

P I M C O

Your Global Investment Authority

On Modeling Long-Horizon Asset Returns and Implications for Retirement Plans

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The Crux of the Problem



- Investors planning for retirement are asked to make decisions under uncertainty for **LONG** periods of time
- Asset Returns do not appear to be “well behaved”
- Can we do a better job of constructing tools that
 - Square with Empirical Research and Economic Intuition
 - Take advantage of advances in modeling techniques and computing power to design better products and strategies for investors?

Asset Returns do not appear to be “well behaved”

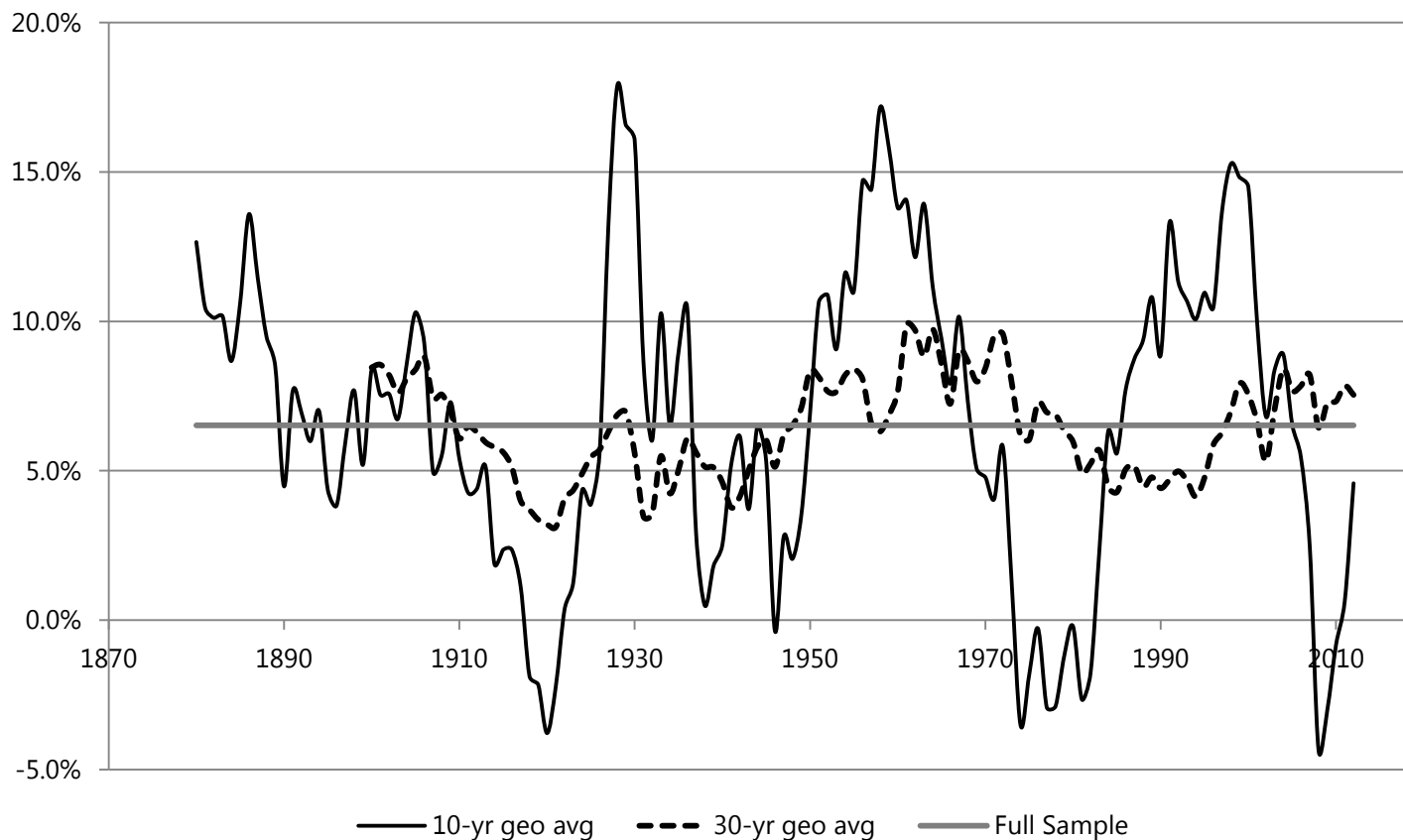


- Asset returns deviate from Normality (Mandelbrot, various others)
 - Fat Tails (aka: Leptokurtotic)
 - Skew
- Positive Serial Correlation in the Short to Medium Term (Lo & MacKinlay, others)
- Long-Run Mean Reversion (Summers & Poterba, others)
- Further questions as to what we really “know” (Kahneman & Tversky, Pastor & Stambaugh, others)

What is the “True” Average Return for Equity?



