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Session 74 L, Strategic Asset Allocation & Derivatives: Applications to Pricing and Asset Liability Management

Moderator:

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Henry Yim, FSA, CFA

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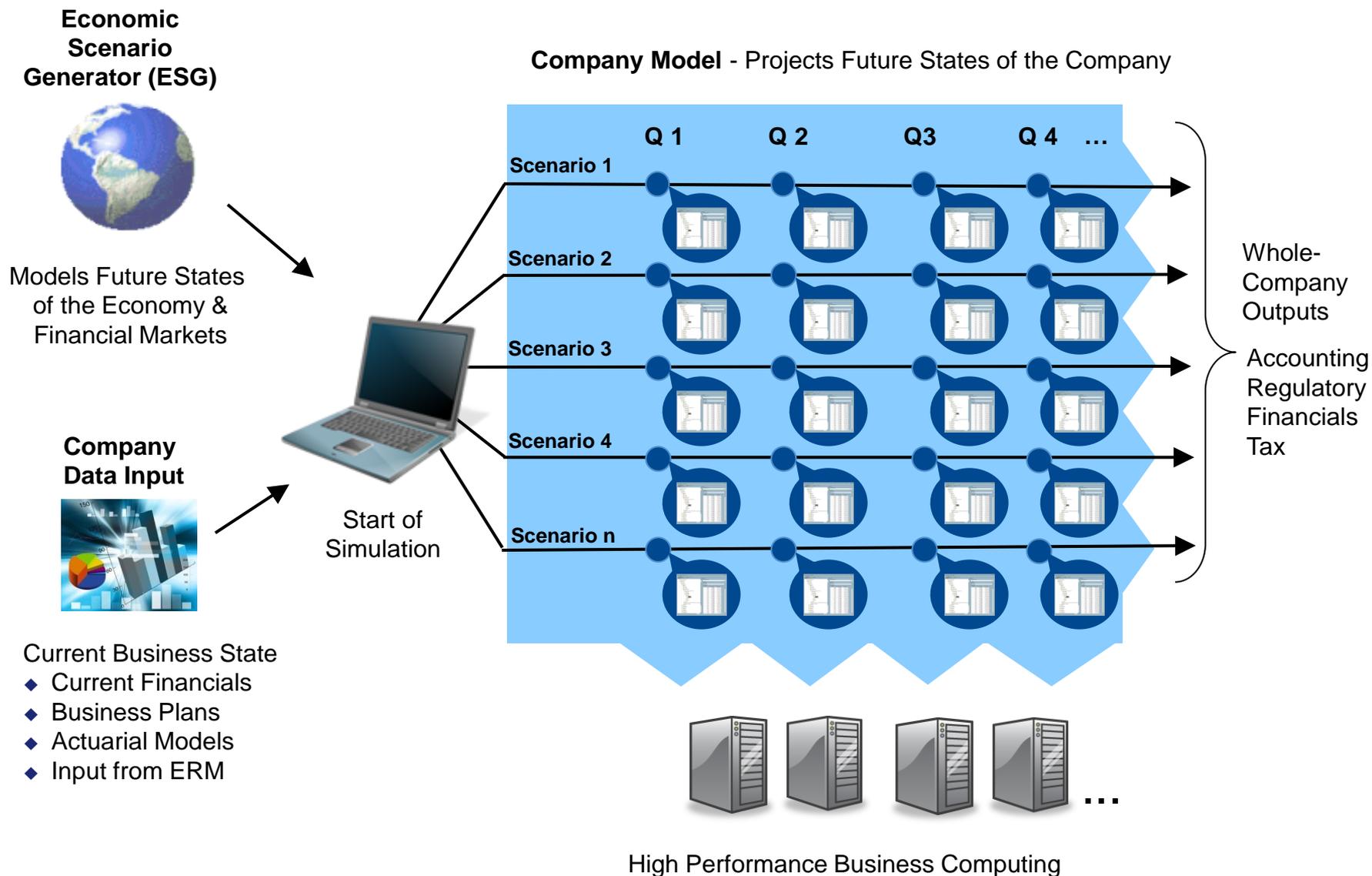
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**Strategic Asset
Allocation &
Derivatives:
Applications to Pricing
and Asset Liability
Management**

May 9, 2017

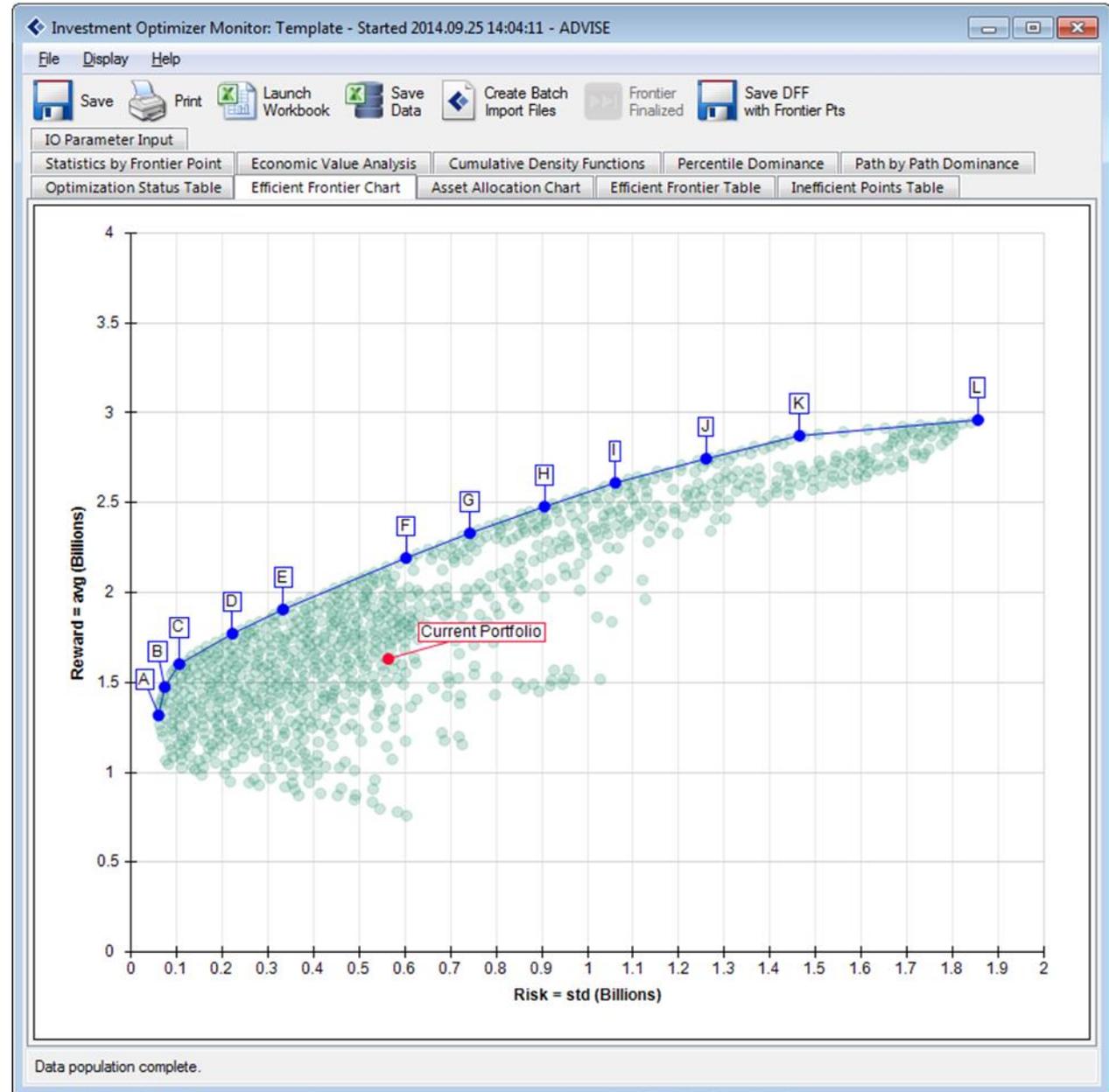
Simulation Modeling Approach



Economic Value (EV) Efficient Frontier

Integrated ALM

- ◆ Identify investment strategy to meet specific risk/reward profile
- ◆ Maximize economic value - not just investment returns - for various levels of risk
- ◆ Provides a platform for aggregating enterprise risks

