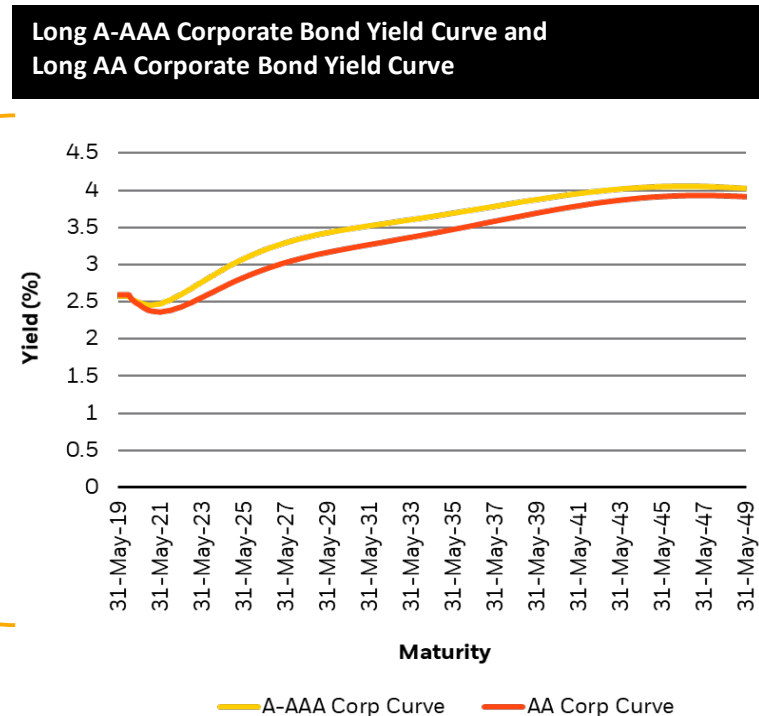


HEDGING THE DISCOUNT RATE

	Treasury risk	Credit spread risk	Curve risk
Risk	Overall change in the Treasury component of the Aa discount rate	Overall change in the Aa credit spread component of the Aa discount rate	Nonparallel changes in the Treasury (and possibly Aa spread component)
Measure	DV01 / duration IR hedge ratio	CS01 / Aa spread duration CS hedge ratio	Key rate DV01 Key rate CS01
Instruments	<ul style="list-style-type: none"> ▪ Treasury bonds ▪ STRIPS ▪ Treasury futures ▪ Total return swaps ▪ Interest rate swaps 	<ul style="list-style-type: none"> ▪ Aa corporate bonds ▪ IG corporate bonds ▪ Other credit that is correlated to Aa spread 	All of the above
Hedge degree and precision	Open: High Frozen: High	Open: Moderate to high Frozen: High	Open: Moderate Frozen: Moderate to high

Discount rates used by corporate pension plans are based on the yield on high quality corporate bonds

Purpose	Description	Curve	Frequency
Funding	Used to calculate the liability value under applicable funding regulations in order to determine required contributions	High quality (A-AAA) corporate bond yield curve (reflects "smoothing" in some cases)	Annual
Accounting	Used to calculate the present value of the projected benefit obligation for purposes of financial disclosures	High quality (AA) corporate bond yield curve (reflects universe "trimming" in some cases)	Annual (actuarial curves typically available monthly)
Investing	Used to value the liability on a frequent basis to inform portfolio management decisions	High quality corporate bond yield curve	Daily
Termination / Buyout	Used to estimate the value of the liability for annuitization	Broad (all IG) corporate bond yield curve minus expected lift	Ad-Hoc



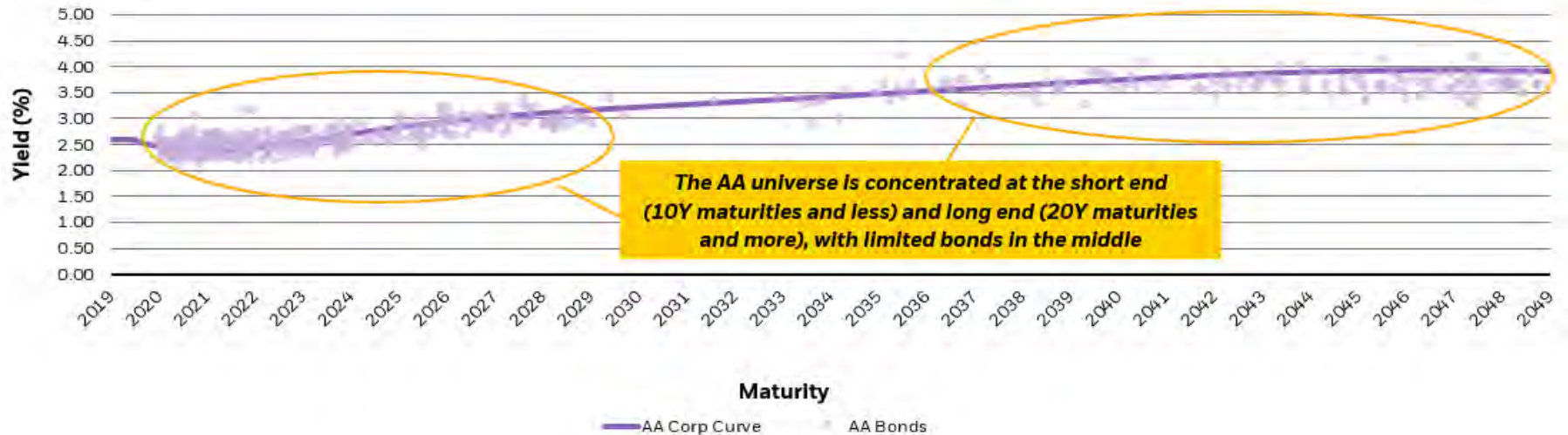
Source: BlackRock, BofA Merrill Lynch. As of May 31, 2019

The liability discount curve is made up of high quality rated corporate bonds... but it is not investable

In theory, to be 100% matched versus liabilities corporate plans should buy every bond in the same proportion as the bonds in the discount rate... However, that is not possible or practical

Long AA Corporate Bond Yield Curve vs. Actual Bond Yields

As of May 31, 2019



Source: BlackRock, BofA Merrill Lynch. As of May 31, 2019

Three structural challenges with corporate bond allocations in LDI portfolios

Concentration Risk

The liability discount curve is highly concentrated to few issuers

Not all Credit is Equal

Credit performance is nonlinear across the market – issuer, sector, and quality all impact a given bond's performance

The Credit Downgrade Headwind

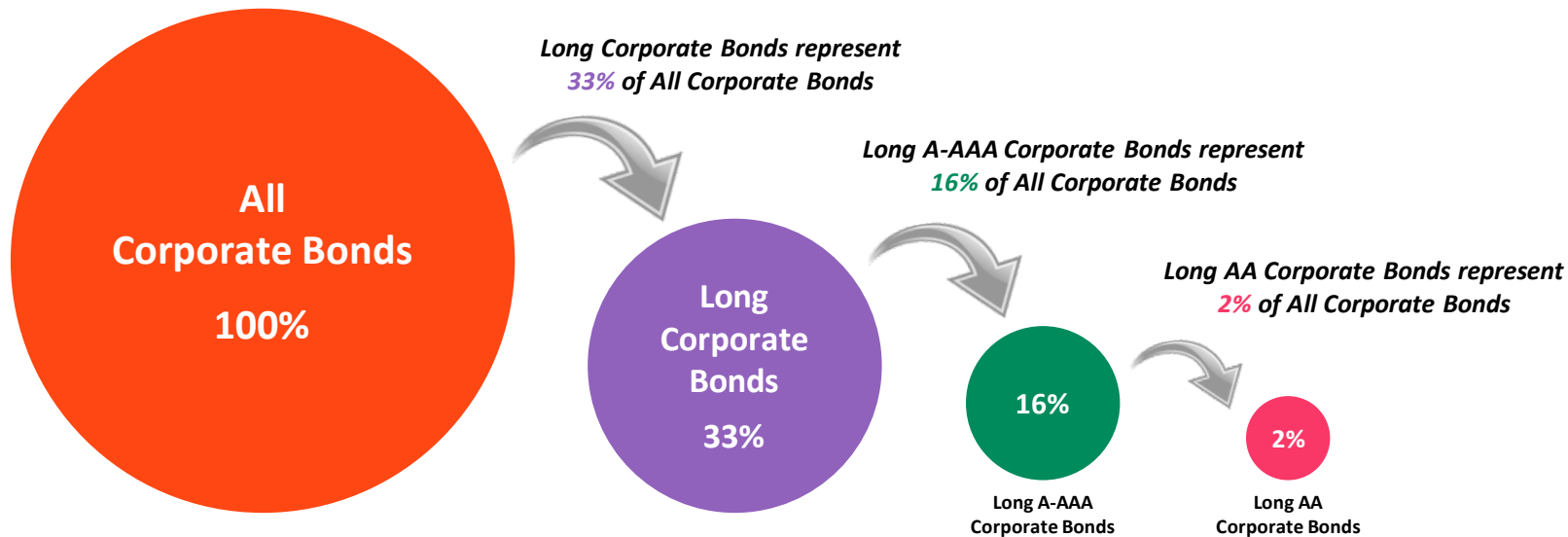
The liability discount curve is not subject to downgrades and defaults, whereas investors in corporate bonds take on this risk