Averages of S&P Composite Real Returns 1871-2012



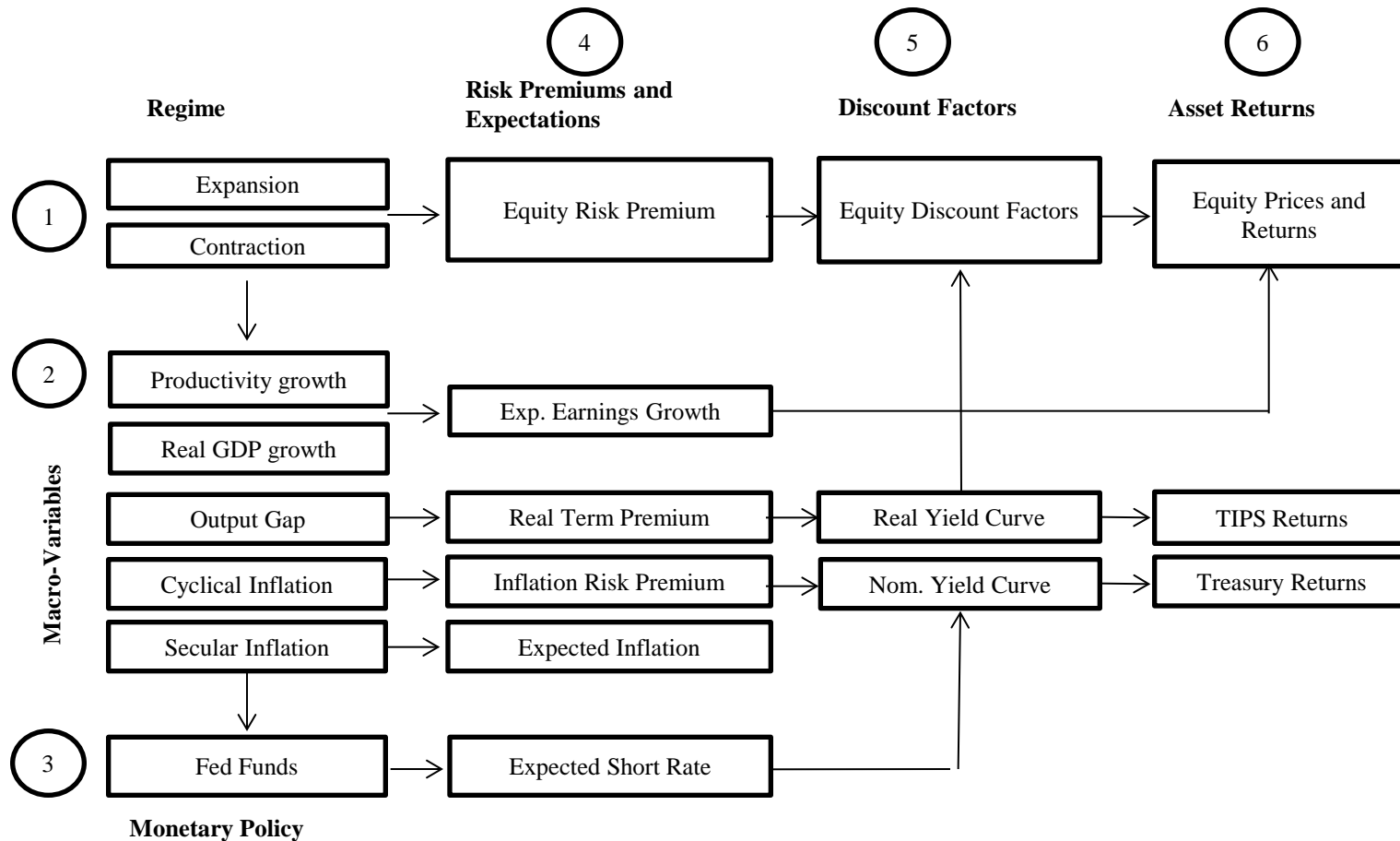
SOURCE: Robert Shiller
Returns represented by Robert Shiller data from 1871 through 1926, S&P 90 from 1926 through 1956 and S&P 500 from 1957 through present.