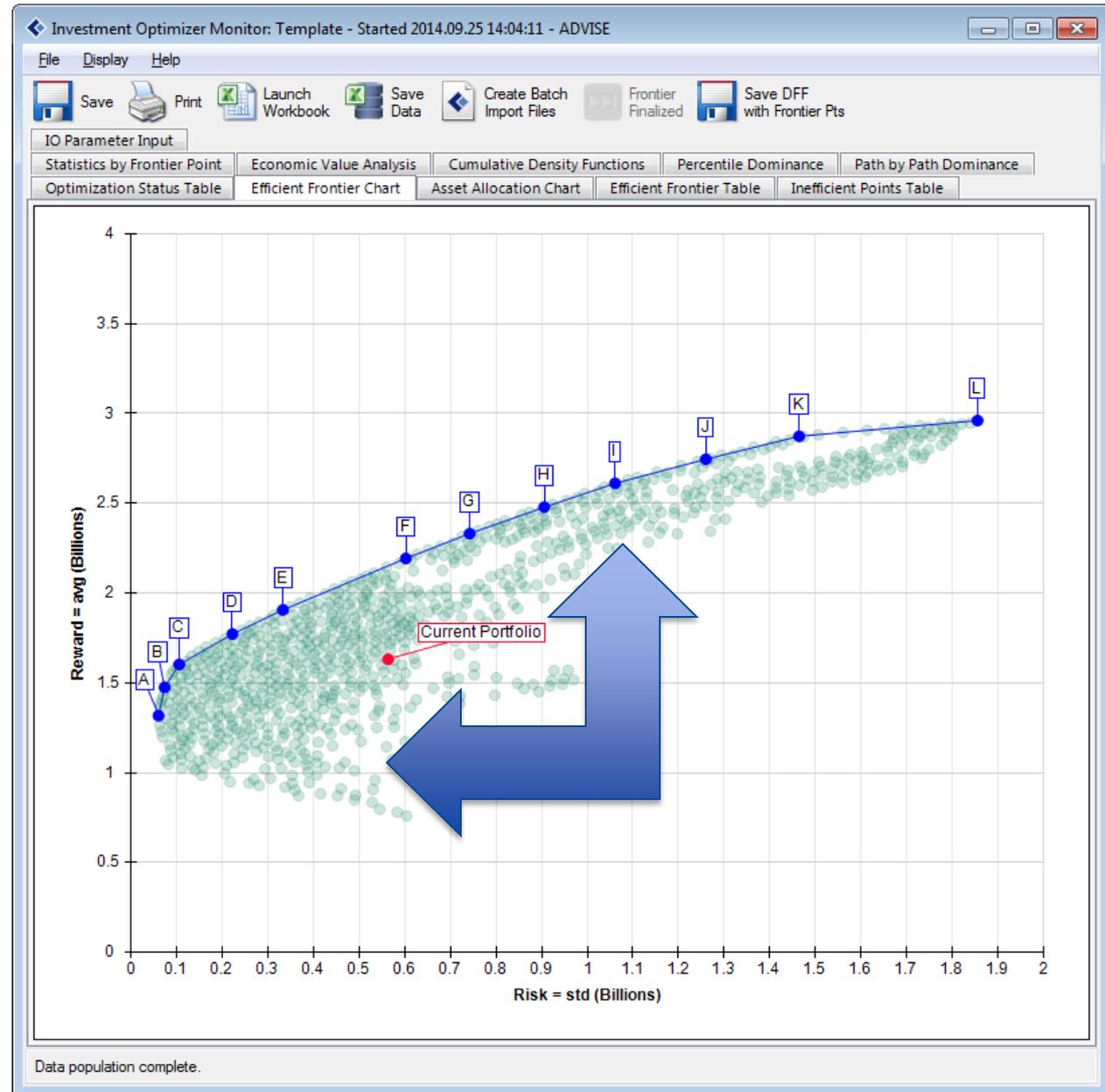


Source: Conning ADVISE

Economic Value (EV) Efficient Frontier

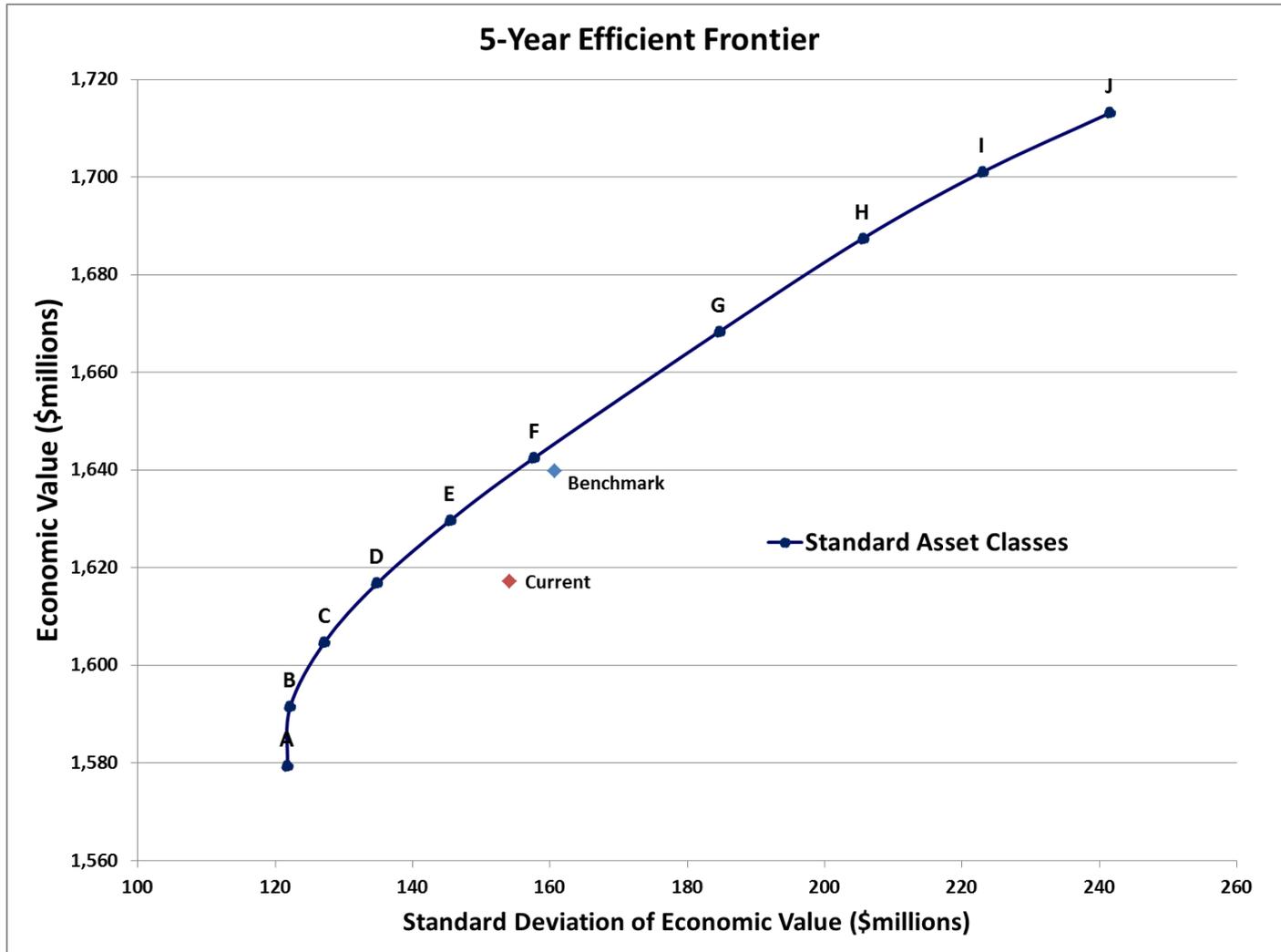
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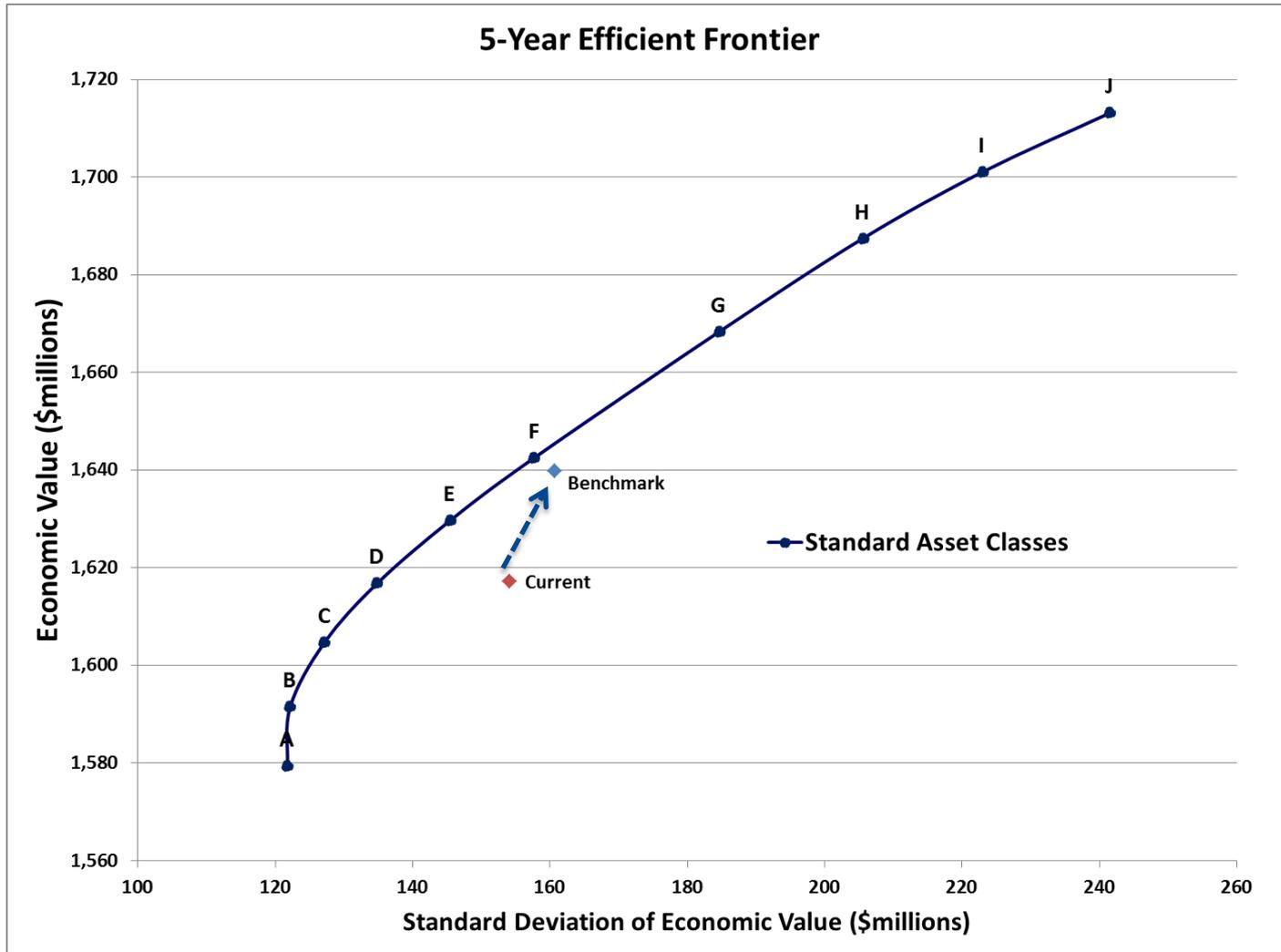
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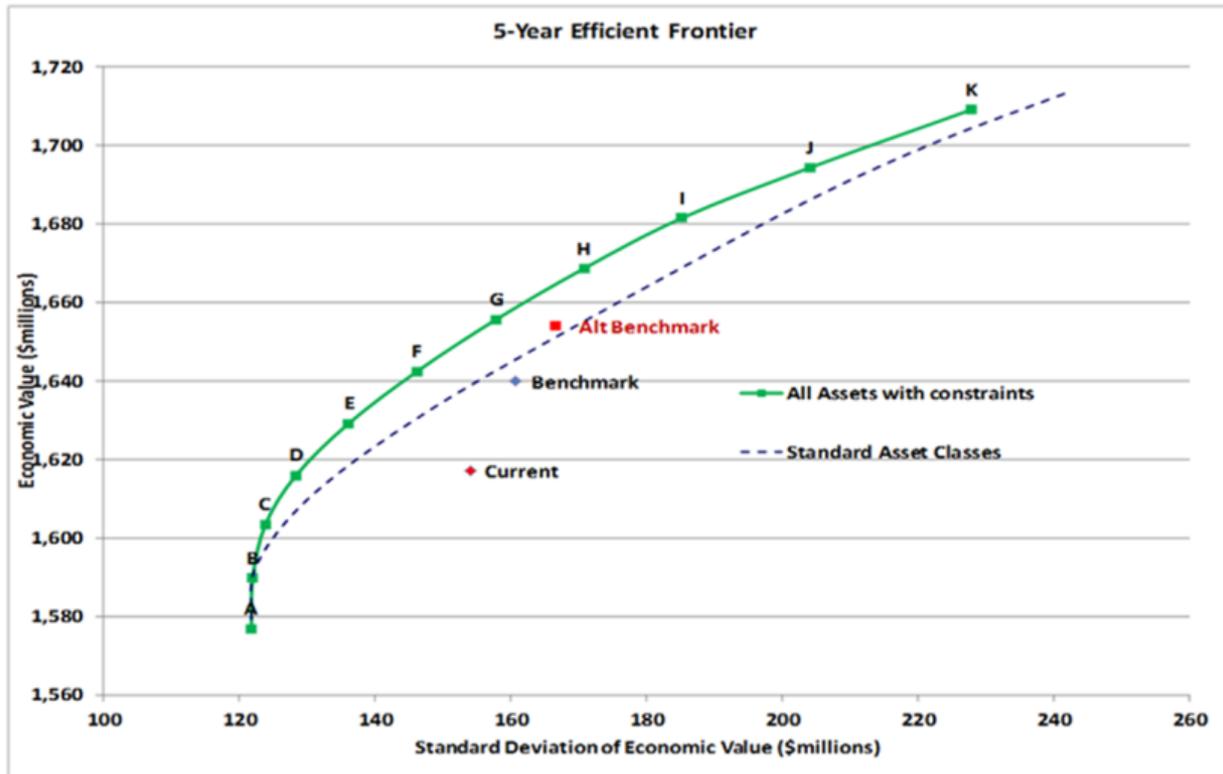
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Source: Conning analysis

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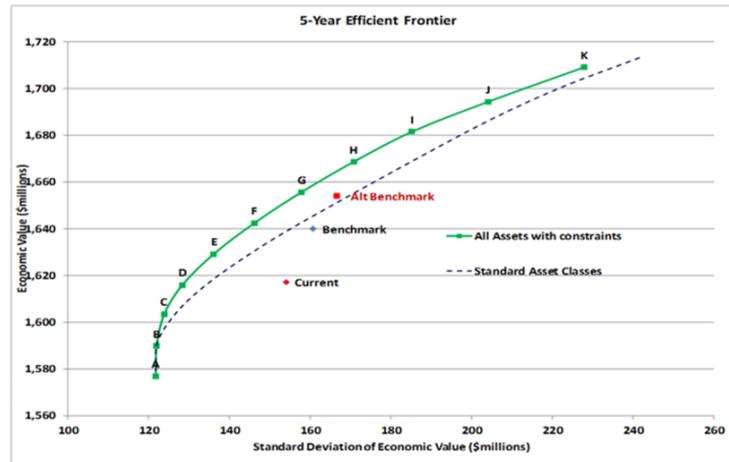
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Cash and Govt	5%	4%	36%	16%	8%	6%	1%	-	-	-	-	-	-
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US Equity	-	1%	-	-	-	-	-	-	-	-	-	1%	4%
Alternative Assets	-	3%	-	-	1%	1%	1%	1%	3%	3%	3%	3%	3%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
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Economic Value (\$MM)	1,617	1,654	1,577	1,590	1,603	1,616	1,629	1,642	1,656	1,669	1,681	1,694	1,709
Risk (\$MM)	154	167	122	122	124	128	136	146	158	171	185	204	228

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Economic Value (EV) Asset Allocation

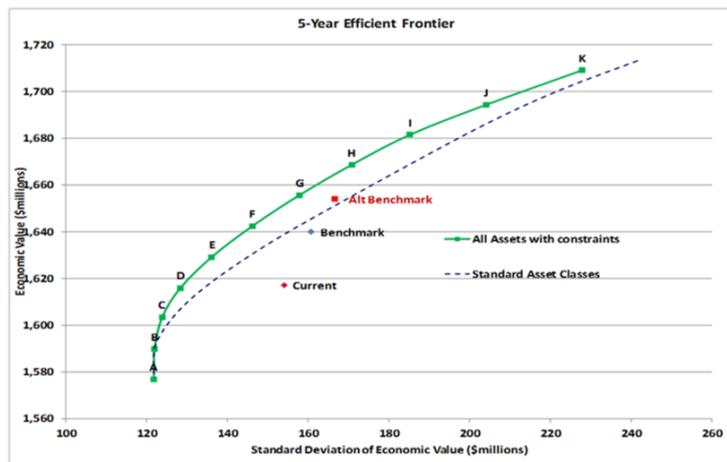


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- ◆ Credit Risk
- ◆ Illiquidity Exposure
- ◆ Alternative Assets
- ◆ Prepayment Risk
- ◆ Diversification
- ◆ Duration Targeting

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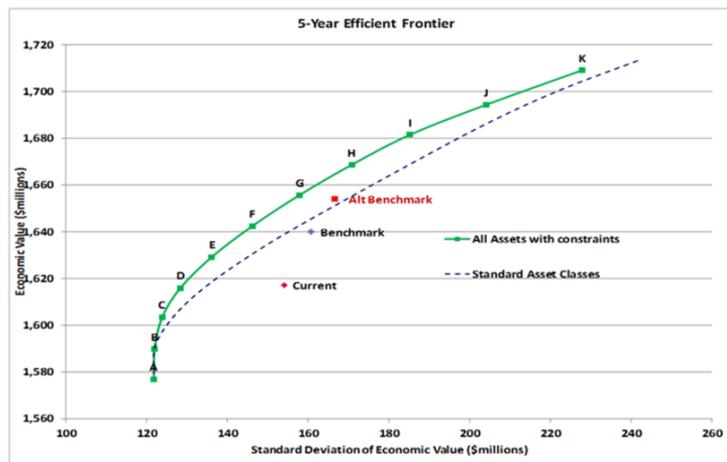


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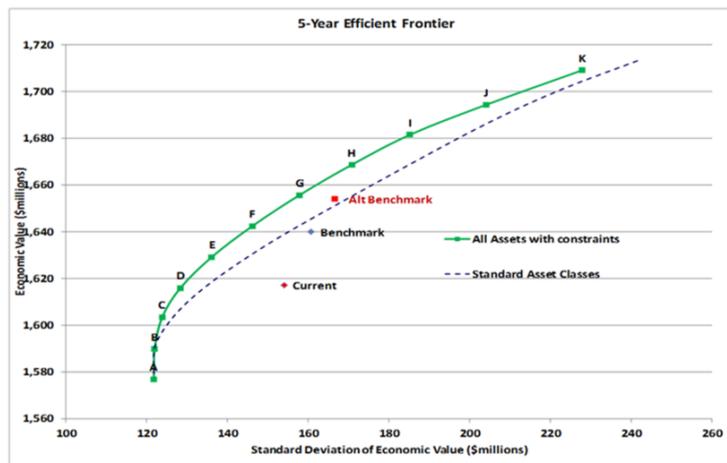
◆ Prepayment Risk

◆ Diversification

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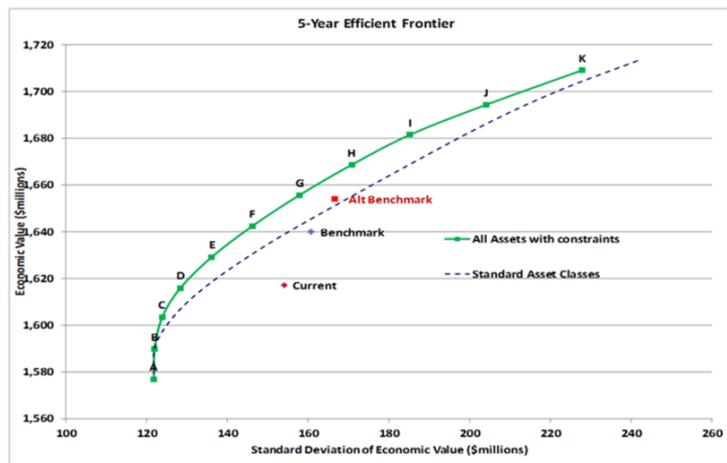


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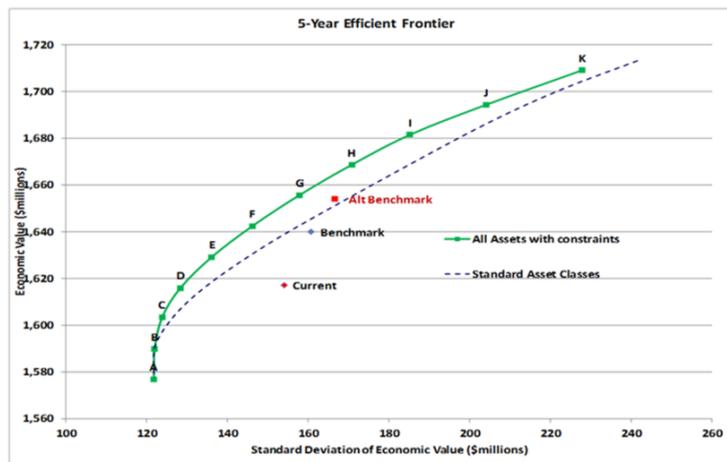


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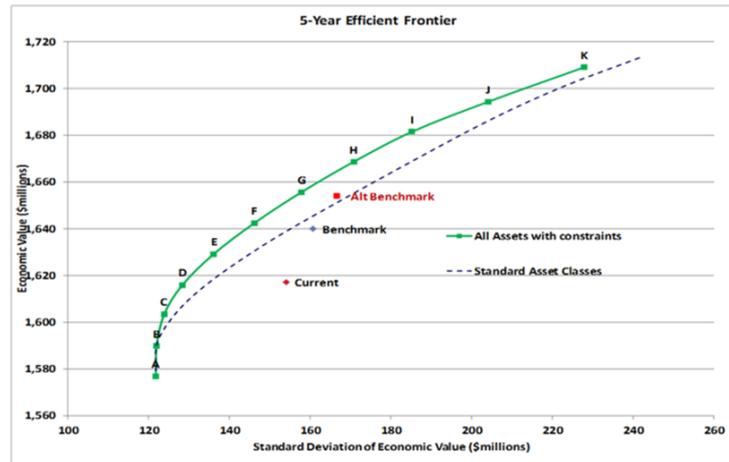