In LDI portfolios, we recommend deliberate steps to overcome each of these structural challenges that plans face

Source: BlackRock. For illustrative purposes only and not meant to be a recommendation to buy or sell any security

The US high quality corporate bond market is very narrow...

Relative Corporate Bond Market Sizes (to scale)

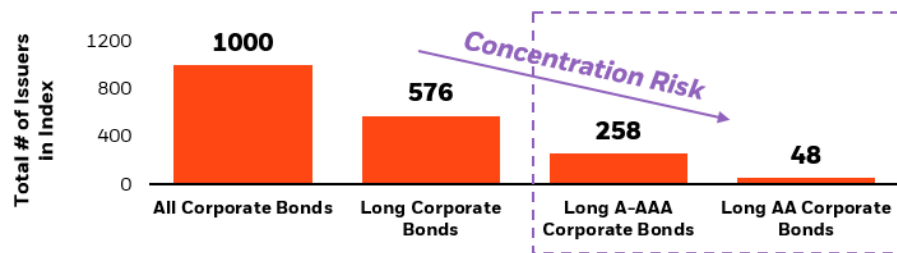
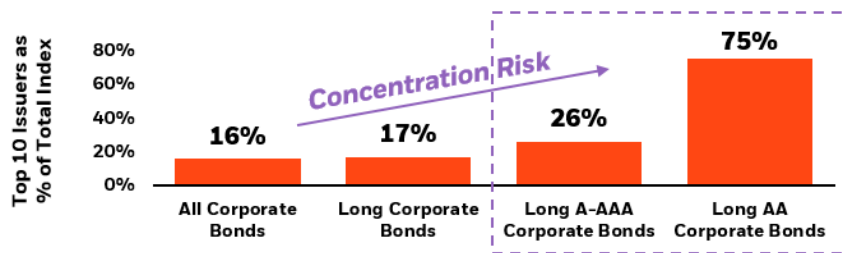


Source: BlackRock, as of May 31, 2019. Size of shape based on relative size of the market, based on representative index. All Corporate Bonds based on Bloomberg Barclays U.S. Corporate Bond Index; Long Corporate Bonds based on Bloomberg Barclays U.S. Long Corporate Bond Index; Long AA Corporate Bonds based on Bloomberg Barclays AA U.S. Corporate Bond Index

...And highly concentrated to few issuers

Liability discount curves have exposure to few issuers compared to the broad investment grade market

For example, the top 10 issuers as % of the index issue 75% of the Long AA Corporate bonds



All Corporate Bonds	% of Index
JPMorgan Chase & Co	2.2%
Bank of America Corp	2.2%
Goldman Sachs Group Inc	1.7%
AT&T Inc	1.6%
Citigroup Inc	1.5%
Morgan Stanley	1.4%
Wells Fargo & Company	1.4%
Verizon Communications Inc	1.3%
Comcast Corporation	1.3%
Apple Inc	1.2%
Top 10 Issuers	15.8%
Total # of Issuers	1000

Long Corporate Bonds	% of Index
AT&T Inc	2.7%
Verizon Communications Inc	2.5%
Comcast Corporation	2.2%
Microsoft Corporation	1.9%
JPMorgan Chase & Co	1.4%
Oracle Corporation	1.2%
Anheuser-Busch InBev Inc	1.2%
Goldman Sachs Group Inc	1.2%
Bank of America Corp	1.1%
Apple Inc	1.1%
Top 10 Issuers	16.7%
Total # of Issuers	576

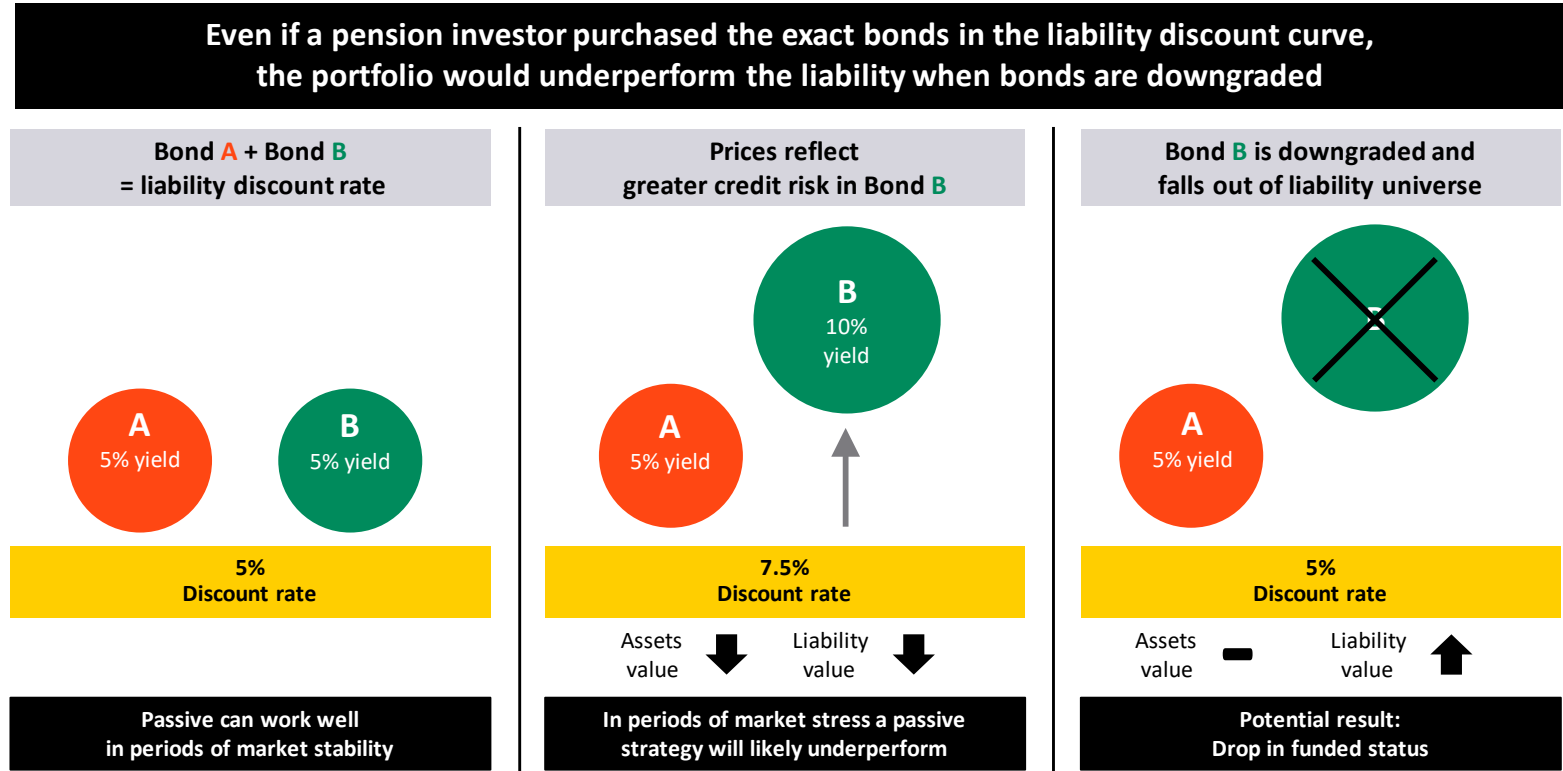
Long A-AAA Corporate Bonds	% of Index
Comcast Corporation	4.5%
Microsoft Corporation	4.0%
JPMorgan Chase & Co	2.9%
Oracle Corporation	2.6%
Apple Inc	2.3%
Walmart Inc	2.1%
Wells Fargo & Company	2.0%
UnitedHealth Group Inc	1.9%
Shell International Finance Bv	1.8%
Bank of America Corp	1.7%
Top 10 Issuers	25.8%
Total # of Issuers	258