The Exercise



- Develop an alternative simulation framework that (hopefully) captures a number of the desired features
 - Macro-Consistent Structural Regime-Switching Model
- Compare it to more traditional approaches
 - Multivariate Normal
 - Block Bootstrap
- Run the simulations through some Real World “Filtrations”
 - Corporate Defined Benefit Plan with PPA Funding Rules for 10 years
 - 40 year Defined Contribution Glidepath

The New Horse: Schematic of Long-Horizon Regime Switching Model

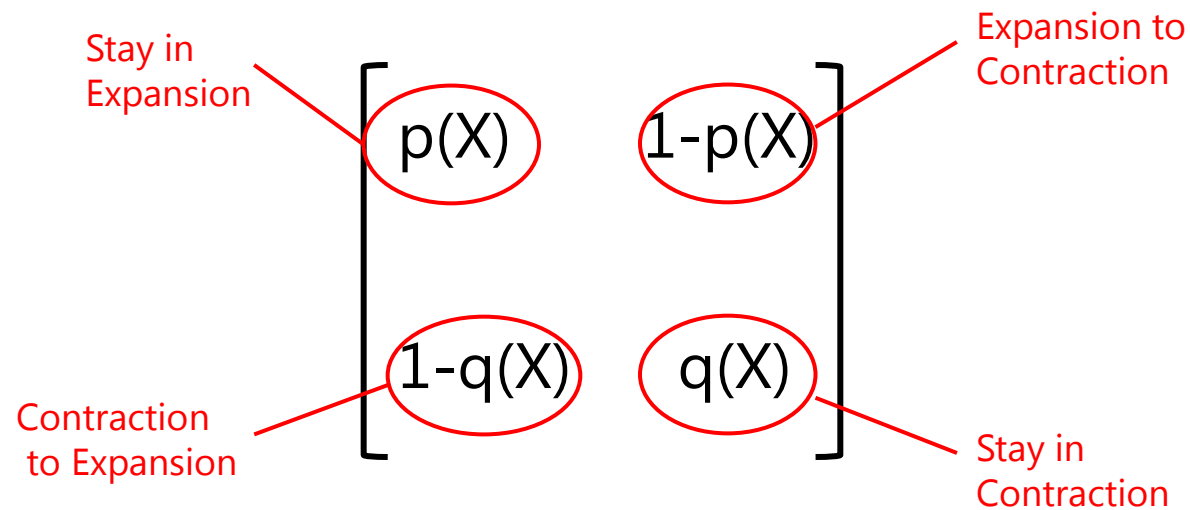


SOURCE: PIMCO

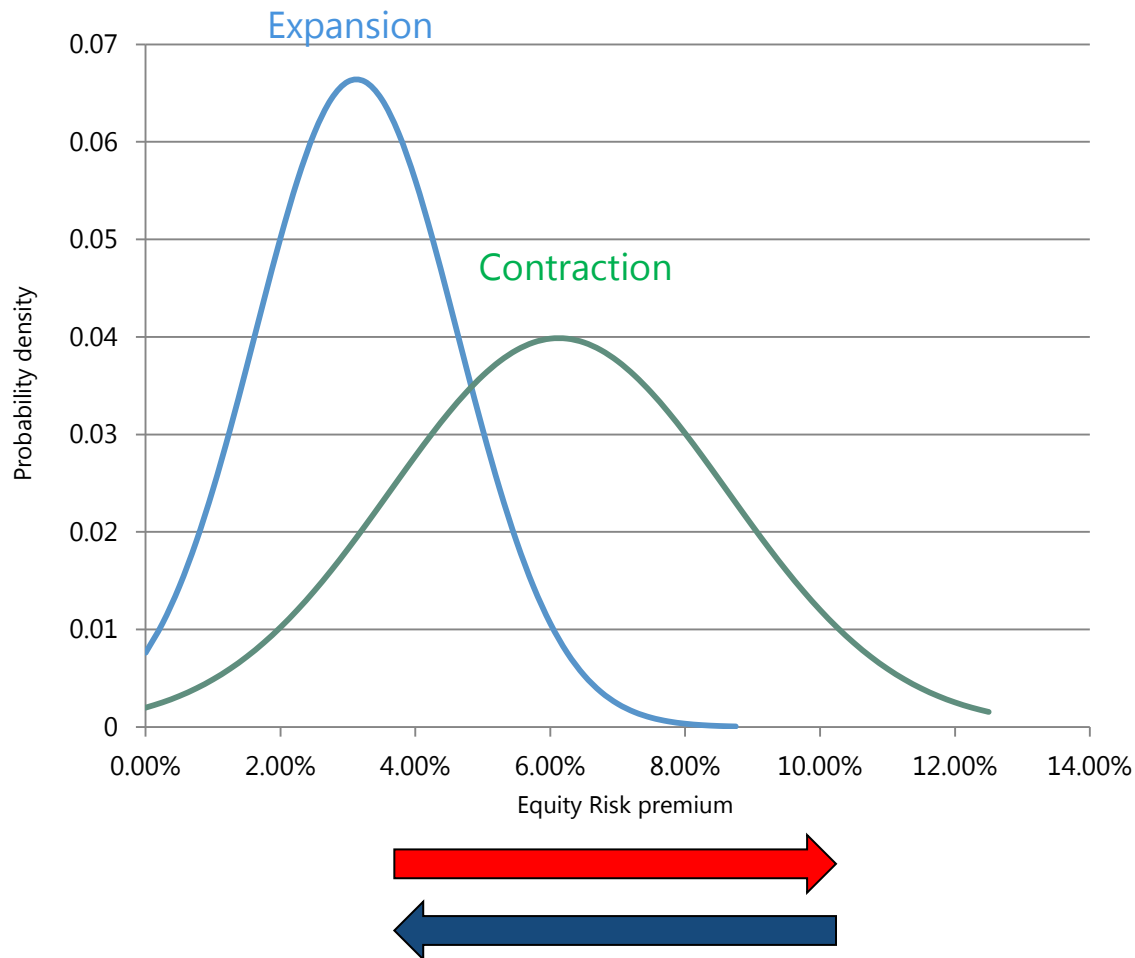
At the Heart of our Schizophrenic Horse



- Markov Switching Process for GDP (a la Hamilton)



A Key Driver of Equity Dynamics: Regime-Dependent Stochastic Equity Risk Premium



Sample for illustrative purposes only.