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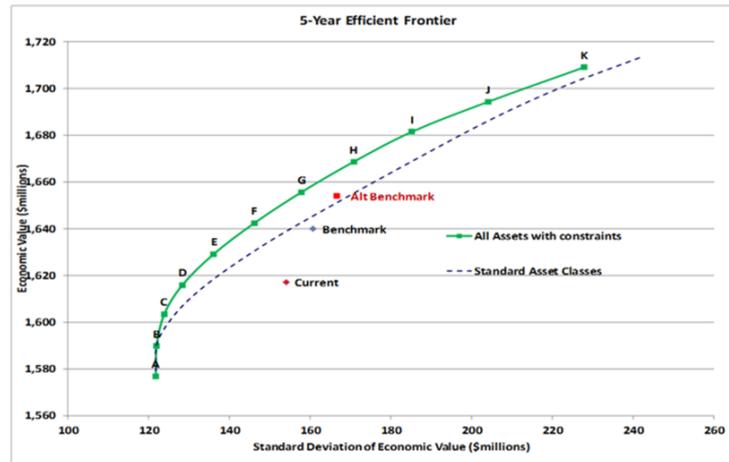


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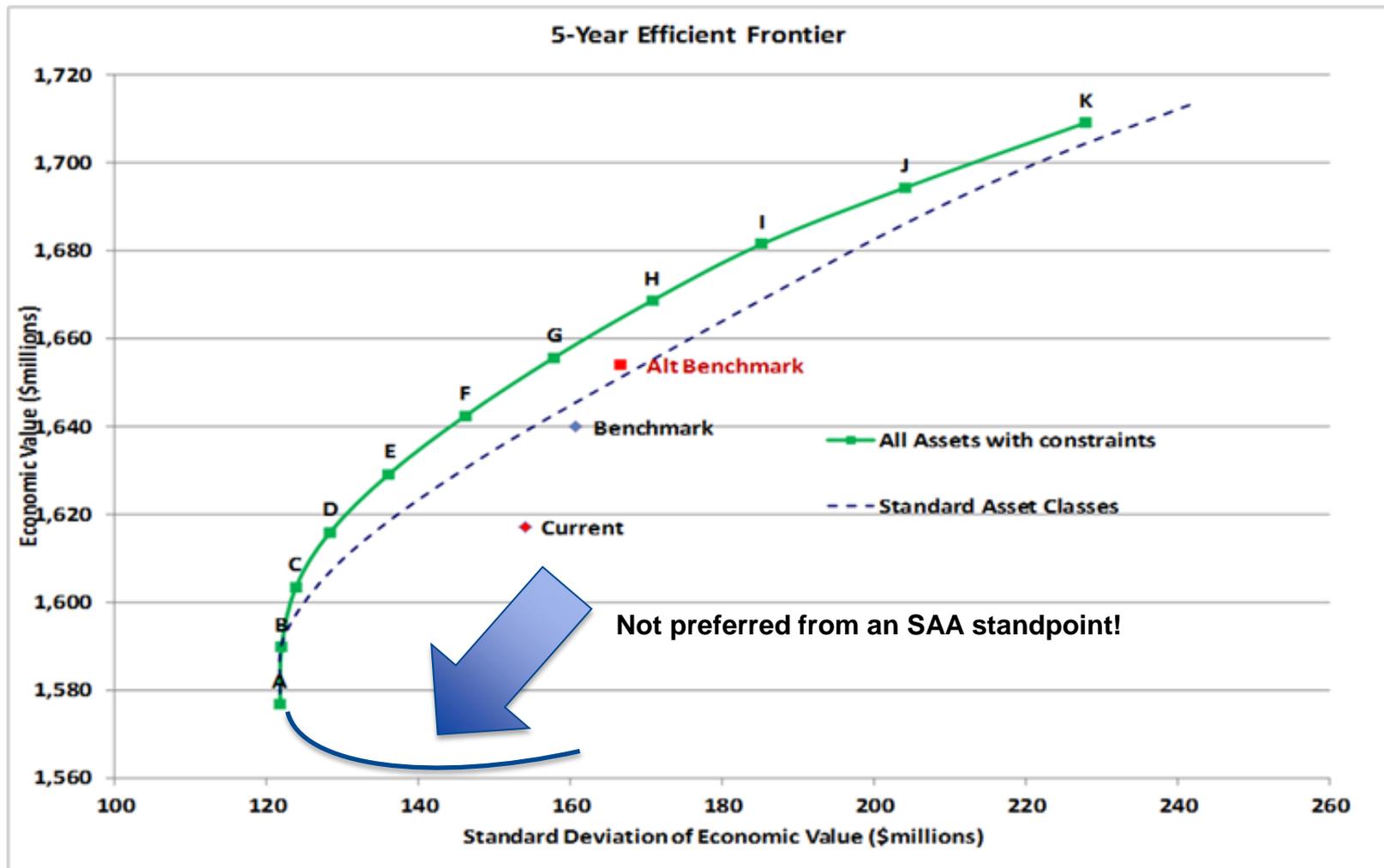


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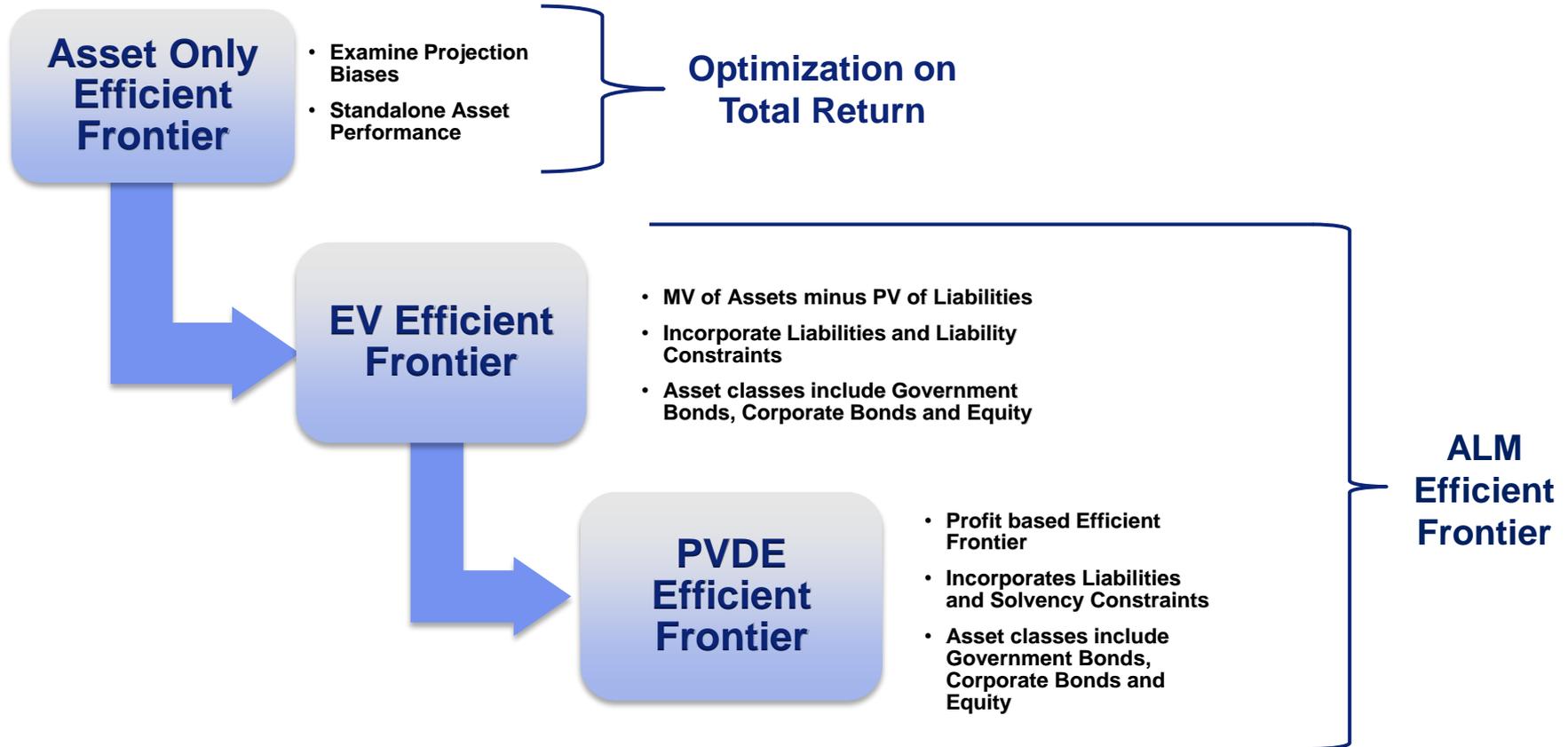
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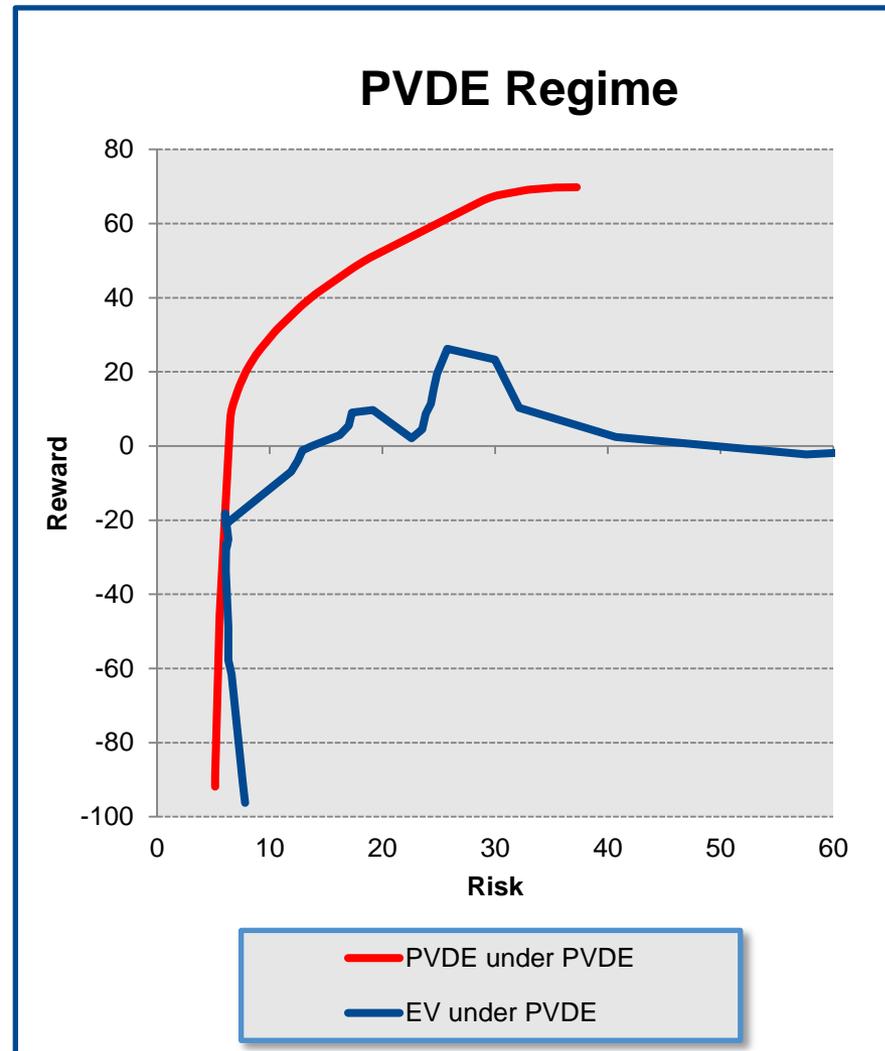
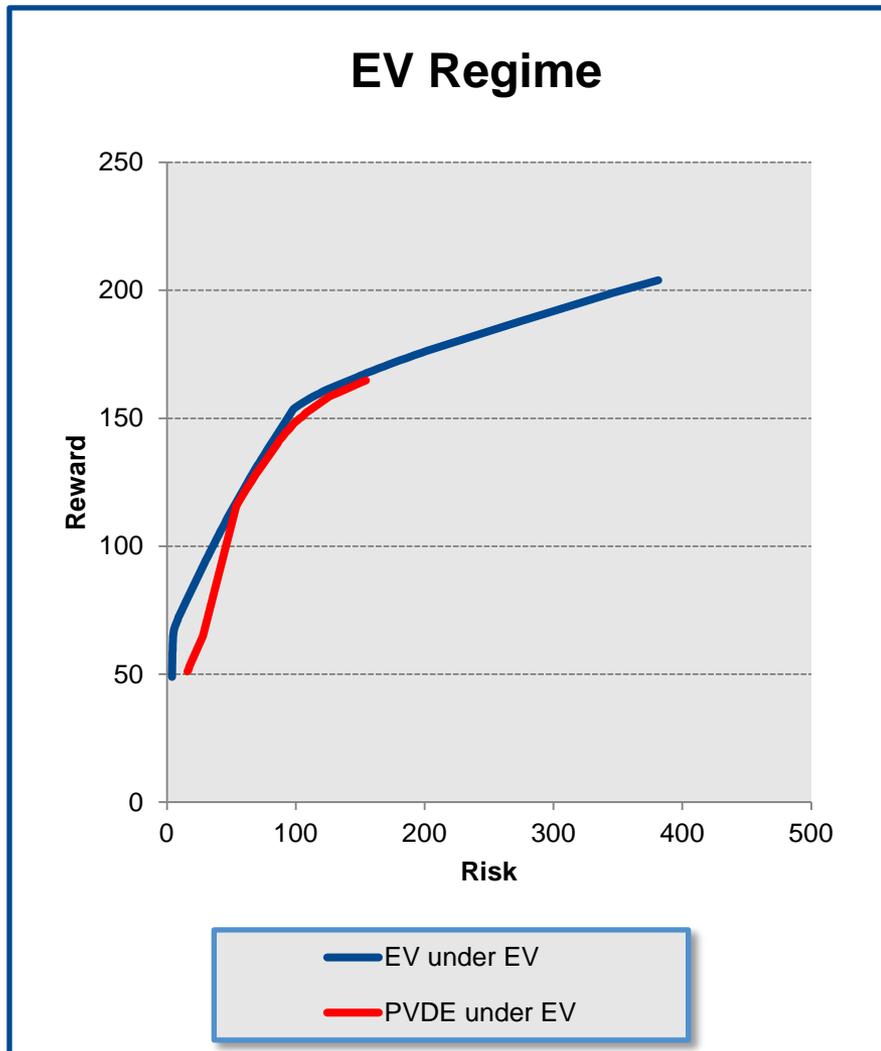
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The Efficient Frontier — Progressive Analysis