Long AA Corporate Bonds	% of Index
Apple Inc	16.6%
Walmart Inc	15.4%
Shell International Finance Bv	13.2%
Florida Power & Light Co	7.8%
Berkshire Hathaway Corp	5.9%
Visa Inc	5.5%
Novartis Capital Corp	3.3%
Exxon Mobil Corp	3.2%
Procter & Gamble Co	2.2%
Kaiser Foundation Hospitals	2.0%
Top 10 Issuers	75.1%
Total # of Issuers	48

Source: BlackRock. As of May 31, 2019. All Corporate Bonds based on Bloomberg Barclays U.S. Corporate Bond Index; Long Corporate Bonds based on Bloomberg Barclays U.S. Long Corporate Bond Index; Long AA Corporate Bonds based on Bloomberg Barclays AA U.S. Corporate Bond Index

Credit downgrade risk

Passive strategies are vulnerable to credit downgrades: illustrative example



Source: BlackRock. The illustrative example above is shown to illustrate the credit downgrade risk of passively matching the liability with corporate bonds. It is not meant to be a recommendation to buy or sell any security

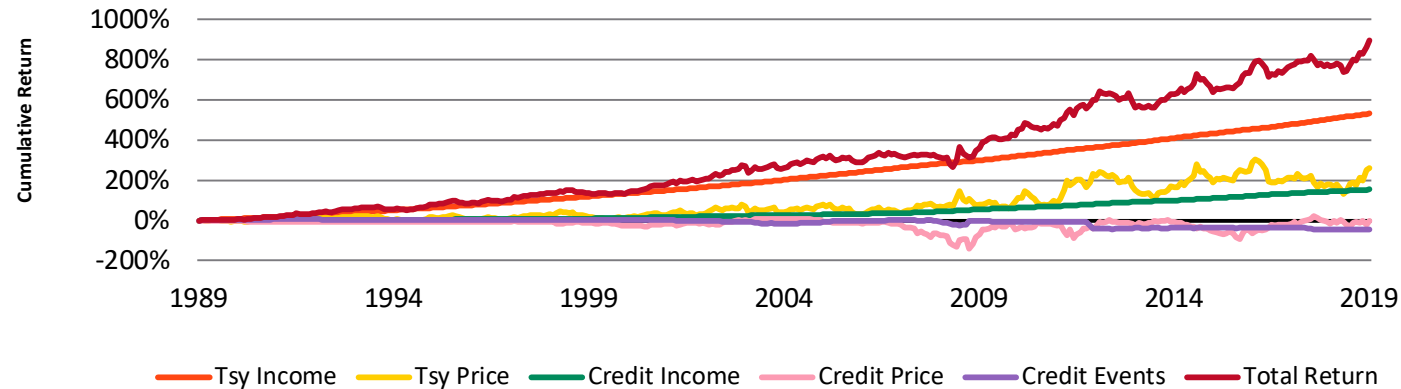
Quantifying the effects of credit events

Long AA Corporates

Over the past three decades, credit events have presented a headwind to excess returns for long corporate bonds

- These credit events have the potential to impact the performance of hedging assets, but not the liability

Quantifying the impact of credit events



Annualized Return Decomposition	
Tsy Income	4.71%
Tsy Price	2.30%
Credit Income	1.36%
Credit Price	-0.02%
Credit Events	-0.42%
Total Return	7.94%

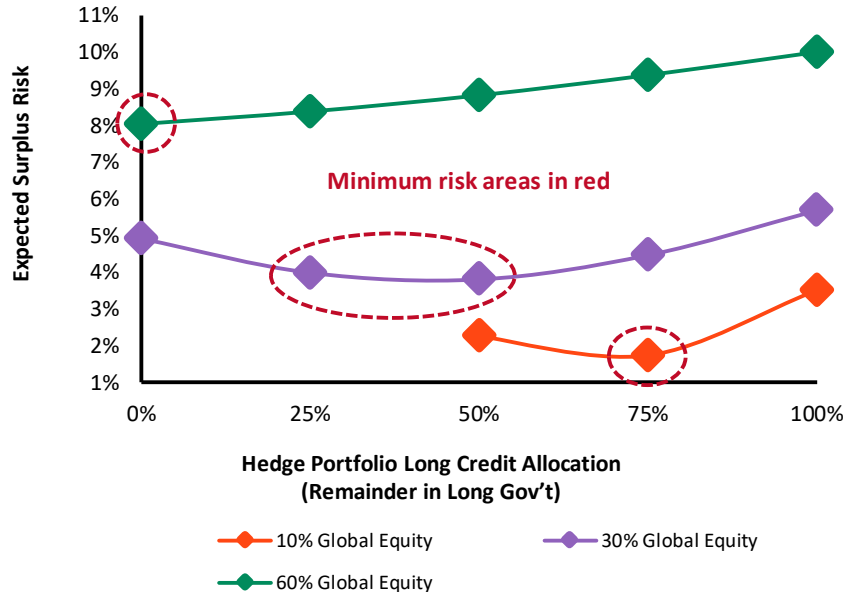
How should returns be sourced to keep up with the liability?

Source: BlackRock, Barclays, data from 6/30/1989 through 6/28/2019. Returns represent BBG Barclays Long AA Corporate Index. For illustrative purposes only. Component contributions to return decomposition are calculated as component cumulative return divided by total cumulative return and multiplied by total annualized return. Past performance is not indicative of future results

Balancing rates and spreads

Does equity have an impact?

The credit allocation should be informed, in part, by the equity allocation...



...but there are other key factors to consider:

Higher than minimum risk at early stage has potential benefits

- Return
- Equities / credit relationship not static
- Growth portfolios tend to have some non-equity / diversifying exposure