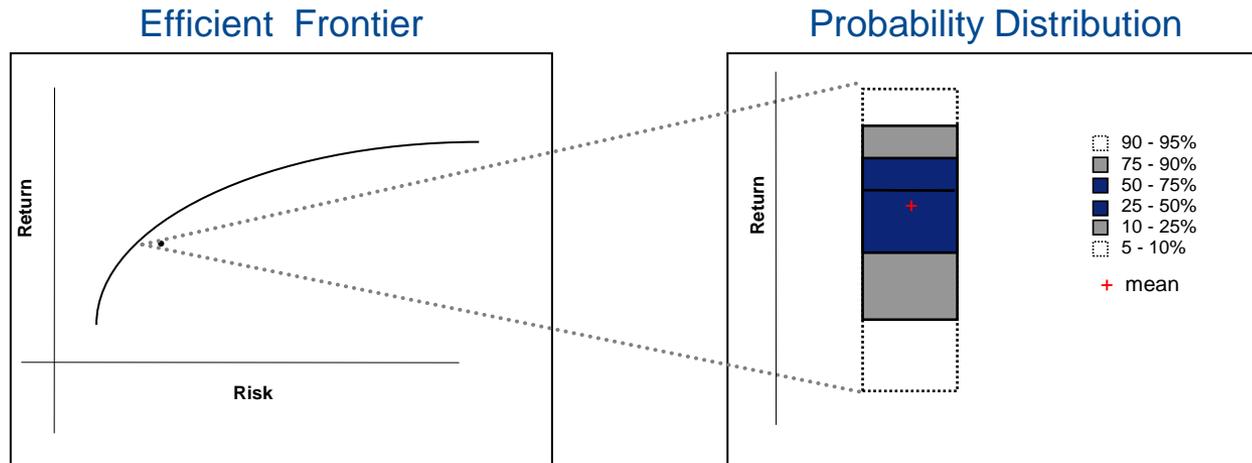
Source: Conning Analysis

PVDE vs Economic Value (EV) Efficient Frontiers



Source: Conning Analysis

Expected Results and Range of Results



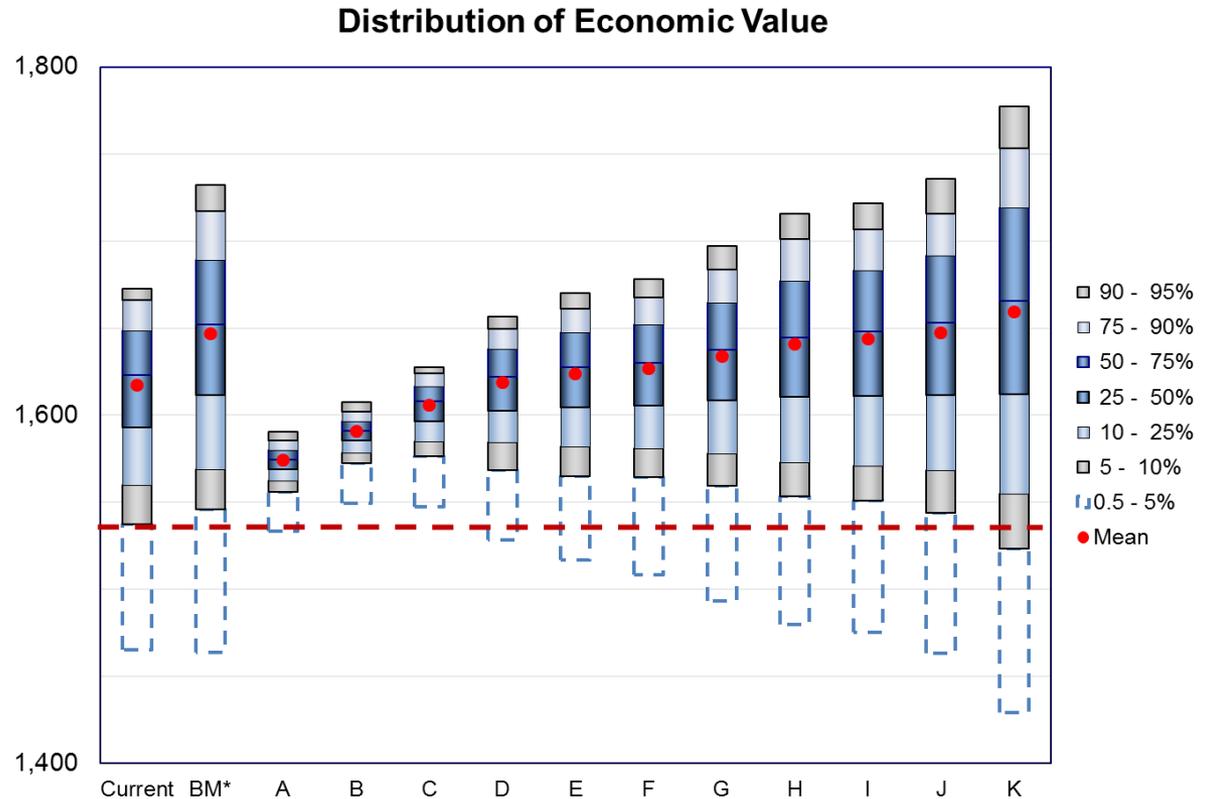
- ◆ Each point on the efficient frontier, defined by a single risk and a single reward measure, is based on the results of 1,000s of scenarios
- ◆ We usually want the investment strategy that on average gives the "best" reward for a given level of risk
- ◆ However, we also want to know the downside risk - how bad could results be?
- ◆ We evaluate this risk by looking at the range of potential results; for example, how bad is the 5% probability level (1 year in twenty), and can we accept that much risk?

Source: Conning Analysis

Economic Efficient Frontier

Observations

- ◆ Benchmark economic value is improved over the Current allocation at nearly every percentile
- ◆ Extreme tail events are similar between the Benchmark and Current allocations
- ◆ Benchmark changes from the Current portfolio:
 - Longer Duration
 - More BBB credit risk
 - More Equities
 - More Alternative Assets



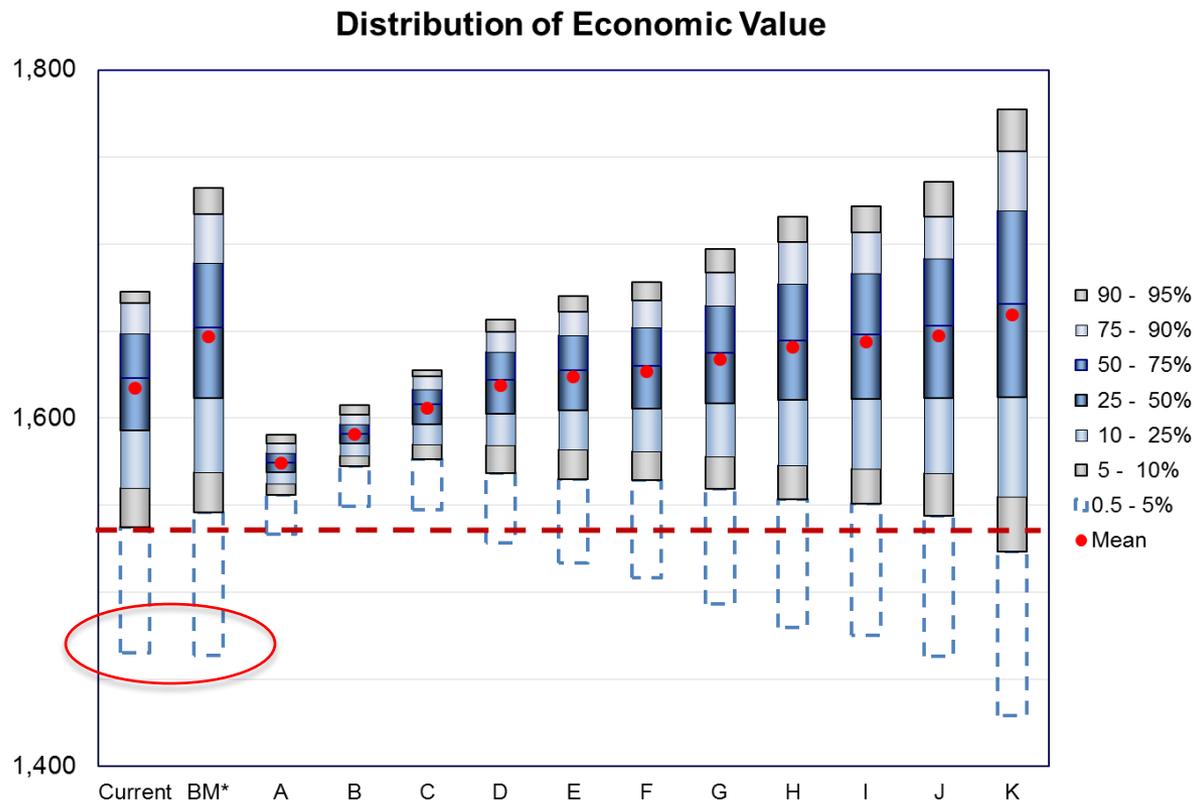
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 Source: Conning Analytics

BM means Benchmark Strategy*

Economic Efficient Frontier

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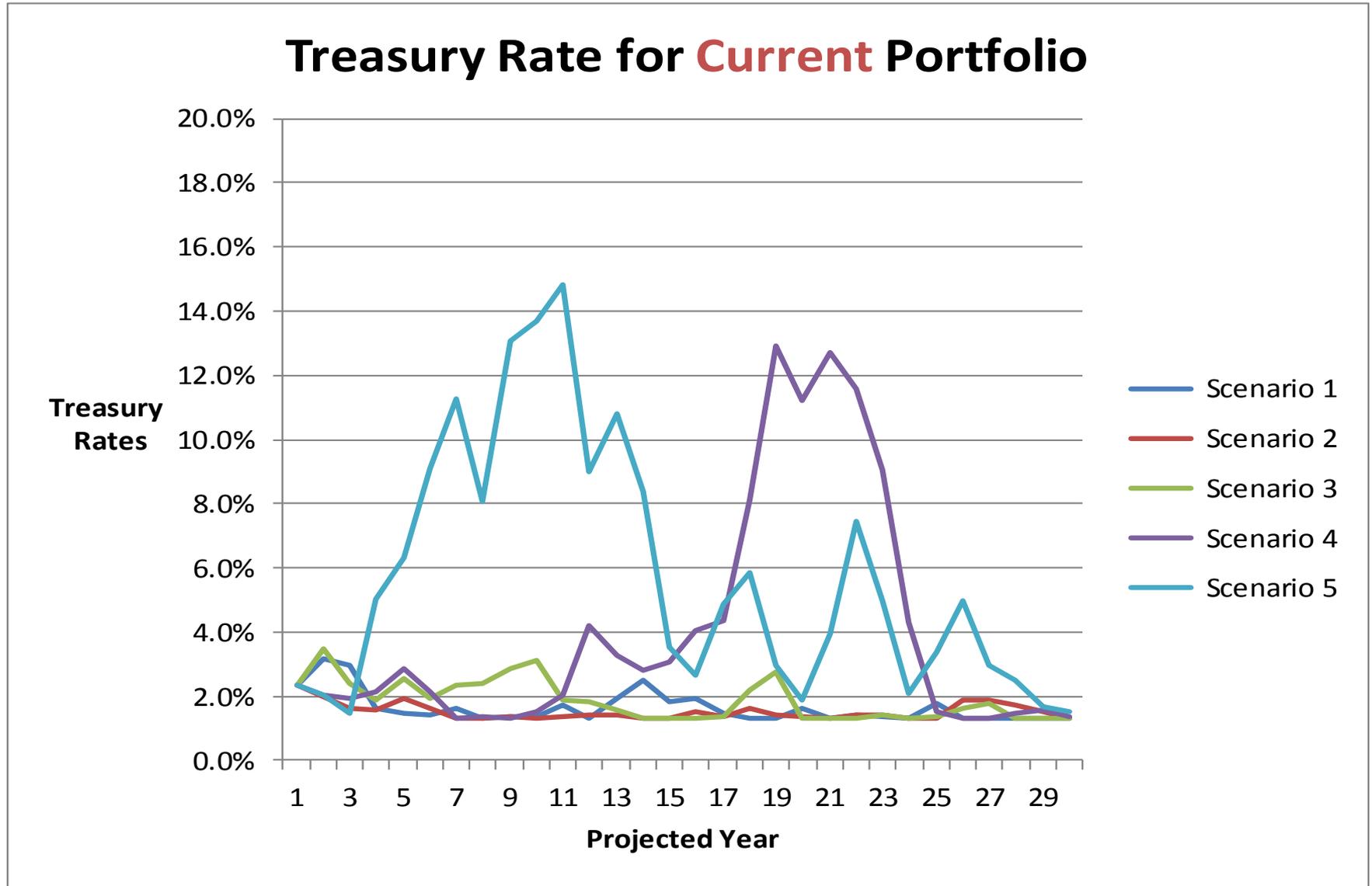
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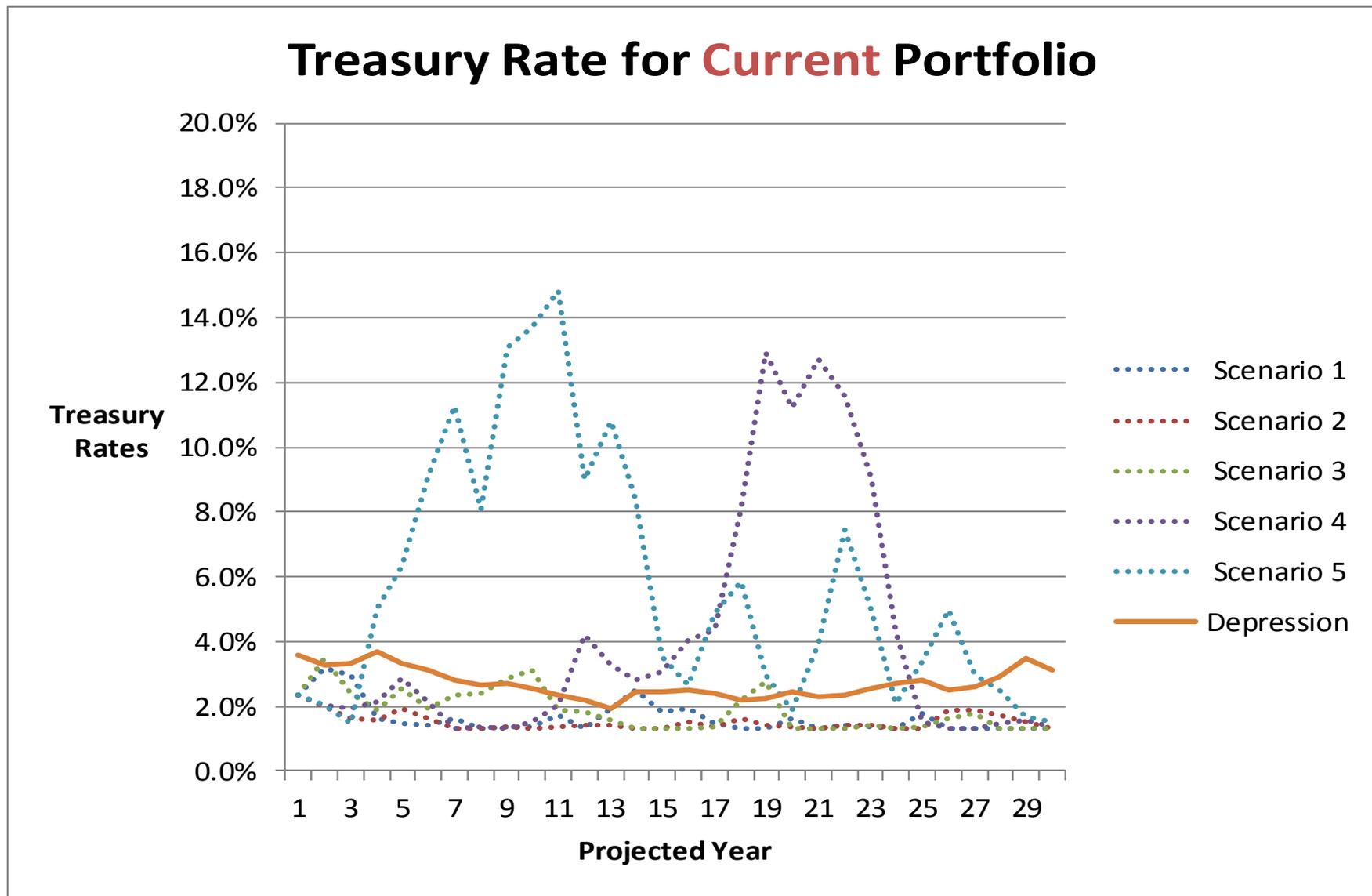
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Five Tail Scenarios (0.3% - 0.7% Worst Percentiles)



Source: Conning Analytics

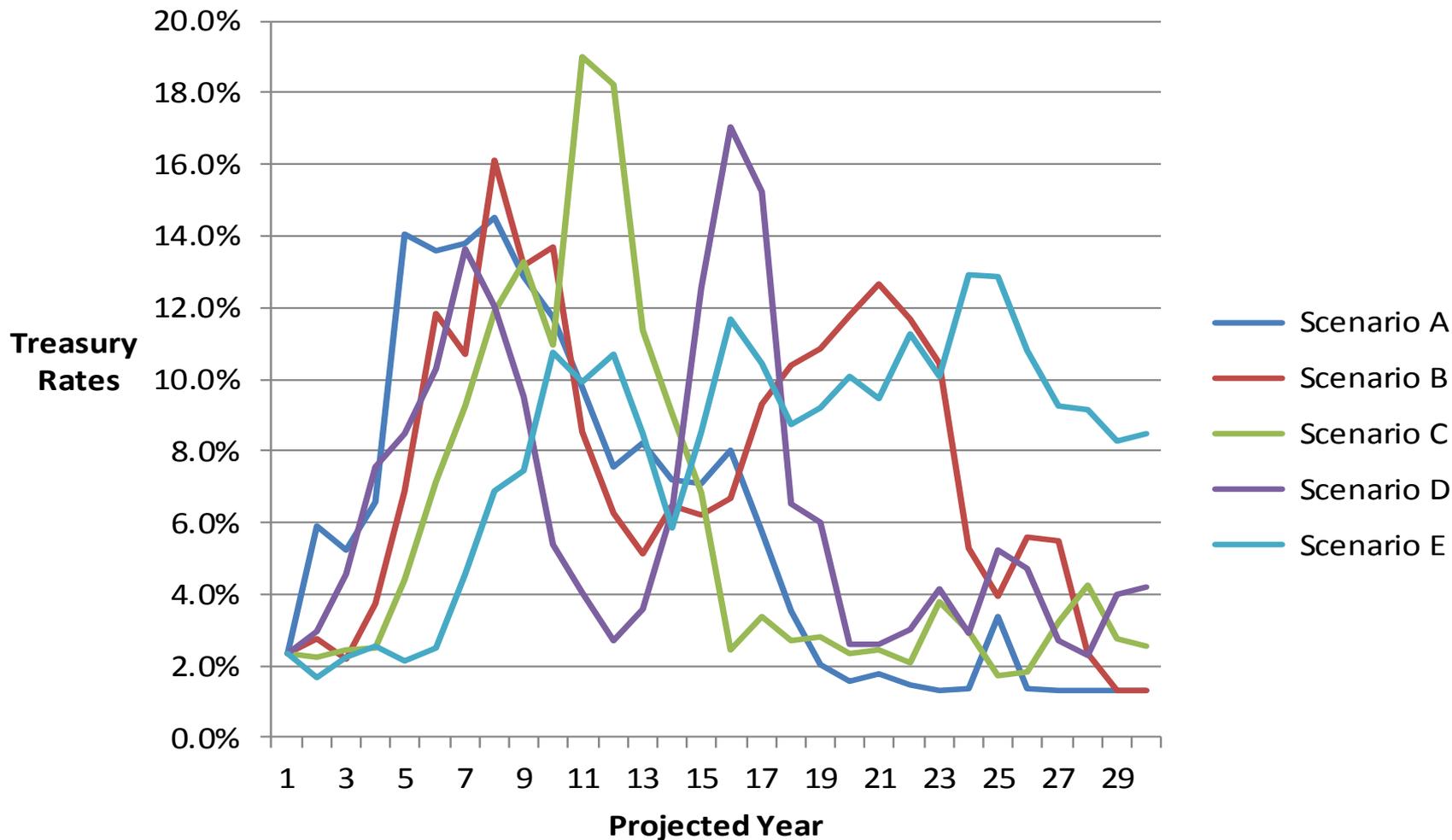
Five Tail Scenarios (0.3% - 0.7% Worst Percentiles)



Source: Conning Analytics

Five Tail Scenarios (0.3% - 0.7% Worst Percentiles)

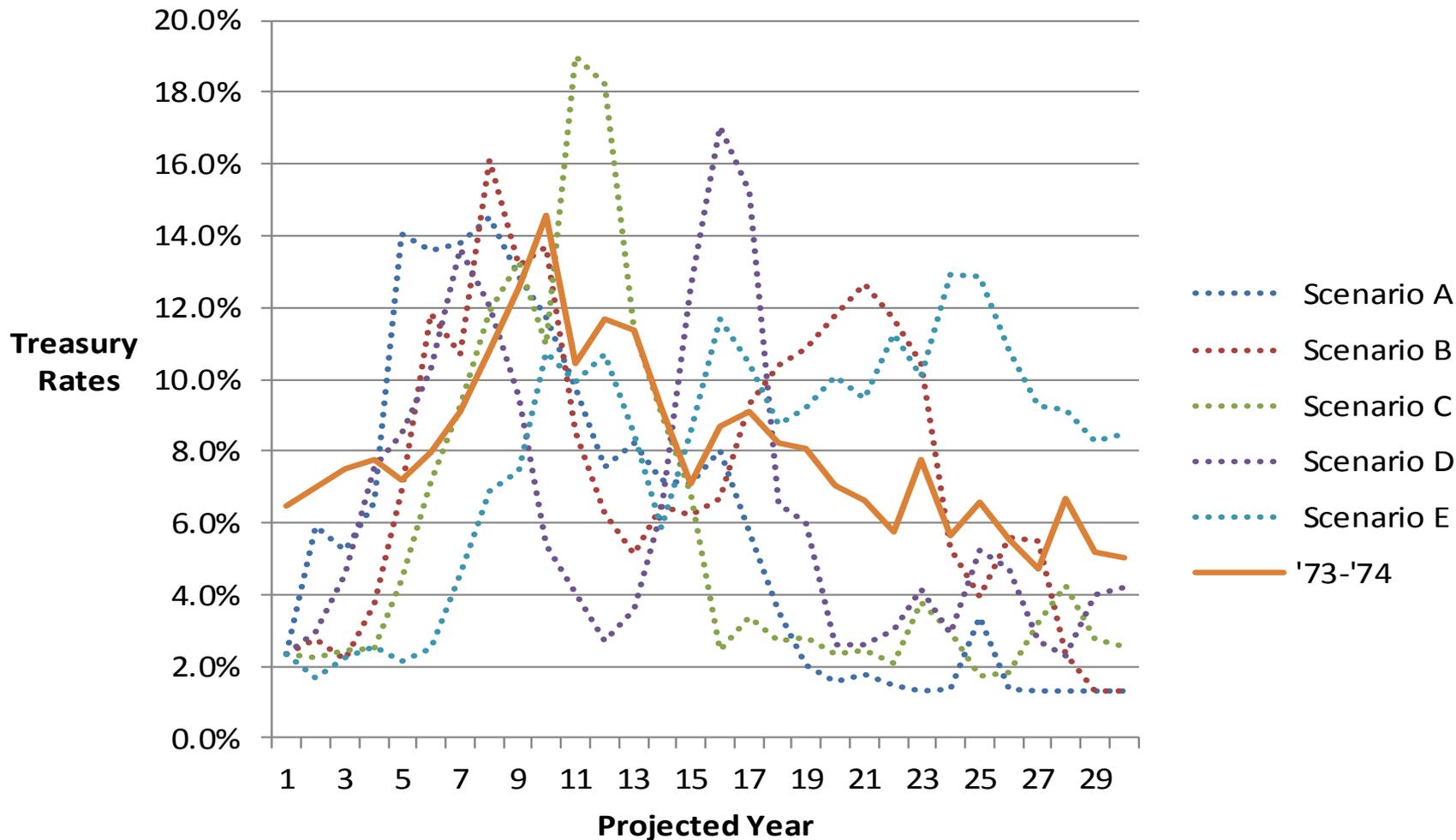
Treasury Rates for **Benchmark** Portfolio



Source: Conning Analytics

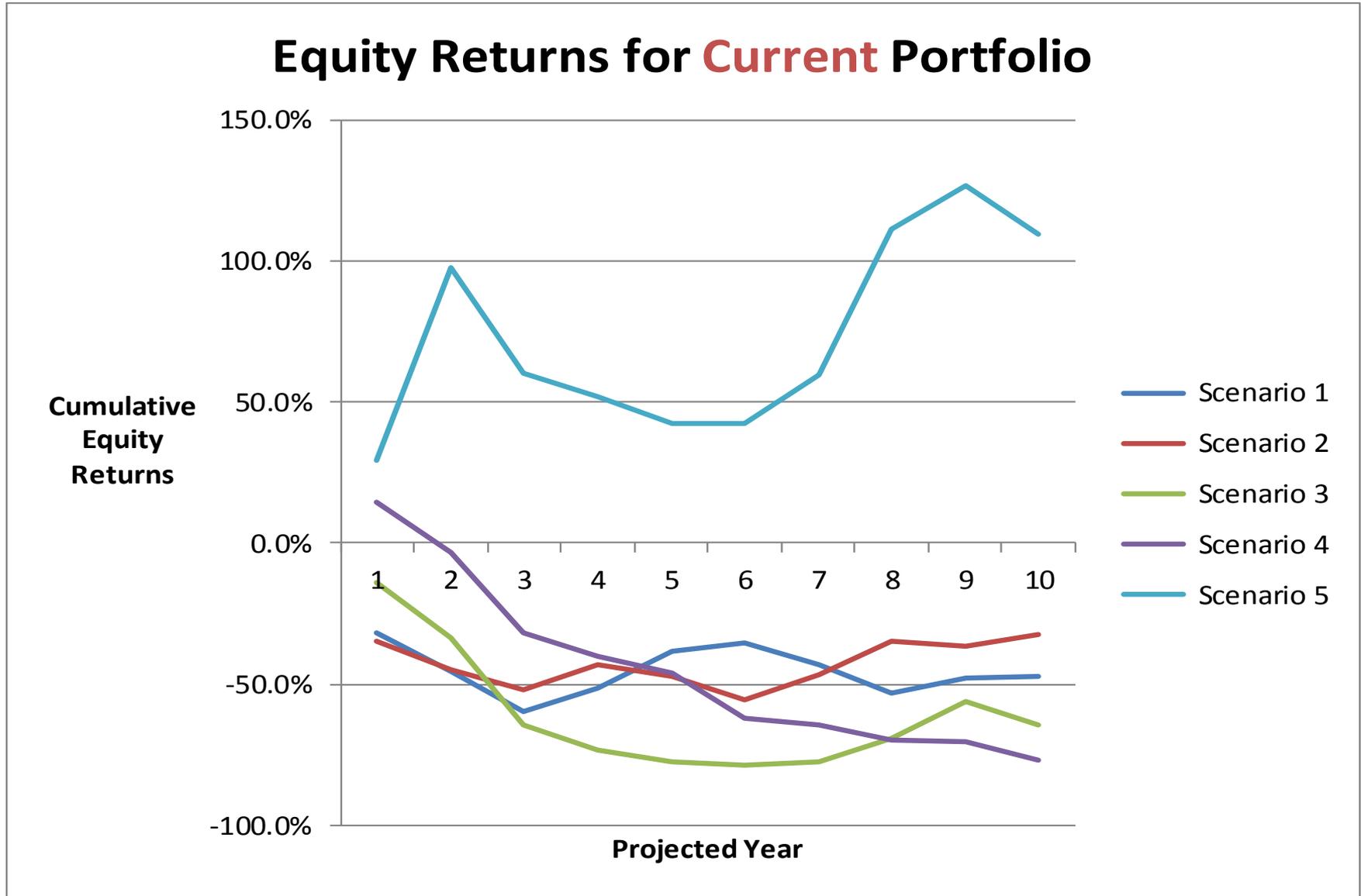
Five Tail Scenarios (0.3% - 0.7% Worst Percentiles)

Treasury Rates for **Benchmark** Portfolio



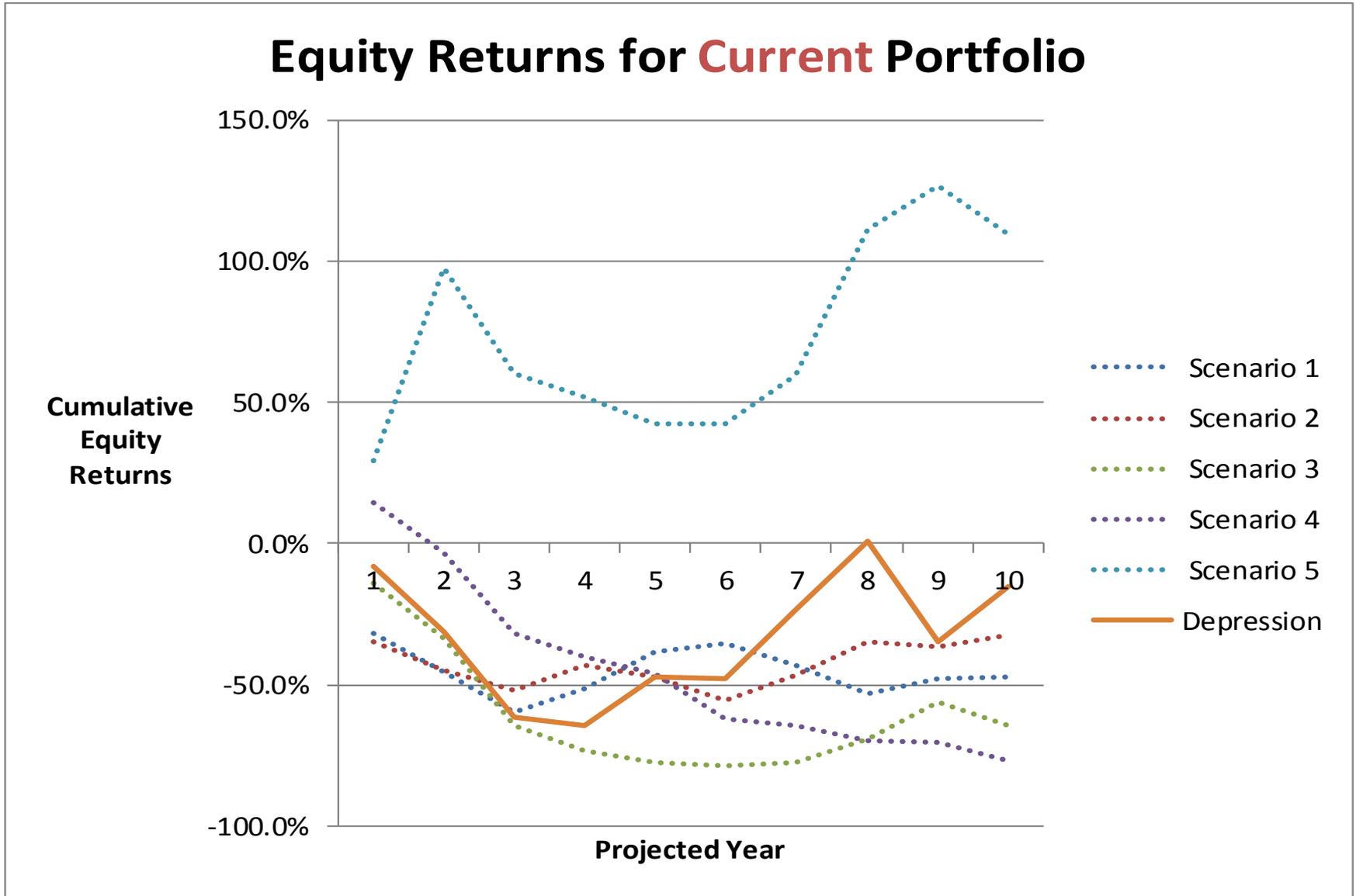
Source: Conning Analytics

Five Tail Scenarios (0.3% - 0.7% Worst Percentiles)