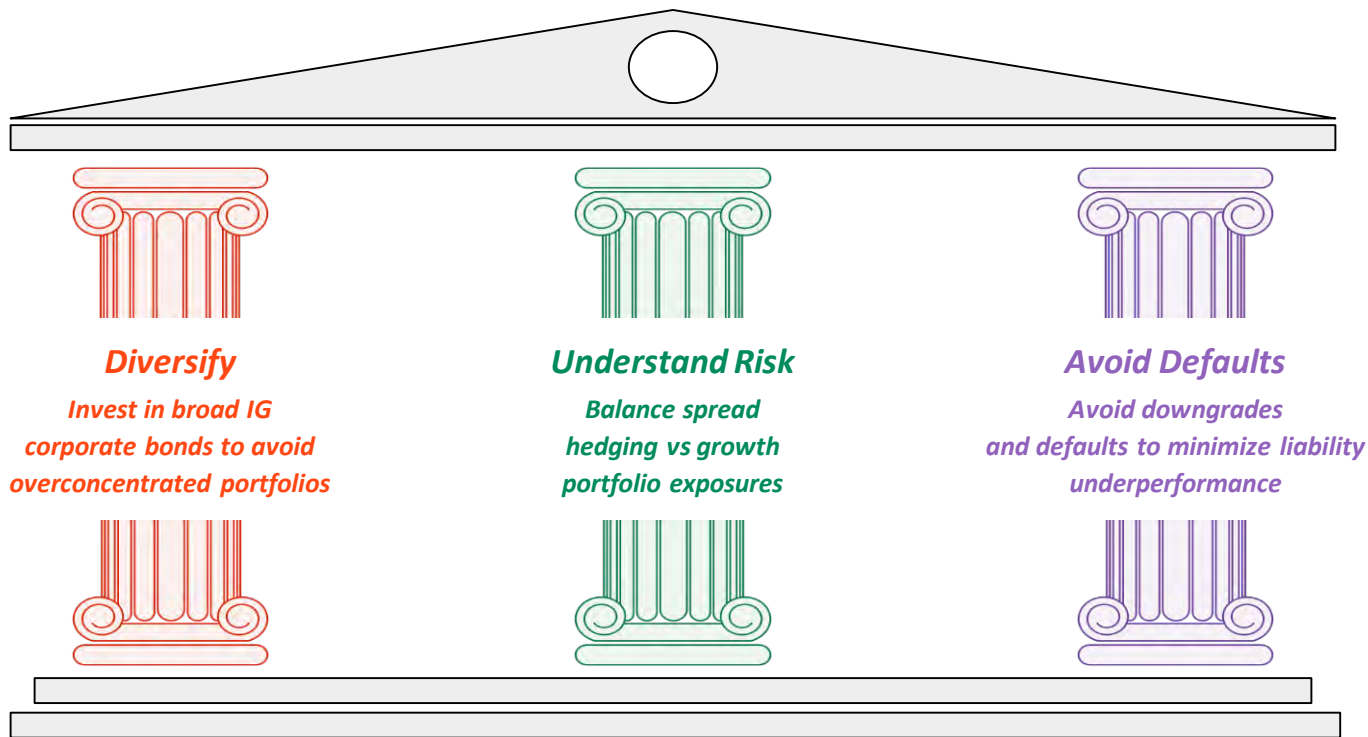
Target should increase over time

- Lower equity allocation opens room for more credit to reduce surplus risk
- As fixed income allocation grows, more credit in total portfolio allocation may have a larger impact on total portfolio return

Source: BlackRock, as of 2/28/2019. The above is an illustrative example for a 90% funded plan. Depicts the expected surplus risks of a series of illustrative portfolios allocated to Global Equity, Long Credit, and Long Gov't in the weights specified in the chart legend and chart horizontal axis. Expected surplus risks are calculated using BlackRock Portfolio Risk Tools as of 2/28/2019 using the trailing 180 months of equal-weighted observations

What this all means for LDI portfolios?

Three implications for corporate bonds in LDI portfolios



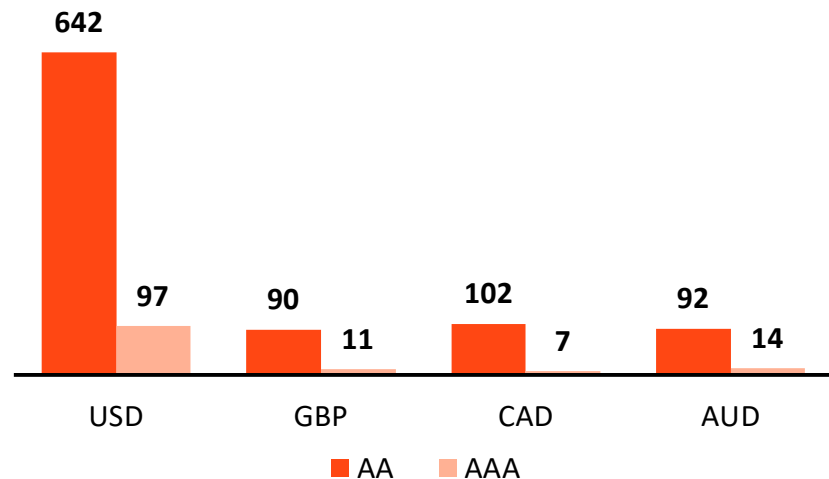
Source: BlackRock. For illustrative purposes only and not meant to be a recommendation to buy or sell any security

High quality issuance across currencies

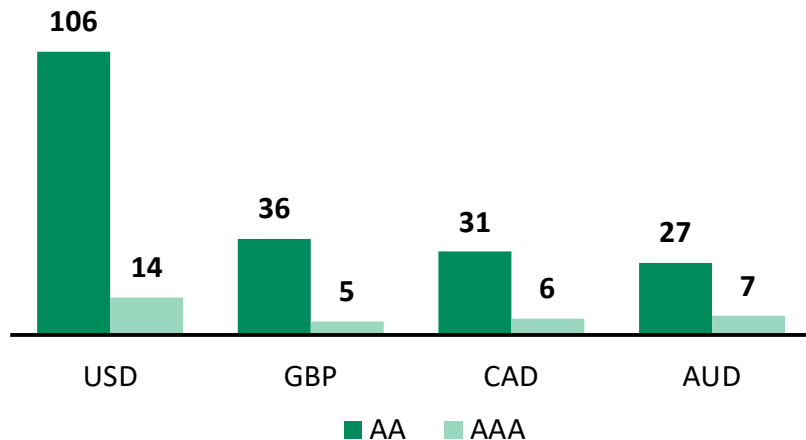
AAA and AA bond issuance is limited across most currencies, creating potential issues for liability valuation

- The valuations of liabilities discounted with curves derived from sparse universes are more sensitive to the price fluctuations of individual bonds, and the idiosyncratic risk of individual issuers
- In many instances, the prices of bonds that rarely or never trade are marked-to-model
- Other bonds may be only “quasi-corporate”, for instance those with implicit or explicit governmental guarantees

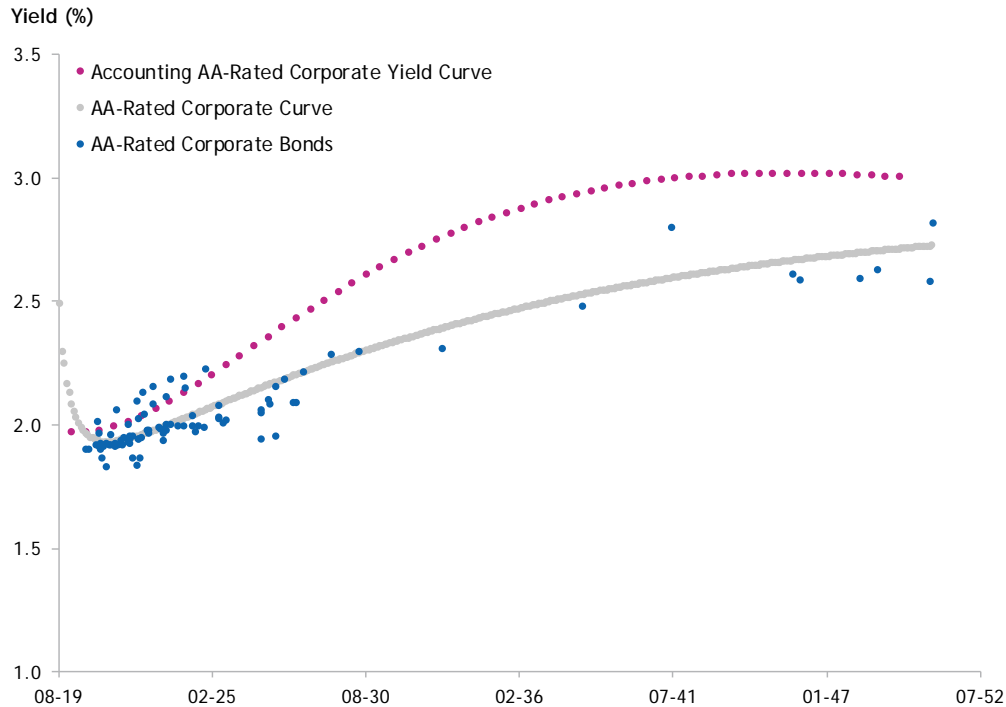
AAA and AA bonds outstanding across currencies



AAA and AA issuers across currencies



AA-Rated Corporate Bond Yield Curve (Canada)