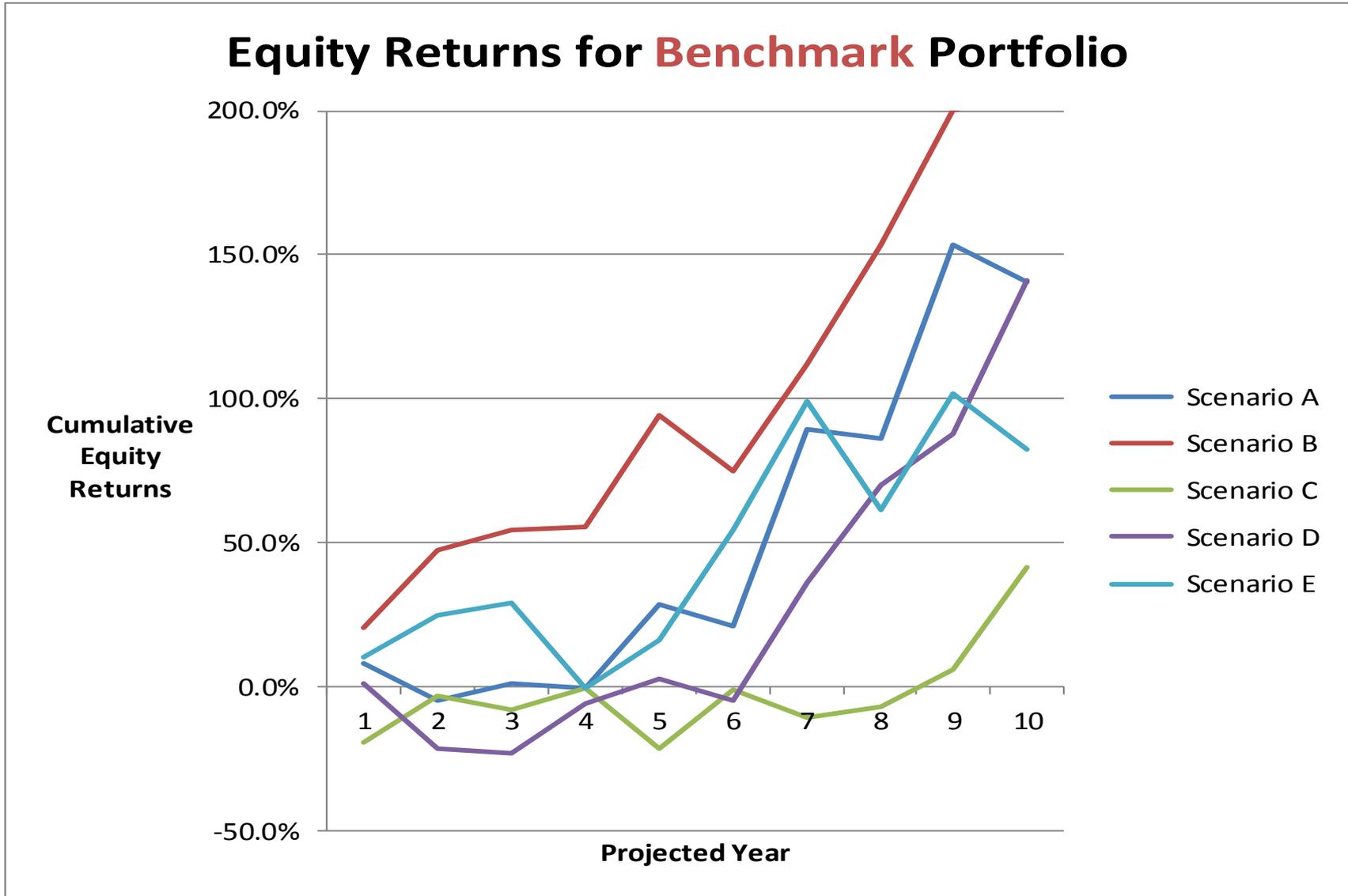
Source: Conning Analytics

Five Tail Scenarios (0.3% - 0.7% Worst Percentiles)



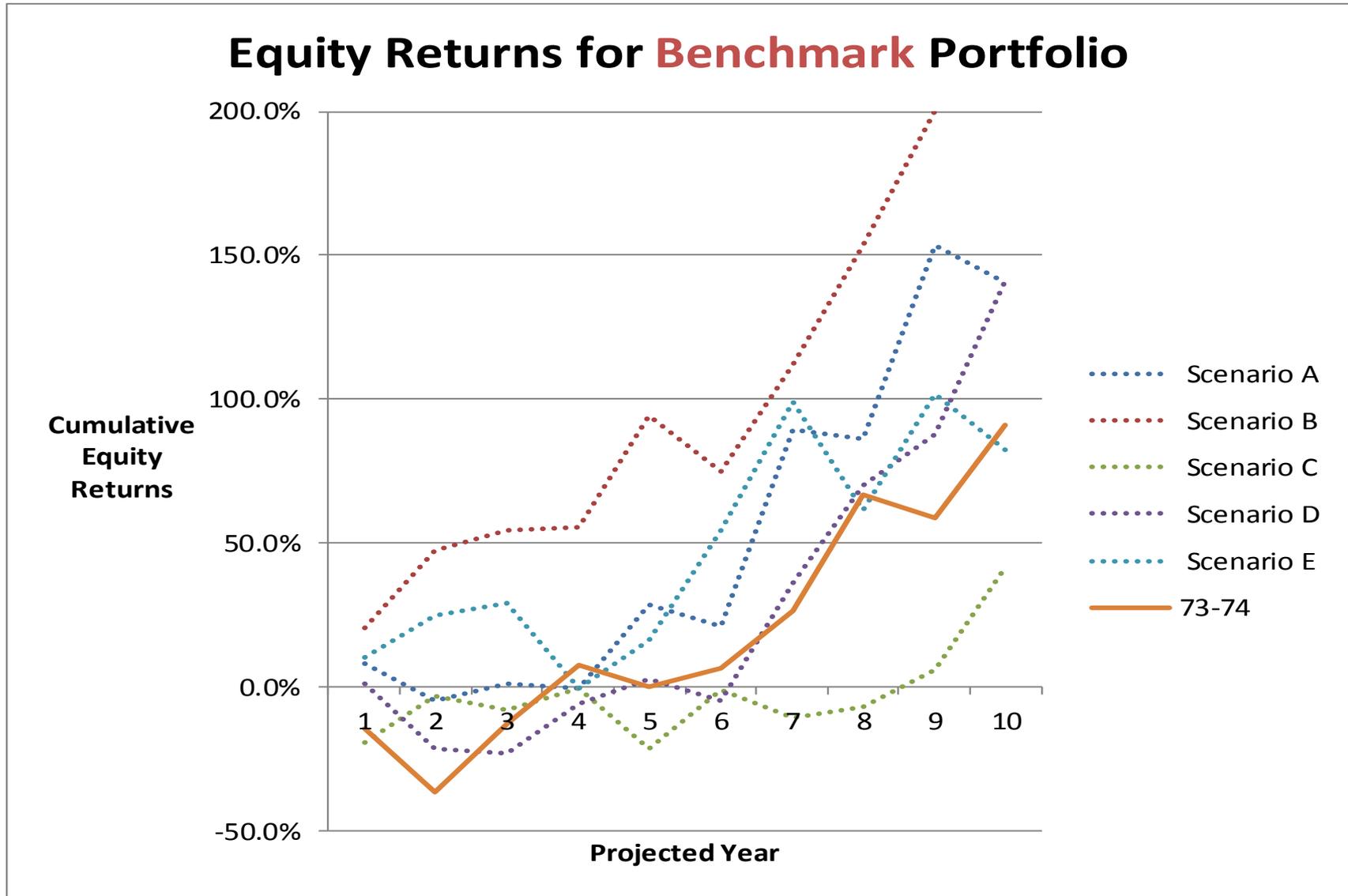
Source: Conning Analytics

Five Tail Scenarios (0.3% - 0.7% Worst Percentiles)



Source: Conning Analytics

Five Tail Scenarios (0.3% - 0.7% Worst Percentiles)



Source: Conning Analytics

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Recent Trends in Derivatives for Life Insurers

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Agenda

- 1) Trends in life insurers' derivatives activity
- 2) Derivatives valuation developments: collateral-based pricing
- 3) New derivatives products: options on risk-controlled indices
- 4) Derivatives market outlook

1. Trends in Life Insurers' Derivatives Activity

Transparency in Derivatives Activity

Detailed derivatives use reporting is produced quarterly

- Transparency exists thanks to the Statutory DB schedules
 - Filed quarterly with information on ownership, new trades, terminations
 - Part A covers forwards, swaps, options, swaptions, collars etc.
 - Part B covers futures
- Measurement metrics
 - Notionals and/or units
 - Book value
 - Fair value
 - Not reported: option Greeks, duration
- Measurement consistency is difficult to achieve

Transparency in Derivatives Activity

Parsing the Schedule DB Data is a highly labor-intensive manual process

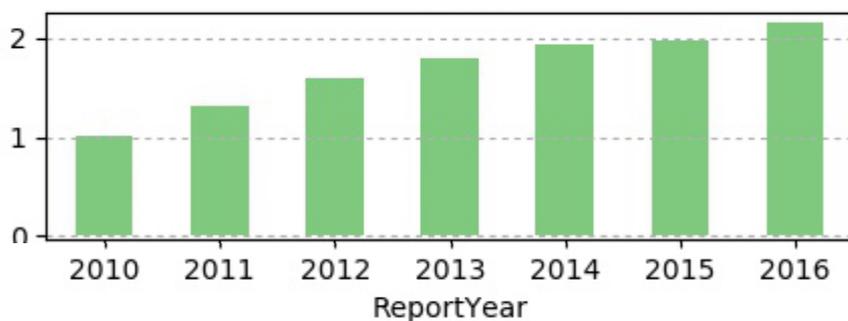
- The statutory blanks change over time
- There is little conformity on how different companies report different types of options (across the industry and even through time)
 - Notional vs. Units
 - Strike inconsistencies (\$ vs %)
 - Expiration Date vs. Termination Date
 - Risk Classification (Equity / Rates / FX / Credit...) and ways to transcribe
 - Currency of the notional (\$ is requested)
 - Treatment of call/put (cap/floor/swaption) spreads (sign of notional/strike; single line or multiple lines)
 - Different treatment of same trade in “Owned” vs. “Terminated” reports
 - Typos (e.g. Trade Dates in future, transposed digits in year/months etc.)
- **Takeaway: an amount of subjectivity is necessary when parsing the data!**
 - We create an approximate metric of adjusted notional representing a “best guess” estimate

Derivatives Held at Year-End

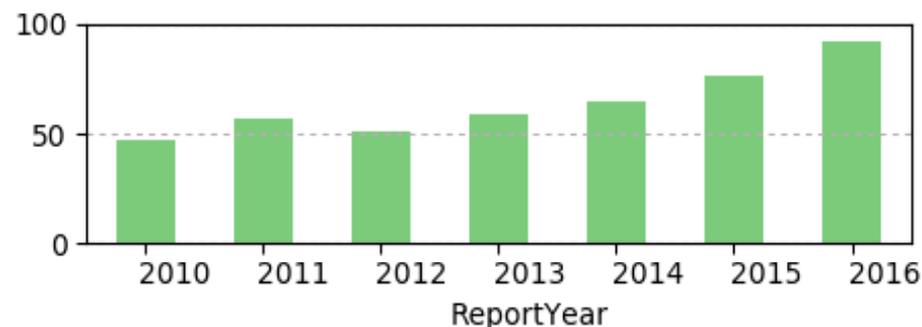
Derivatives holdings continue to grow but the composition is changing

- Over \$2 trillion adjusted notional of Schedule DB Part A assets (forwards, swaps, collars, options, swaptions, caps/floors) held by life insurers at the end of 2016
 - Part A assets annualized growth rate: ~21% between 2010 and 2013; ~6% since 2013
- ~\$100 billion notional of Schedule DB Part B assets (futures) held by life insurers at end of 2016
 - Part B assets growth rate: ~8% between 2010 and 2013; ~16% since 2013
- Charts illustrate absolute value of notional at year-end

Part A: Absolute Adjusted Notional (\$, tr)



Part B: Absolute Adjusted Notional (\$, b)

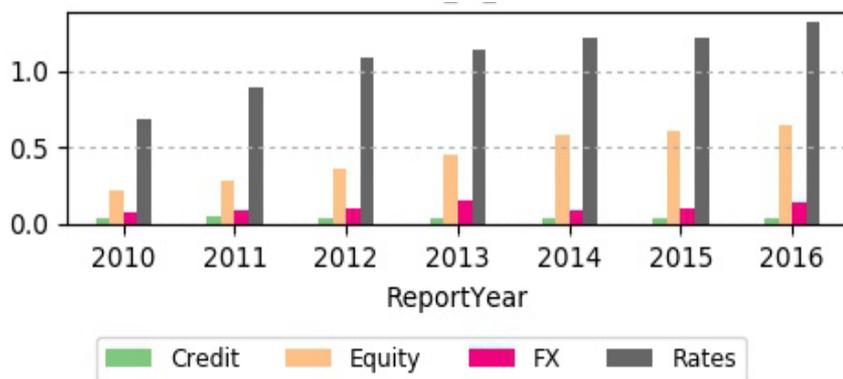


Derivatives Held at Year-End By Risk Type

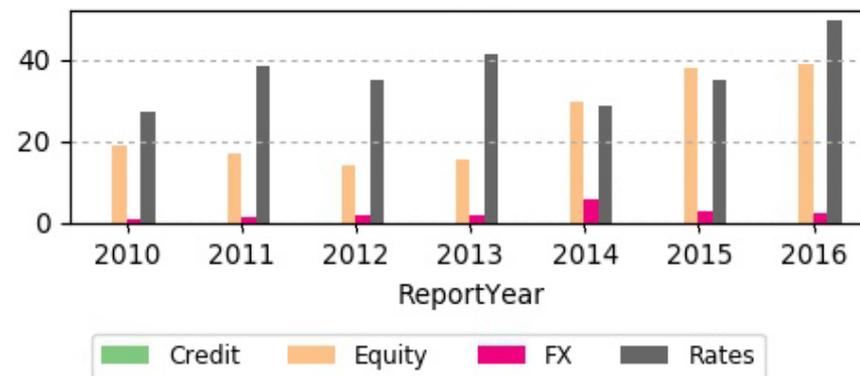
Rate and equity derivatives continue to be the most prominent types

- Rates continue to be the biggest derivatives holding on insurers' balance sheets by adjusted notional
 - However, a slowdown in adjusted notionals' growth noticeable since 2013
- Equities are roughly half of rates' adjusted notionals
- Futures' use has been on the rise recently both for rates and equities

Part A: Absolute Adjusted Notional (\$, tr)



Part B: Absolute Adjusted Notional (\$, b)

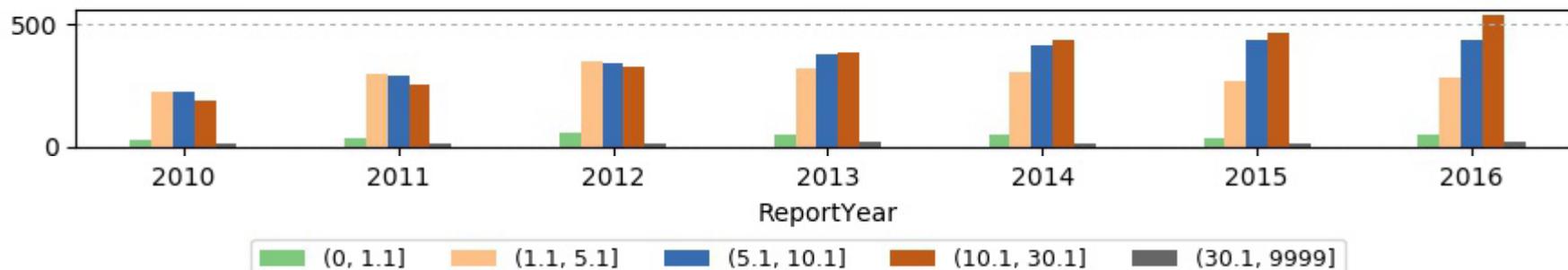


Derivatives Held at Year-End By Tenor

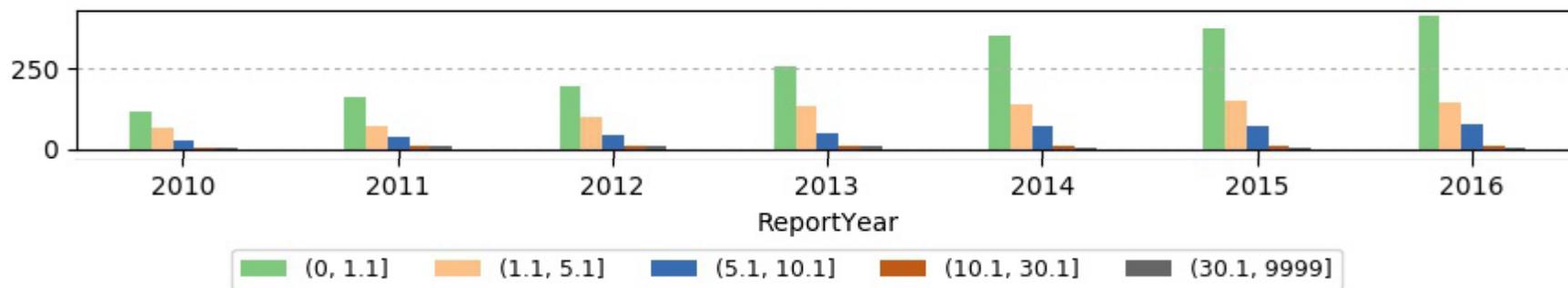
There has been a noticeable shift in maturities in both rates and equities

- Rates derivatives extending in tenors
- Equities derivatives shortening in tenors

Rates Absolute Adjusted Notional (\$, b)



Equities Absolute Adjusted Notional (\$, b)



Observations

Derivatives use continues to grow but composition is changing

- Several recent developments have contributed to changes in volumes traded
 - Derivatives **usage is growing albeit at a slower rate than pre-2013**
 - There has been a shift toward listed products though **majority of trades continue to be over-the-counter**
 - While rates derivatives have seen a slowdown in notional growth, **impact on duration is less clear**
 - Equity derivatives have seen a meaningful shortening in maturity, consistent with **new product designs with less onerous vega risks**
- Other observations
 - Consolidation/unwinds of captives and their derivative portfolios by several large insurers over past 3 years may have impacted recent numbers

2. Derivatives Valuation Developments

Collateral-based pricing

Discounting

Prior to 2008...

- Build a discount curve based on:
 - Interest rate swaps
 - Cross-currency basis swaps
 - Intra-currency basis swaps
- PV is computed by discounting future cashflows using this discount curve
- Very simple example:
 - \$100 cashflow due in 5 years
 - USD cash collateral
 - Assume that the USD swap curve implies 5-year spot rate of 1.89% (effective)
 - **Present value = \$91.06 ($\$100 / (1+1.89\%)^5$)**
- Key assumption:
 - LIBOR is the risk-free rate
 - LIBOR can be earned

Collateral-Based Pricing

Since 2008...

- Does cash really earn LIBOR?
 - However, cash [owned by a depository institution] *can* approximately earn the US Federal Funds Effective Rate [by being lent out to other depository institutions]
- Hence, rather than use LIBOR, build a discount curve based on:
 - Overnight index swaps (OIS)
 - Cross-currency basis swaps
 - Intra-currency basis swaps
- Very simple example:
 - \$100 cashflow due in 5 years
 - USD cash collateral
 - Assume that swap curve implies 5-year spot rate of 1.59% (effective)
 - **Present value = \$92.41 ($\$100 / (1 + 1.59\%)^5$)**
- Key assumption: same as before: Fed Funds can be earned and overnight is closer to risk-free

Collateral-Based Pricing

What if the collateral is not USD cash?

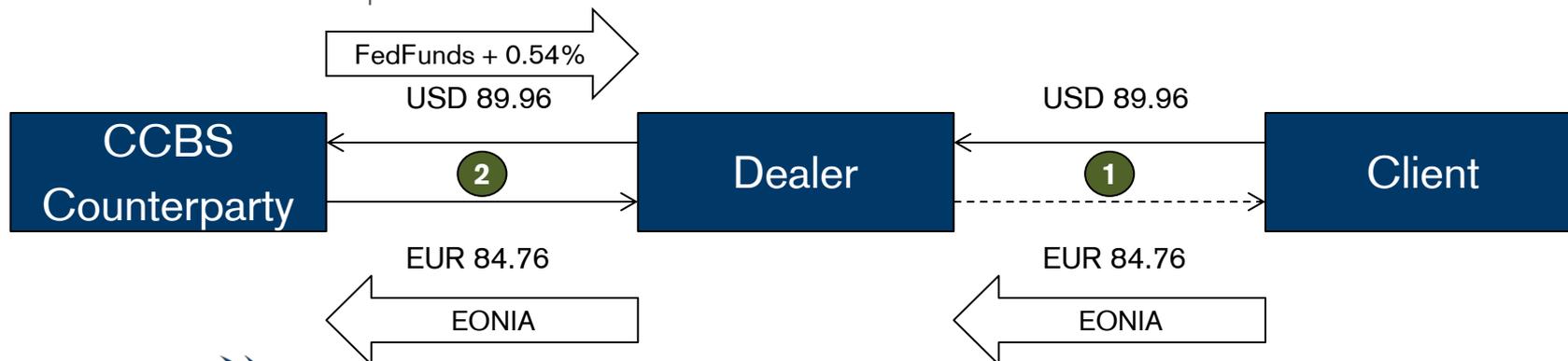
- The higher-yielding collateral posted, the cheaper the cashflow should be
- Assume that the collateral is EUR cash & analyze the same simple trade:
 - \$100 cashflow due in 5 years
 - EUR cash collateral
 - Assume that OIS & cross-currency basis swaps imply 5-year spot rate of 2.13% (effective)
 - **Present value = \$89.96 ($\$100 / (1 + 2.13\%)^5$)**

Collateral-Based Pricing: Example

What if the collateral is not USD cash?

- 1 Dealer receives USD 89.96 today to pay USD100 in 5 years
 - Dealer posts EUR 84.76 collateral (assume EURUSD = 1.0614) and receives EONIA interest on it
- 2 To hedge at the FX risk, enter into a cross-currency basis swap
 - Upfront, exchange the USD 89.96 and receive EUR 84.76 (to on-post to client)
 - Over time, pay the EONIA on the EUR 84.76 notional (received from the posted collateral) and receive Fed Funds on the USD 89.96 notional
 - At expiry, receive back the USD 89.96, pay the EUR 84.76 (reclaimed collateral from Client)

(in reality the CCBS may be vs. LIBOR/EURIBOR so extra steps may be necessary)
- 3 At expiry, pay back the USD 89.96 to client with interest earned from the CCBS (FF+54bps)
 - Results in a 5Y spot rate of 2.13%



Collateral-Based Pricing

Reality is much more complex

- Typical products are more complicated than just a single cashflow
 - For an option margined daily, the amount of collateral is always subject to change and thus the CCBS needs to be re-hedged constantly
 - Bid-offers on the underlying CCBS may further impact value
 - Correlations between the value of the option and the funding rate may further impact value
- Typical CSAs may allow for posting of various types of assets (cash, treasuries, corporates, etc.) and for switching those as needed
 - Just because today a particular currency is “cheap” does not mean this will continue
 - The switch option is difficult to value and even harder to hedge

Collateral-Based Pricing

Summary

- Discounting post-2008 is based on:
 - Overnight index swaps
 - Cross-currency basis swaps
 - Intra-currency basis swaps
- LIBOR is now used...
 - ...for calculating swap rates and forward rates (however, once struck, the *PV of a swap* would be driven by the type of collateral)
 - ...not for discounting
- Plenty of complexities remain (hidden convexities , switch options)
 - CSA simplifications and low PVs can help

3. New Derivatives Products

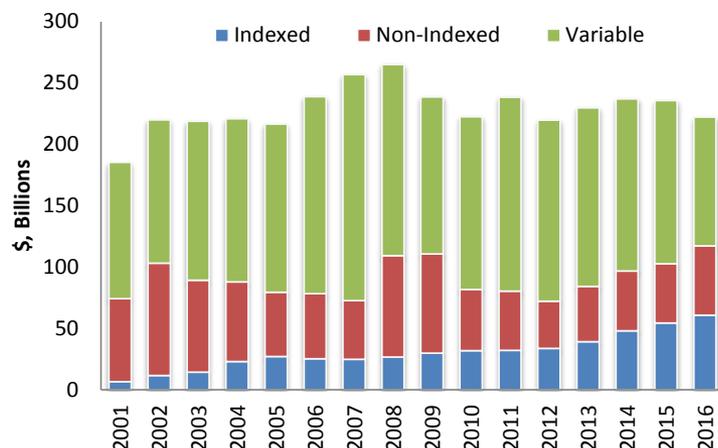
Options on risk-controlled
underlyings

Risk-Controlled Underlyings in Annuity Market

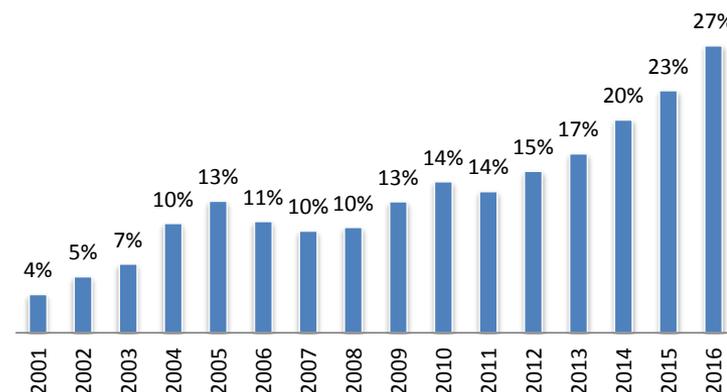
Risk-control usage is growing in both VA and FIA

- US annuity industry generated \$222 billion of sales in 2016
- Variable annuities still represent over \$105 billion of annual sales
 - Managed-vol portfolios AUM >\$250b (Source: Soleares Research)
- Fixed annuities gaining market share (\$117 billion)
 - Indexed products showing strong growth, currently up to 27% of sales (\$61b)
 - Risk-controlled indices are estimated to account for 25-30% of new FIA sales (so over \$20b annually)

Breakdown of Annual Annuity Sales



Fixed Indexed Annuity - % of Total Sales



Risk-Controlled Underlyings

Overview

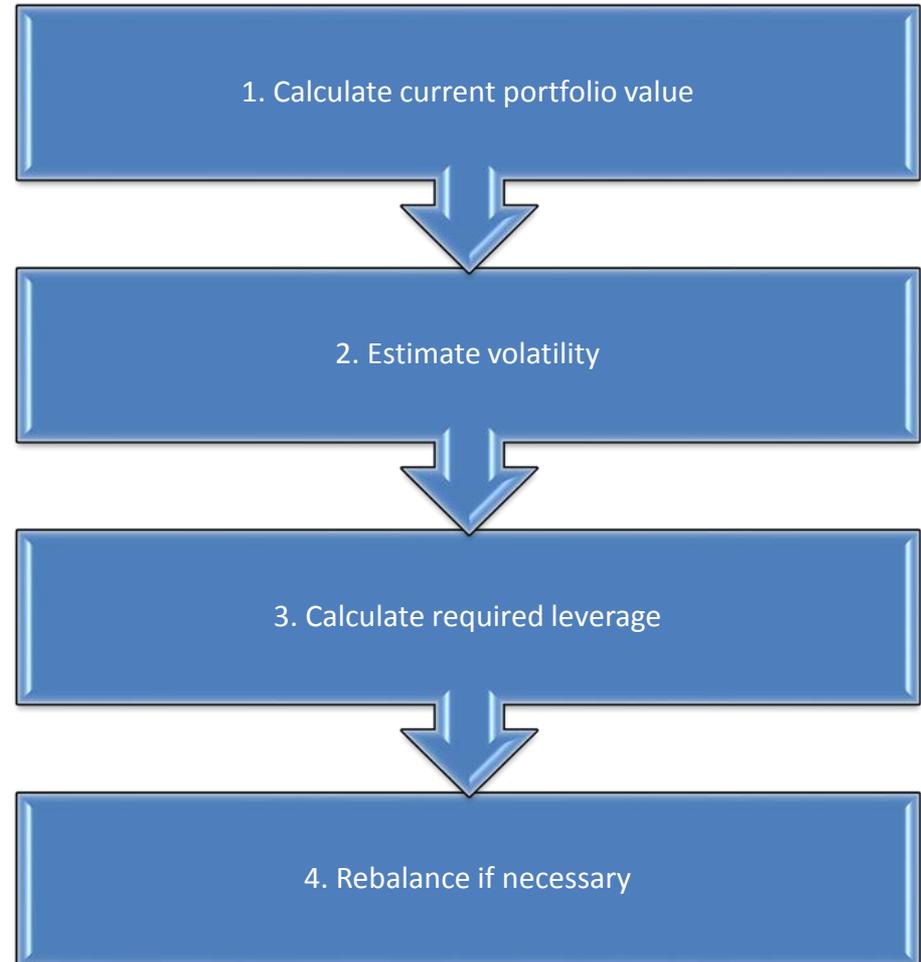
- Dynamically adjust exposure between risky asset and safe asset to achieve a portfolio with more predictable volatility
 - Distant cousin to portfolio insurance (CPPI)
 - Post 2008 financial crisis, increased used in VA space
 - Since 2012, risk-controlled indices have entered in FIA / IUL space
- Motivations
 - Easier to manage option greeks
 - VA: risk transfer from insurer to policyholder, management of vega risk
 - FIA / IUL: more stable options prices, higher participations
- There are two important valuation question related with options on a risk-controlled index:
 - At what implied volatility should options trade?
 - What is the forward of the index?