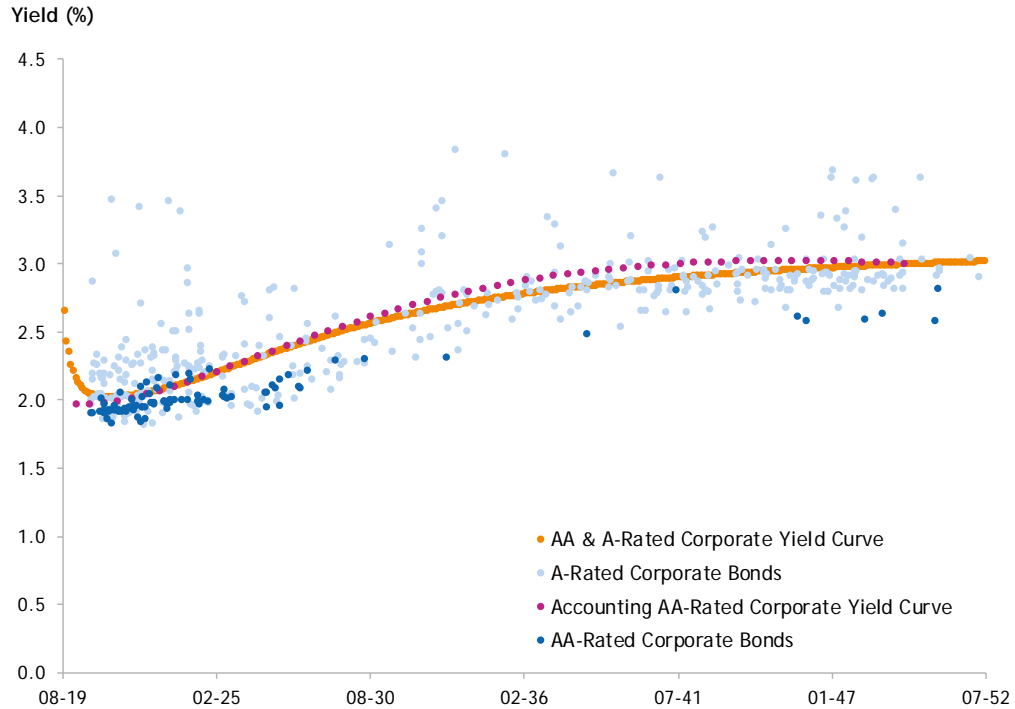
Scarcity of AA-rated corporate bonds with long maturities

Accounting composed of AA-rated provincial bonds plus a spread adjustment beyond 10 years

As at September 30, 2019

Source: FTSE Canada, Addenda Capital

A and AA-Rated Corporate Bond Yield Curve (Canada)











As at September 30, 2019

Source: FTSE Canada, Addenda Capital

Liability hedging: capital efficiency

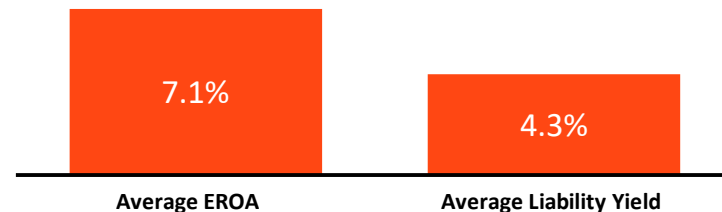


Strategically, plans need more efficient use of capital

Action	Expected Return Impact	Expected Surplus Risk Impact
Increase Hedge Portfolio Capital Allocation Example: Sell public equity and buy Treasuries and corporate bonds		
Increase Credit Exposure Example: Sell public equity and buy equity futures and corporate bonds		
Increase Rates Exposure Physically Example: sell whole bond Treasuries and buy long-dated Treasury STRIPS		
Increase Rates Exposure Synthetically Example: buy Treasury futures or other rate derivatives to increase total portfolio duration		

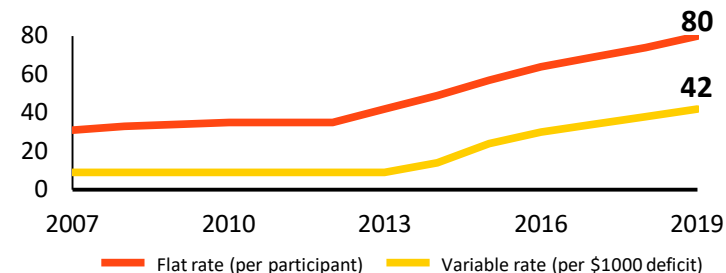
Source: BlackRock. Red, white, and green arrow colors indicate BlackRock's assessment of the likely impact of the above actions on the expected return and expected surplus risk of a US corporate defined benefit pension plan. Actions assessed as likely to increase expected return or decrease expected surplus risk are depicted with green arrows, those assessed as likely to decrease expected return or increase expected surplus risk are depicted with red arrows, and those assessed as unlikely to have a substantial impact are depicted with gray arrows. This assessment is as of 2/28/2019 and is subject to change. For illustrative purposes only and not a recommendation to buy or sell any security. Derivatives may involve certain costs and risks such as liquidity, interest rate, market, credit, management and the risk that a position could not be closed when most advantageous. Investing in derivatives could lose more than the amount invested. Expectations may not be achieved as forecasted.

Substantial growth exposure required to hit expected return targets



Source: company regulatory filings. Depicts average expected return on and liability yield for largest 50 US corporate defined benefit pension plans of companies included in the S&P 500 Index

PBGC rates have created higher hurdle rates and raised penalties for increased deficits

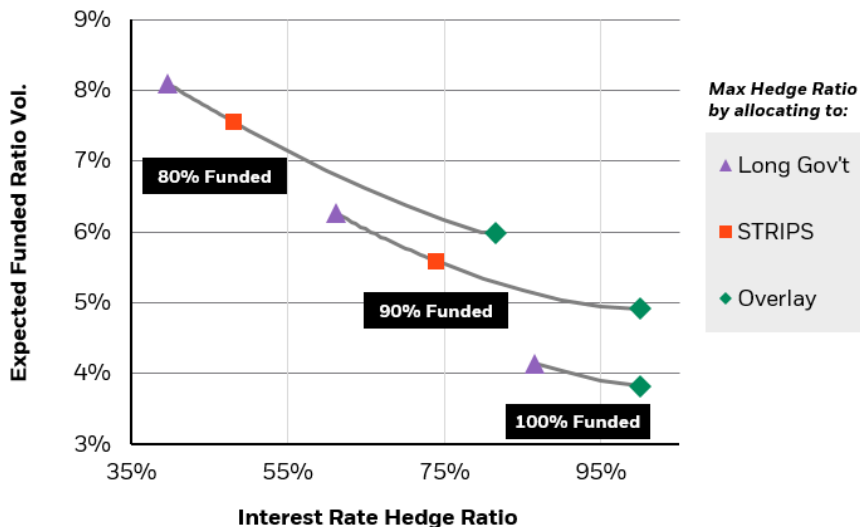


Source: PBGC (Pension Benefit Guaranty Corporation), as of 2/28/2019. Depicts the PBGC Flat Rate Premium ("Flat Rate (Per Participant)") and PBGC Variable Rate Premium ("Variable Rate (Per \$1,000 Deficit)") from 12/31/2007 to 2/28/2019

Capital efficient instruments can potentially reduce funded status volatility

- Including capital efficient instruments in rate hedging portfolio allows for more flexibility in targeting hedge for the same capital allocation at each funded ratio
- At each funded status level, assumes equal allocations to Long Corporate bonds, Equity and Rates hedging portfolio, expanding opportunity set to include more capital efficient instruments

Long AA Corporate Bond Yield Curve vs. Actual Bond Yields



	% Equity	% Long Corporate	% Rate Hedging
80% Funded	60%	25%	15%
90% Funded	45%	35%	20%
100% Funded	30%	45%	25%

Source: BlackRock, as of 2/28/2019. Material differences between and risks of investing in STRIPS, IRS on STRIPS, Treasury Futures, and Interest Rate Swaps are provided on page 54. For illustrative and educational purposes only and not meant to be a recommendation to invest in any security or instrument. Derivatives may involve certain costs and risks such as liquidity, interest rate, market, credit, management and the risk that a position could not be closed when most advantageous. Investing in derivatives could lose more than the amount invested

Basic forms of capital efficient rates implementation

STRIPS

- Definition: Zero coupon bonds representing specific interest and principal payments “stripped” from outstanding Treasury bonds
- How it’s traded: STRIPS are created when dealers separate the coupons and principal payments from US Treasury securities
- Characteristics: Traded like traditional bonds, have duration approximately equal to their maturity



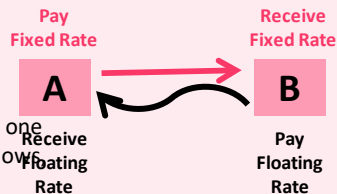
Treasury Futures

- Definition: A contract to buy/sell a specified maturity Treasury at a fixed price in the future
- How it’s traded: Trades take place on an organized exchange, reducing counterparty risk; forwards are private agreements between two parties
- Characteristics: Futures contracts have standardized terms like maturity; forwards are customized



Interest Rate Swaps

- Definition: Two parties agree to exchange one set of cash flows for another
- How it’s traded: Traded in cleared over-the-counter markets
- Characteristics: Swaps are used to exchange one set of cash flows for a different set of cash flows, often one fixed and the other variable



Total Return Swap

- Definition: Two parties agree to exchange the total return of the underlying for a financing cost
- How it’s traded: Traded in over-the-counter markets (not cleared)
- Characteristics: Can be structured against return on specific bonds, such as STRIPS, or indices. Require collateral agreements with counterparties

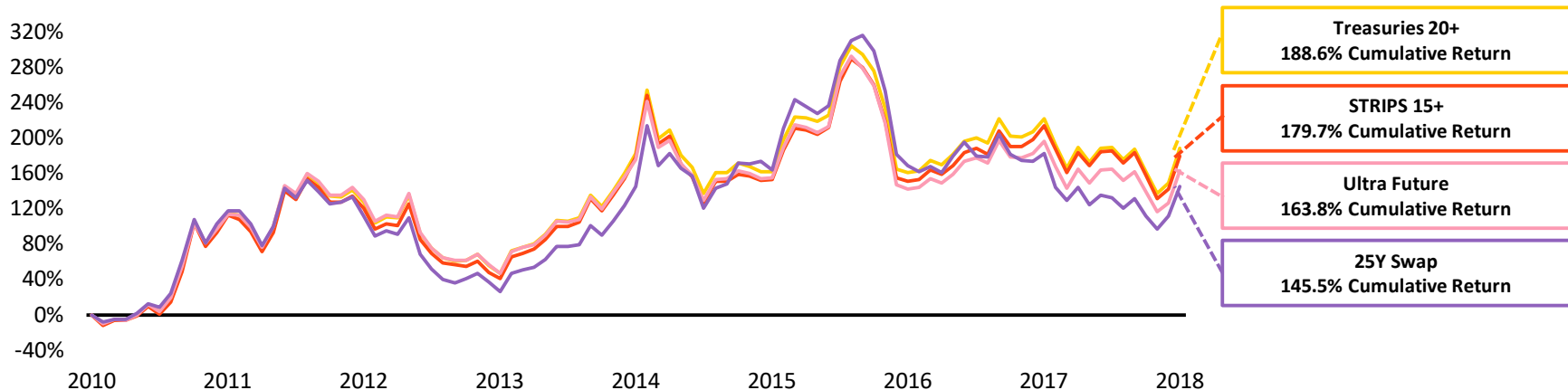


Source: BlackRock, as of 2/28/2019. Material differences between and risks of investing in STRIPS, TRS on STRIPS, Treasury Futures, and Interest Rate Swaps are provided on slide 64. For illustrative and educational purposes only and not meant to be a recommendation to invest in any security or instrument. Derivatives may involve certain costs and risks such as liquidity, interest rate, market, credit, management and the risk that a position could not be closed when most advantageous. Investing in derivatives could lose more than the amount invested

Instrument selection matters

Physical Treasuries have exhibited greater efficiency than interest rate derivatives net of financing costs

Cumulative returns



	Treasuries 20+	STRIPS 15+	Ultra Future	25Y Swap
Annualized Return	14.2%	13.7%	12.9%	11.9%
Annualized Risk	33.3%	34.1%	33.2%	33.6%
Sharpe Ratio	0.41	0.39	0.38	0.34

Source: BlackRock analysis from 12/31/2010 to 12/31/2018. The above figures assume the underlying indices / instruments have all been scaled to duration of 50 years. Treasuries and STRIPS assume financing cost of 1-month LIBOR, applied to the difference of notional value less capital. Cash collateral assumed to earn 3-month Treasury Bills return for Ultra Future and 3-month LIBOR return for 25Y Swap. For illustrative purposes only. Past performance is not an indicator of future results. Derivatives may involve certain costs and risks such as liquidity, interest rate, market, credit, management and the risk that a position could not be closed when most advantageous. Investing in derivatives could lose more than the amount invested

Considering the attributes of various capital efficient tools

	Treasury Futures	Interest Rate Swaps	STRIPS	TRS on STRIPS
Precision	Duration	Curve and Duration	Curve and Duration	Curve and Duration
Value Drivers	Negative Crowded Positioning and CTD Drag	Negative Lower Yield and Higher Basis Risk	Positive Relative Cheapness and Relative Value Potential	Positive Relative Cheapness and Relative Value Potential
Transaction Cost	Lower	Lower	Higher	Higher
Roll Cost	Higher	Higher	N/A	N/A
Financing Cost	Lower	Higher	N/A	Moderate
Capital Efficiency	Higher	Higher	Moderate	Higher
Documentation Required	Yes	Yes	No	Yes

Source: BlackRock, as of October 2019. Material differences between and risks of investing in STRIPS, TRS on STRIPS, Treasury Futures, and Interest Rate Swaps are provided on following slide. Red, yellow, and green text colors indicate BlackRock's assessment of the desirability of the characteristics above for a US corporate defined benefit pension plan seeking to hedge its liability interest rate risk, with red being the least desirable, green the most, and yellow moderately desirable. This assessment is as of October 2019 and is subject to change. For illustrative and educational purposes only and not meant to be a recommendation to invest in any security or instrument. Derivatives may involve certain costs and risks such as liquidity, interest rate, market, credit, management and the risk that a position could not be closed when most advantageous. Investing in derivatives could lose more than the amount invested

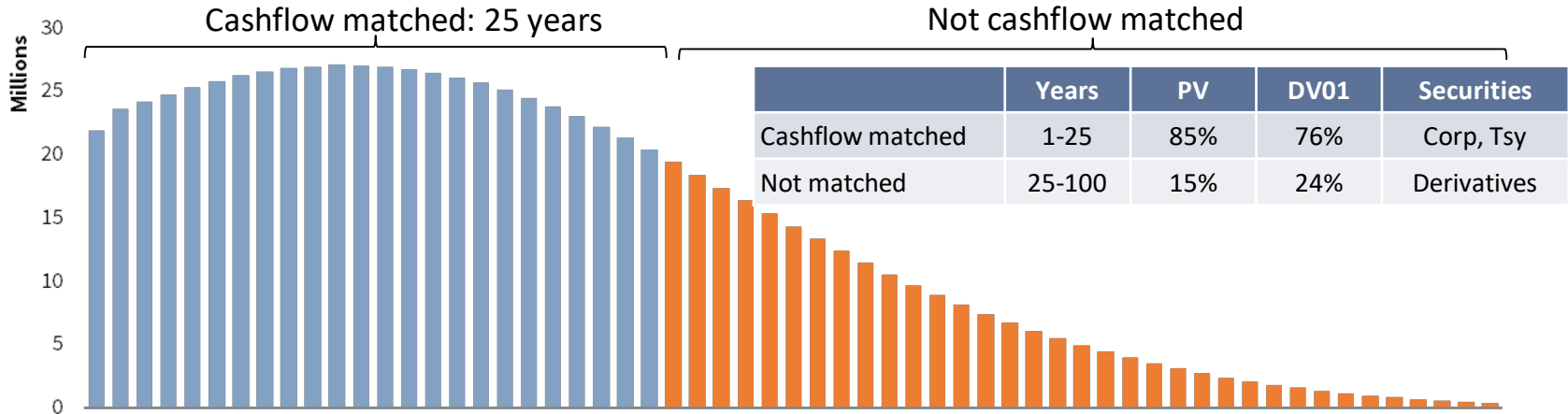
Liability hedging: cashflow matching



CASHFLOW MATCHING

- Matches liability cashflows with high-quality corporate bonds and Treasuries up to a certain number of years, usually at least 20-25
- Implicitly hedges liability interest rate, credit spread, and curve risk for the period matched; requires derivatives to achieve a full hedge
- Somewhat analogous to book yield approach taken by insurance companies

SAMPLE PLAN PROJECTED BENEFIT PAYMENTS



Sample hard-frozen, annuity-only plan, total plan duration is 13.9 years.