Risk-Control Mechanisms: Introduction

Generic volatility-targeting template

- At inception, several characteristics of the strategy must be determined:
 - Underlying
 - Excess or Total Return
 - Target Volatility
 - Leverage Constraints
 - Rebalancing lag
- Goal: achieve portfolio with “stable” volatility

Rebalancing Process



Risk-Control Mechanisms: Introduction

Heuristic overview of theoretical rationale

- Start with a model with non-constant volatility (e.g. Heston) for an excess return index (i.e. zero-drift), S_t and its time-varying variance v_t :

$$\frac{dS_t}{S_t} = \sqrt{v_t} dW_S^Q$$

- Continuously adjust the exposure to index to $\omega_t = \frac{Vol_{TARGET}}{\sqrt{v_t}}$ to create a portfolio π_t :

$$\frac{d\pi_t}{\pi_t} = \omega_t \frac{dS_t}{S_t}$$

- This portfolio now has constant and known volatility!

$$\frac{d\pi_t}{\pi_t} = \frac{Vol_{TARGET}}{\sqrt{v_t}} \times \sqrt{v_t} dW_S^{Q'} = Vol_{TARGET} dW_S^{Q'}$$

- **However, be mindful of potential caps on the leverage (ω_t)**

Risk-Control Mechanisms: Example

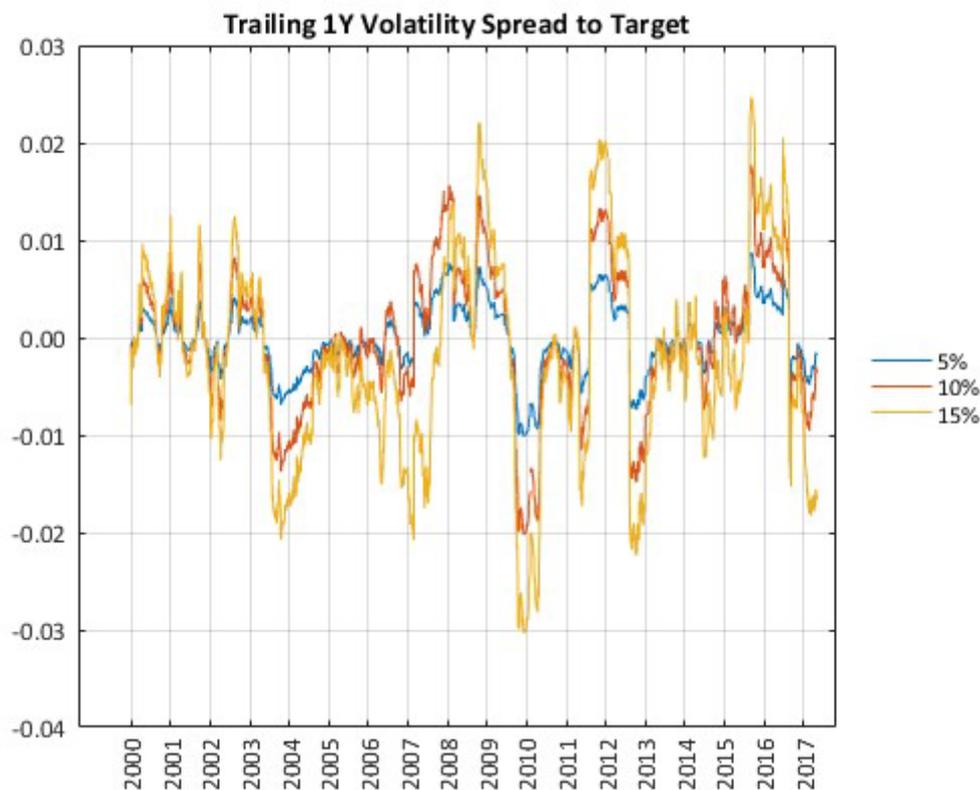
S&P 500 10% Daily Risk Control Excess Return™

Term	Value
Underlying	SPTR
Excess or Total Return?	Excess Return (subtract Interest Rate daily)
Interest Rate	Overnight USD LIBOR
Volatility Target	10%
Volatility Estimate	The greater of two exponential estimates (0.97 and 0.94 decay)
Rebalance Frequency	Daily, with 2 days' lag
Leverage Floor and Cap	0% / 150%

Risk-Control Mechanisms: Effectiveness

A-posteriori realized volatility of risk-controlled index may still deviate from target

- Examine S&P 500 Daily Risk Control 5%, 10%, 15% Excess Return
- The below charts show the rolling realized volatility spreads to their targets for each index
- Positive signifies likely loss for the option seller



1Y Realized Volatility Spread to Target Vol

Risk Control	Min	Mean	Max	StDev
5%	-1.0%	0.0%	0.9%	0.3%
10%	-2.0%	0.0%	1.8%	0.7%
15%	-3.0%	-0.2%	2.5%	1.0%

Options on Risk-Controlled Underlyings

Where should implied volatility be offered?

- Focus on a 1-year at-the-money call option & estimate the PnL of delta-hedging (positive -> bad for the seller)
 - Assume interest rates are 0 (less relevant, especially given Excess Return underlyings)
 - Assume delta is computed using the target volatility (σ_{VT})
 - No “implied” volatility due to lack of listed option markets on risk-controlled indices (for now)

$$\text{HedgedPnL} = \frac{1}{2} (\sigma_{\text{Pricing}}^2 - \sigma_{VT}^2) \int_0^T S^2 \Gamma^{VT} dt \approx \text{Vega}^{VT} \times (\sigma_{\text{Pricing}} - \sigma_{VT}) \times 100$$

- Solve for what would have been the a-posteriori “fair” volatility spread to sell the option

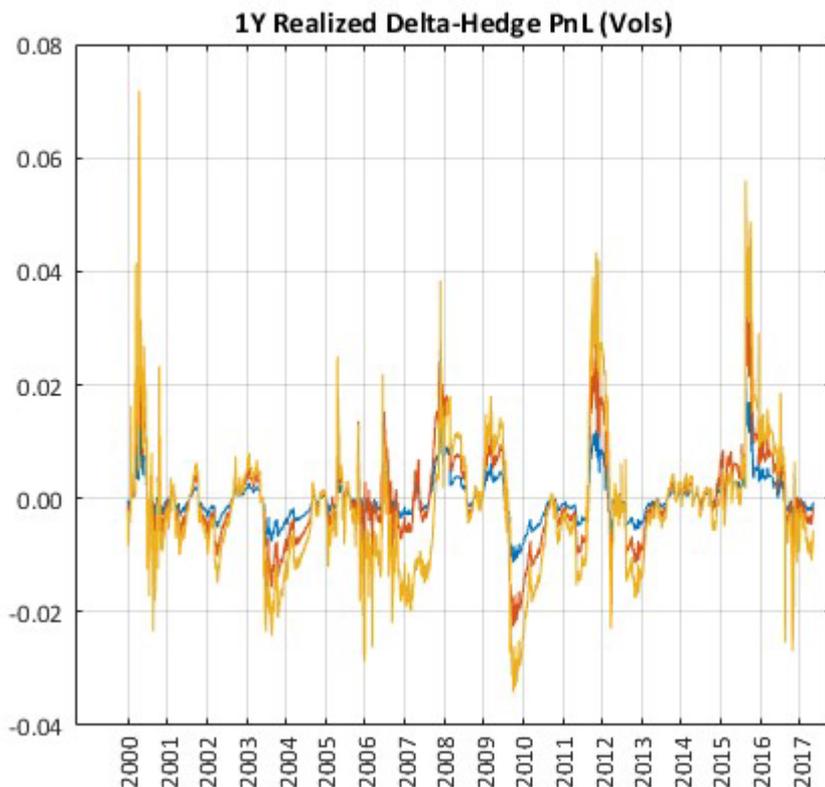
$$\sigma_{\text{Pricing}} - \sigma_{VT} \approx \frac{\text{HedgedPnL}}{100 \times \text{Vega}_{VT}} \approx 2.5 \times \text{HedgedPnL}$$

- Simulate over each historical 1-year period of available data (over 4350 (overlapping) paths)

Options on Risk-Controlled Underlyings

Realized delta-hedge profit and loss shows wider distribution of outcomes

- Examine S&P 500 Daily Risk Control 5%, 10%, 15% Excess Return
- The below charts show the realized delta-hedged PnL for each index as volatility spreads to the target vol
- Positive signifies a loss for the option seller



1Y Realized Delta-Hedge PnL (Vols)

Risk Control	Min	Mean	Max	StDev
5%	-1.1%	0.0%	2.4%	0.4%
10%	-2.3%	0.0%	4.5%	0.8%
15%	-3.4%	-0.2%	7.2%	1.2%

Options on Risk-Controlled Underlyings

So, where should implied volatility be priced?

- Daily delta hedging is reasonably effective
- However, deviations from the Black-Scholes assumptions should be taken into account
 - Discrete hedging / vol of vol / jumps
- Pricing above the volatility target can help alleviate

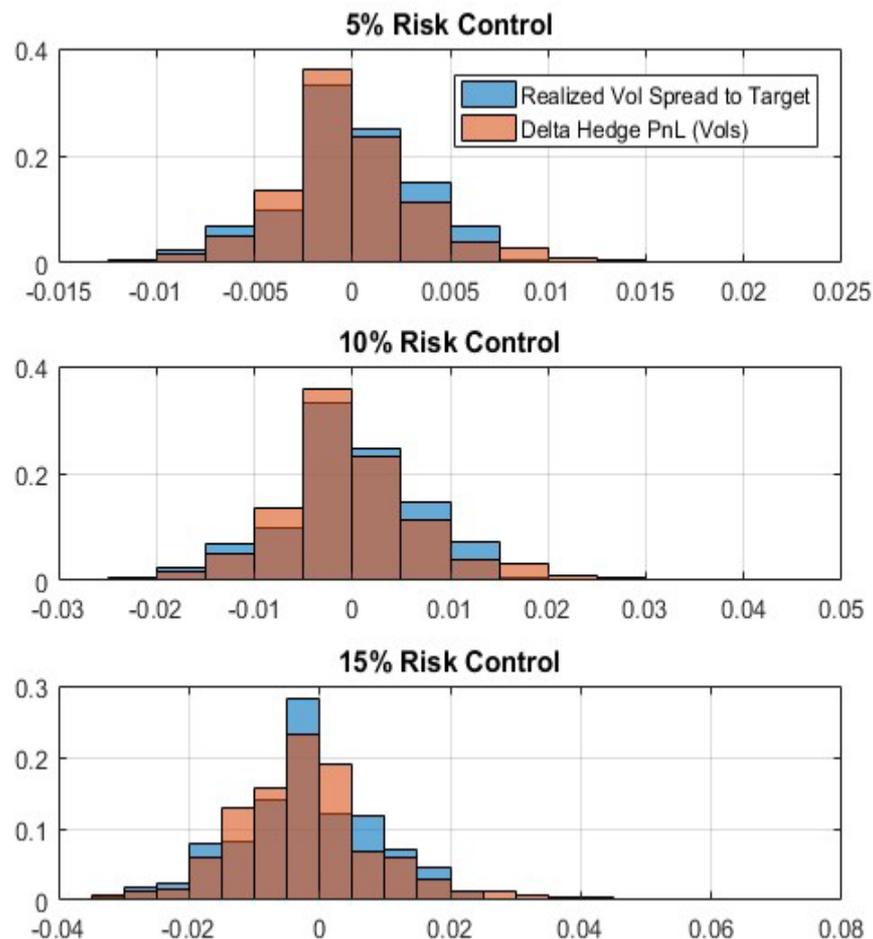
1Y Realized Volatility Spread to Target Vol

Risk Control	Min	Mean	Max	StDev
5%	-1.0%	0.0%	0.9%	0.3%
10%	-2.0%	0.0%	1.8%	0.7%
15%	-3.0%	-0.2%	2.5%	1.0%

1Y Realized Delta-Hedge PnL (Vols)

Risk Control	Min	Mean	Max	StDev
5%	-1.1%	0.0%	2.4%	0.4%
10%	-2.3%	0.0%	4.5%	0.8%
15%	-3.4%	-0.2%	7.2%	1.2%

Frequency of Realized Outcomes

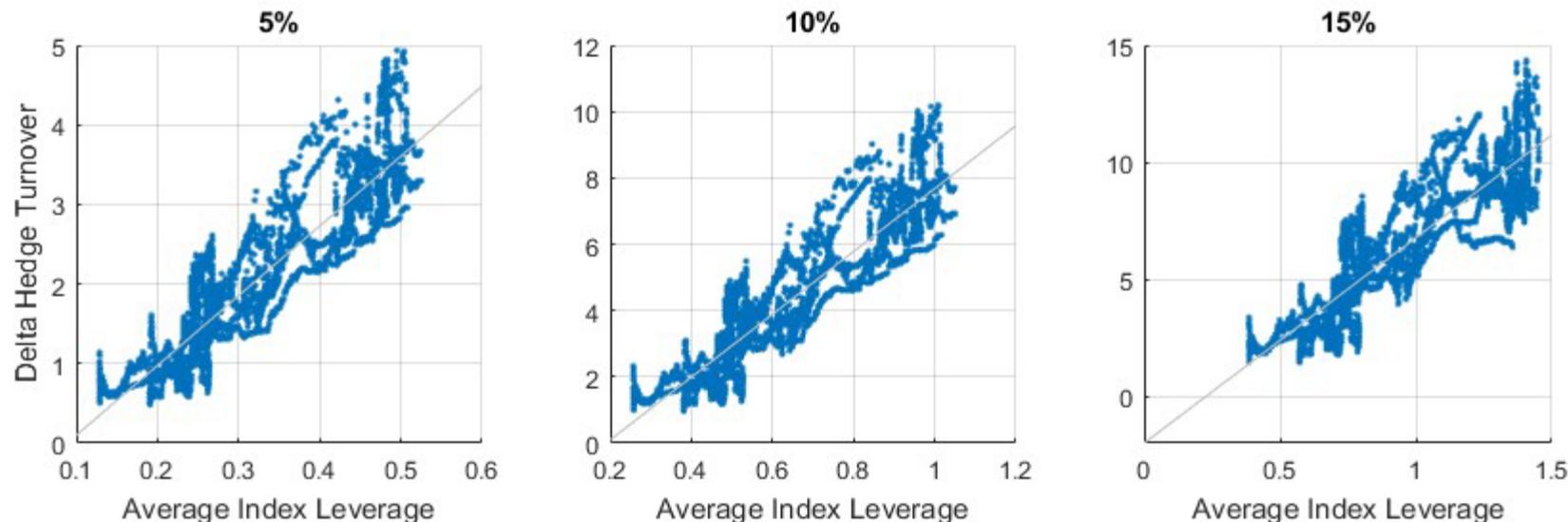


Options on Risk-Controlled Underlyings

Where should the forward be priced?

- Cash and carry arguments need to be applied with caution
 - Dividends, borrow costs, rate basis can all introduce further dependence on volatility
- Bid-offers on the “base” index can also negatively impact the hedger if turnover is high
 - Varying leverage creates turnover in the base index (and thus exposure to vol of vol)

Delta Hedge Turnover vs. Average Index Leverage
(overlapping periods)



Options on Risk-Controlled Underlyings

Summary

- Can significantly lower vega risk assuming that:
 - The volatility estimator is reasonably good
 - The index is able to realize at the target volatility (i.e. leverage cap not in the money)
 - Dividends, borrow are not a factor
- However, new problems are created:
 - Significantly higher gamma and turnover (even before the option, the index requires daily rebalancing now)
 - The forwards of the index may be a function of volatility (imagine a price-return index or an underlying that is hard to borrow)
 - Bank stress scenarios result in punitive capital positions
- Remember to price in collateral

4. Derivatives Market Outlook

Derivatives Outlook

- Potential changes to US GAAP accounting for variable annuities
 - Currently GMDB, GMIB, and some GMWB fall under SOP 03-1
 - A move closer to fair valuation will add new rate and equities risks to hedge
- FIA GLWB hedging is currently rare and limited to mostly rho
 - Increased hedging activity will be a positive for both rates and equity derivatives
- On the other hand, interest in Investment-only VA may be a force driving down the use of derivatives

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