CASHFLOW MATCHING: HIGHLIGHTS

- For plans with well-defined cashflows (i.e., hard-frozen plan, no lump sums, no cash balance), this presents a very certain match for the period matched
- Intended as a “set it and forget it” portfolio (unless the liability changes)
- Generally very low turnover (and therefore low trading costs)
- Generally low management fees
- May be higher quality than market-based portfolios, with a sharp focus on avoiding downgrades and defaults
- Benchmark-agnostic

CASHFLOW MATCHING: CONSIDERATIONS

- Not applicable for plans with somewhat unpredictable and/or changing cashflows (i.e., open plans, plans that pay lump sums)
- May defeat its purpose if liability cashflow profile changes due to demographics, assumptions, or plan formulas
- Generally locks in yields available at the time of implementation and limits opportunity for value-add through active management and new issuance
- May result in higher trading costs and/or coarse matching at longer maturities
- May not be dynamic enough to hedge the Aa spread component
- May not generate sufficient excess return to offset administrative expenses
- Benchmarking is either nonexistent or complex

Liability hedging: moment matching



Moment Matching Immunization

Linear optimization to achieve minimum portfolio cost for selected immunization level

Asset and liability price functions are equivalent if the moments of their Taylor series are the same

Objective: Minimum cost

Subject to: Present Value_{Assets} ≥ Present Value_{Liabilities}

Asset Moments = Liability Moments

$$\sum_{i=1}^N [I_{k,i} \times PV_i] = \sum_{j=1}^L [J_{k,j} \times PV_j] \quad , \quad k = \{1, 2, \dots, m\}$$

$I_{k,i}$ and $J_{k,j}$ are k th immunization moments of the i th securities and j th liability payments, respectively

Hedges against parallel and non parallel changes to interest rate curve

Also subject to investment policy's constraints and diversification guidelines

Trade-off between policy constraints, immunization objectives and portfolio's YTM

Why Using Moment Matching

Advantages

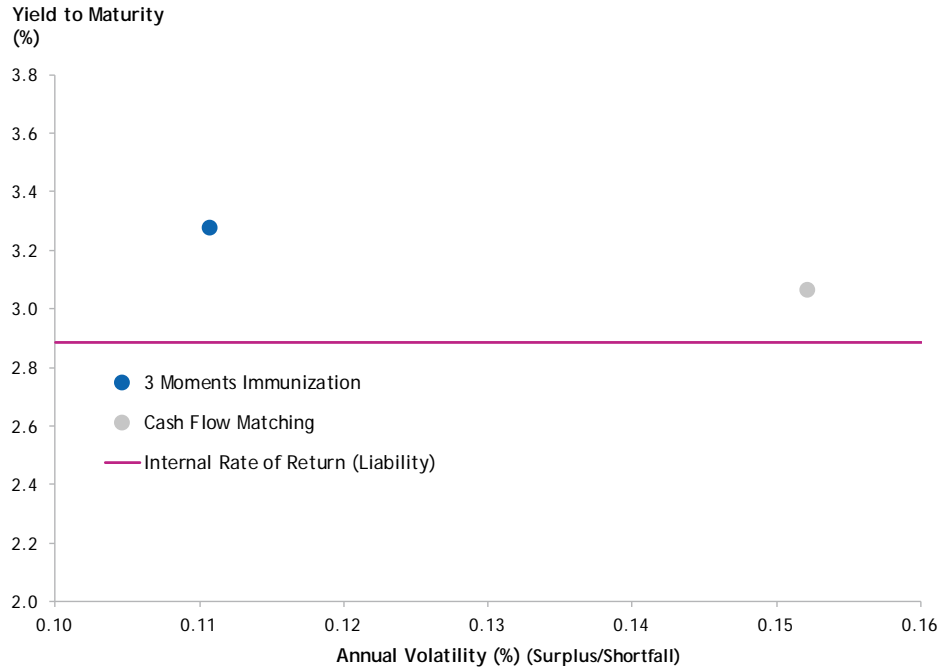
- Simplicity and flexibility, one-step portfolio construction process
- Immunizes long term liability cash flows
- Facilitate use of derivatives (bonds forwards or repo) to increase hedging ratio
- Bond pooled funds may be integrated to the solution as single securities
- Scalability

Disadvantages

- Does not separate credit spread and base rate components
- Less appropriate with some discount curves (e.g. 2-tier rate commuted value assumptions)

Immunization Portfolio Comparisons

Present value-driven immunization method produces lower surplus volatility



Duration of 10 years as of September 30, 2019

Sources: FTSE Canada, Addenda Capital

Stochastic Rate Sensitivity Analysis and Key Rate Duration Comparison

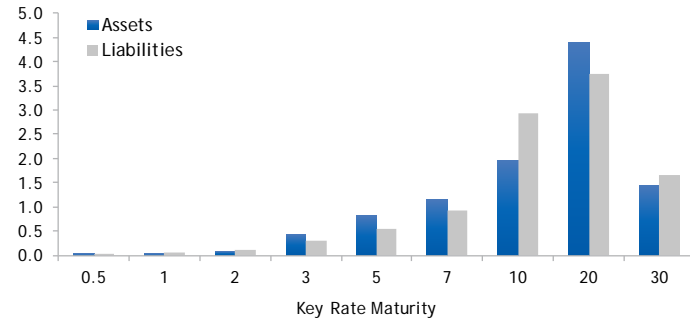
Moment Matching requires fewer securities

Three-Moment Matching

Yield to Maturity (%)	3.28
VaR (95%) – Annualized (%)	-0.18
VCaR (95%) – Annualized (%)	-0.23
Std. Deviation – Annualized (%)	0.11
Number of Securities	25

Key Rate Duration

Duration (Years)



Duration of 10 years as of September 30, 2019

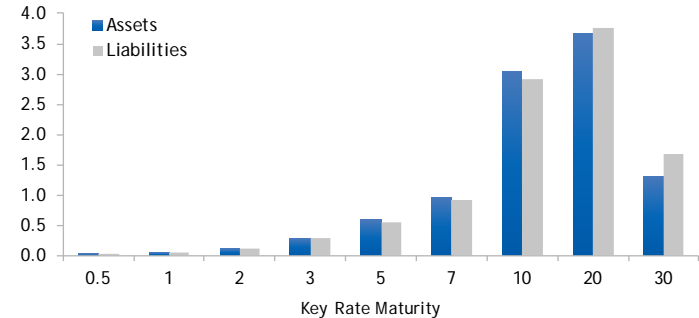
Sources: Addenda Capital, FTSE Canada

Cash Flow Matching

Yield to Maturity (%)	3.07
VaR (95%) – Annualized (%)	-0.26
VCaR (95%) – Annualized (%)	-0.32
Std. Deviation – Annualized (%)	0.15
Number of Securities	185

Key Rate Duration

Duration (Years)



Benchmarking considerations



BENCHMARKING OBJECTIVES

- Ultimate objective is to measure the success of the hedge, which can often be measured via (1) attribution of funded status and (2) maintenance of hedge ratios
- A traditional benchmark may still be needed or required by various stakeholders
- Traditional benchmark is appropriate for standard market strategies, where alpha may be expected, e.g., Long Credit

POTENTIAL CUSTOM BENCHMARKS

	Blend of market benchmarks	“Uninvestible” liability benchmark	“Investible” liability benchmark
Benchmark	Match a blend of market benchmarks to the liability duration or key rate profile	Actual liability cashflows discounted with a Aa curve	Blend of market credit and Treasury benchmarks and Treasury futures matched to the liability key rate profile
Complexity	Lowest	Moderate to High	High
Transparency	Highest	Moderate	High
Match to the liability	Moderate to high, but may deviate over time	Highest (it is the liability!)	High
Leverage	Usually does not incorporate	Can incorporate	Can incorporate

INVESTIBLE CUSTOM TREASURY BENCHMARK

Objective	Investible benchmark approximating the uninvestible liability benchmark
Construction	<ul style="list-style-type: none">▪ Target key rate DV01s = interest rate hedge ratio × Liability DV01s – other credit assets DV01s▪ Determine unique blend of Treasury benchmarks and Treasury futures contracts to (1) match these DV01s and (2) reflect market value of physical assets in the Treasury portfolio▪ If desired, can use alternative derivatives (e.g., interest rate swaps), but be aware of basis risk to the liability
Return	<ul style="list-style-type: none">▪ Return of this blend of Treasury benchmarks and Treasury futures▪ Note that cost of leverage is embedded in the return of the Treasury futures
Reconstitution	<ul style="list-style-type: none">▪ Typically monthly

Comparison of LDI benchmarking approaches

The table below provides an overview of the key characteristics of various approaches to LDI benchmarking

	Asset-Based Benchmark (Traditional)	Asset-Based Benchmark (Custom Blend)	Liability benchmark (managed via commingled funds)	Liability Cash Flow Benchmark
Strategy managed / evaluated against third-party benchmark	✓✓	✓✓	✓	
Hedge curve risk		✓✓	✓✓	✓✓✓
Rebalancing efficiency	✓✓	✓✓	✓✓	✓✓✓
Benchmark tracks desired liability DV01		✓	✓	✓
Leverage Flexibility	✓✓	✓✓	✓	✓✓
Emphasis on value-add	✓✓	✓✓	✓	✓✓
Compatible with completion management approach		✓	✓	✓
Operational setup simplicity	✓	✓	✓✓✓	✓
Counterparties do not have recourse to total plan assets	✓	✓	✓	✓

Source: BlackRock. For illustrative purposes only. This is not meant to be a recommendation to buy or sell any securities.

Liability hedging: longevity risk



Hedging Longevity Risk

Market-Based Solutions for Hibernating Pension Plans

- Neglected source of contribution and surplus risk
- Non diversifiable
- Size doesn't reduce longevity risk
- Growing portion of the risk budget
- Low interest rate and lower expected returns increase vulnerability

Longevity Risk Solutions

Currently limited to longevity risk transfer to insurers and reinsurers

- Annuity buy-outs/buy-ins are the most common forms of risk transfer
 - Transfer the investment and longevity risks to insurers
 - Capacity is limited
 - Costs could be significant and the process is irreversible
- Longevity swaps (insured)
 - Better suited to large plans because of their complexity and costs
 - More prevalent in the U.K. where regulations encourage de-risking

Publicly-Traded Longevity Products vs. Risk Transfer

Potentially more cost efficient and provides flexibility

- Retain full control over the pension plan
- Reversible solution
- Active management of longevity risk
- Liquidity
- Transparency
 - Mortality index
 - Market prices
- Customization mortality

Potential Participants in a Liquid Longevity Market

Participants

Pension Plans

Life Insurers and Reinsurers

Investors

Buyers of Longevity Protection

Hedging

Hedging (annuities)

Sellers of Longevity Protection

Hedging (life insurance)

Uncorrelated source
of risk premium

Examples of Longevity Derivatives Instruments



Pension fund pays fixed S-Rate equal to expected survival rate plus risk premium



Pension fund receives fixed q-Rate equal to expected mortality rate less risk premium

Desired Features of an Efficient Longevity Market

Longevity derivatives could be a valuable addition to your tool box

- Simple yet robust mortality and pricing models
- Availability of a mortality index on a timely basis for settlement and mark-to-market purposes
- Transparency
- Cross-population modelling tools would contribute to reduce basis risk and expand market scope
- Explore possibility of incorporating interest rate hedging into longevity hedging instruments

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CAPITAL MARKET ASSUMPTIONS FOR SAME PORTFOLIOS

- Cambridge's 10-year capital market assumptions for equities and other growth assets is a forecast that explicitly models the current valuation of each asset class today, the "fair" or average valuation of each asset class historically, and the estimated return associated with reverting to "fair value" over a 10-year period. These assumptions assume moderate real earnings growth and a return from current values to fair value for equity multiples, largely based on historical averages. For fixed income Cambridge's 10-year capital market assumptions reflect yield to maturity for the applicable Bloomberg Barclays Indices and the liability discount rate as provided by the plan's actuary. We focus on fixed income yields, rather than returns in the pension context as under US accounting standards, the liability discount rate reflects current bond yields without any assumptions about changes in interest rates. (We model impact of interest rates on both fixed income assets and the liability as part of scenario analysis.) This approach assumes an inflation rate of 2.5%.
- Expected asset returns reflect expected market (beta) returns and are net of investment management fees; they do not incorporate any manager value-add other than the assumption that active manager value-add fully offsets the active manager investment management fees.
- Capital market assumptions are intended to inform asset allocation but they are not predictive of the future. Actual investment experience may be significantly different from the capital market assumptions shown in this analysis.

		Intermediate-Term			Correlations											
		Arithmetic	Geometric	Std Dev	GLE	AR	PE	PCR	HYB	CA	LUSIGC	IntUSIGC	LUSIGC	LUSGov	ULT	
GLE	Global Equity	6.2%	4.8%	17.5%	GLE	1.00	0.58	0.74	0.68	0.68	-0.05	0.28	0.30	0.28	-0.01	-0.01
AR	Absolute Return	5.0%	4.6%	9.9%	AR	0.58	1.00	0.42	0.52	0.52	0.00	0.20	0.21	0.20	0.07	0.07
PE	Private Equity	9.2%	6.8%	23.6%	PE	0.74	0.42	1.00	0.49	0.49	-0.03	0.24	0.24	0.24	0.01	0.01
PCR	Private Credit	8.1%	6.7%	17.5%	PCR	0.68	0.52	0.49	1.00	1.00	0.00	0.48	0.50	0.48	0.11	0.11
HYB	High Yield Bonds	5.5%	4.7%	13.0%	HYB	0.68	0.52	0.49	1.00	1.00	0.00	0.48	0.50	0.48	0.11	0.11
CA	Cash	2.0%	2.0%	2.0%	CA	-0.05	0.00	-0.03	0.00	0.00	1.00	0.19	0.20	0.19	0.27	0.27
LUSIGC	Long U.S. Investment Grade Credit	4.2%	3.5%	12.0%	LUSIGC	0.28	0.20	0.24	0.48	0.48	0.19	1.00	0.96	1.00	0.72	0.72
IntUSIGC	Intermediate U.S. Investment Grade	2.6%	2.3%	7.0%	IntUSIGC	0.30	0.21	0.24	0.50	0.50	0.20	0.96	1.00	0.96	0.75	0.75
LUSIGC	Long U.S. Investment Grade Credit	4.2%	3.5%	12.0%	LUSIGC	0.28	0.20	0.24	0.48	0.48	0.19	1.00	0.96	1.00	0.72	0.72
LUSGov	Long U. S. Government Bonds	2.6%	1.9%	12.0%	LUSGov	-0.01	0.07	0.01	0.11	0.11	0.27	0.72	0.75	0.72	1.00	1.00
ULT	Long STRIPS	3.9%	2.0%	20.0%	ULT	-0.01	0.07	0.01	0.11	0.11	0.27	0.72	0.75	0.72	1.00	1.00

Material differences between and risks of investing in STRIPS, TRS on STRIPS, Treasury Futures, and Interest Rate Swaps

STRIPS: Treasury STRIPS (Separate Trading of Registered Interest and Principal of Securities) are fixed income securities consisting of a single cash flow at maturity and backed by the full faith and credit of the US Federal Government. They are created through the separation of the interest and principal cash flows of Treasury securities into individual securities. Investing in STRIPS bears interest rate risk.

TRS on STRIPS: Total return swaps on Treasury STRIPS are contracts in which two counterparties agree to exchange payments according to a specified schedule based on a specified principal amount. One party's payments are based on a specified fixed or floating rate, and the other party's are based on the total return of one or more specified Treasury STRIPS securities. The latter party has long exposure to fluctuations in Treasury rates. Total return swaps on Treasury STRIPS trade over the counter and are not centrally cleared. Investing in TRS on STRIPS bears interest rate risk and counterparty credit risk.

Treasury Futures: Treasury futures are contracts in which two counterparties agree to exchange a Treasury security at a specified price on a specified date in the future. One counterparty is obligated to deliver the Treasury security, and the other to receive it. The latter party has long exposure to fluctuations in Treasury rates. Treasury futures are centrally cleared. Investing in Treasury Futures bears interest rate risk.

Interest Rate Swaps: Interest rate swaps are contracts in which two counterparties agree to exchange future interest payments according to a specified schedule based on a specified principal amount. One party's payments are based on a specified floating rate, and the other party's are based on a specified fixed rate. The latter party has long exposure to fluctuations in Treasury rates and swap spreads. Interest rate swaps trade over the counter and are not centrally cleared. Investing in Interest Rate Swaps bears interest rate risk and swap spread risk.

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The sensitivity analysis was based on a decomposition of the Canada yield curves through a Principal Components Analysis process (PCA) over a reference period of 10 years ending September 30, 2019. The liabilities were calculated using representative pension cash flows discounted with over three thousand simulated accounting discount yield curves. The market values of the assets were estimated based on the immunization portfolios and the interest rate simulations.

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