Tale of the Tape

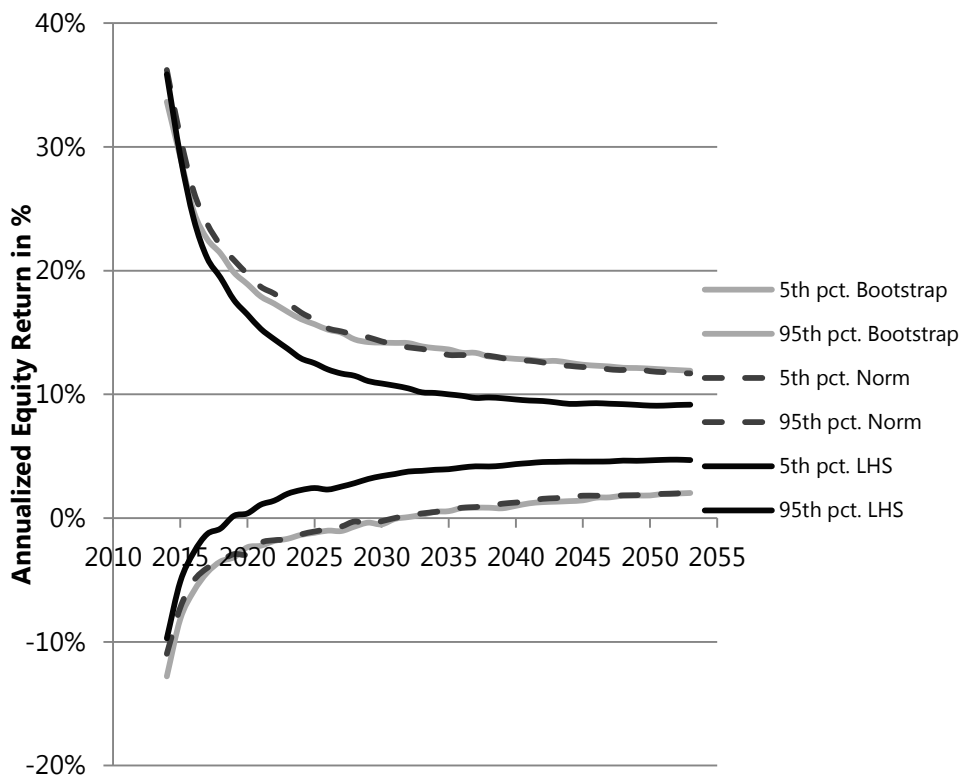


	<u>Normal</u>	<u>Bootstrap</u>	<u>Structural LHS</u>
Parsimonious	✓	✓	Not so much...
Easy to Calibrate (First Two Moments)	✓	✓	Define Easy...
Fat Tails	✗	✓	✓
Short-Horizon Momentum	✗	✓	✓
Long-Horizon Mean Reversion	✗	✗✗	✓
Econ/Fundamentally Consistent Scenarios	✗	✗	✓
Knightian Uncertainty	✗	✗	✗

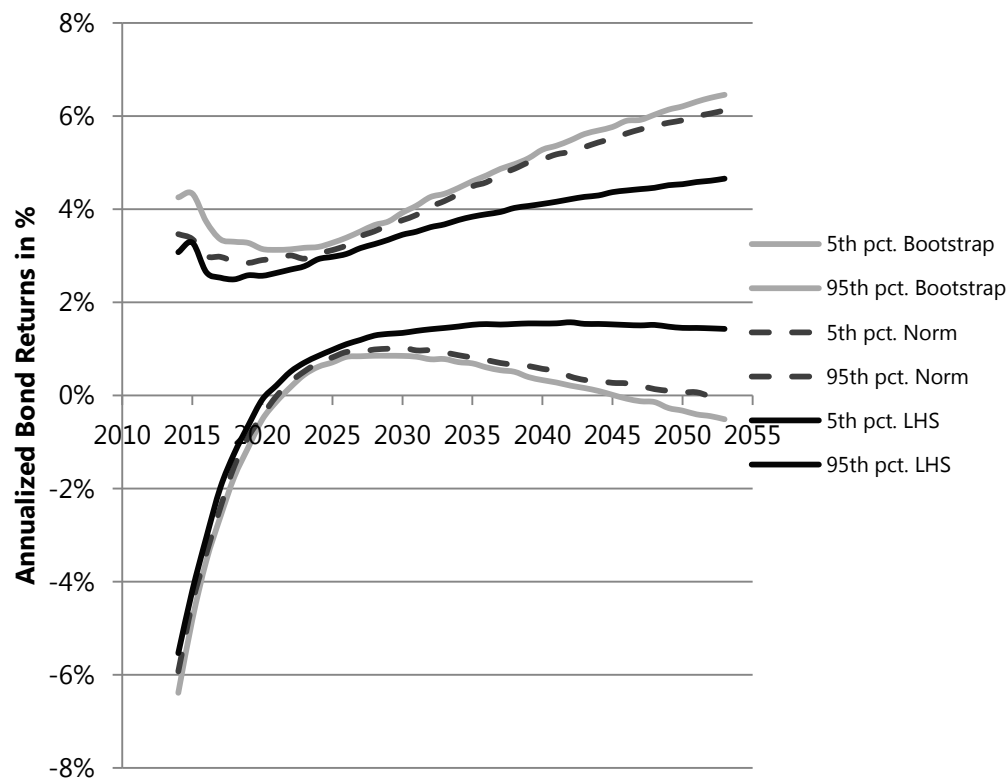
Comparison of Spread of Annualized Returns



Annualized Horizon Equity Returns



Annualized Horizon Bond Returns



As of 15 March 2103
SOURCE: PIMCO

Hypothetical example for illustrative purposes only.

Results based on proprietary PIMCO model and do not reflect the past or future performance of any PIMCO products. Refer to Appendix for additional forecast and hypothetical example information.

Is it a Race Track or a Steeplechase? Courses for Evaluation of our Horses

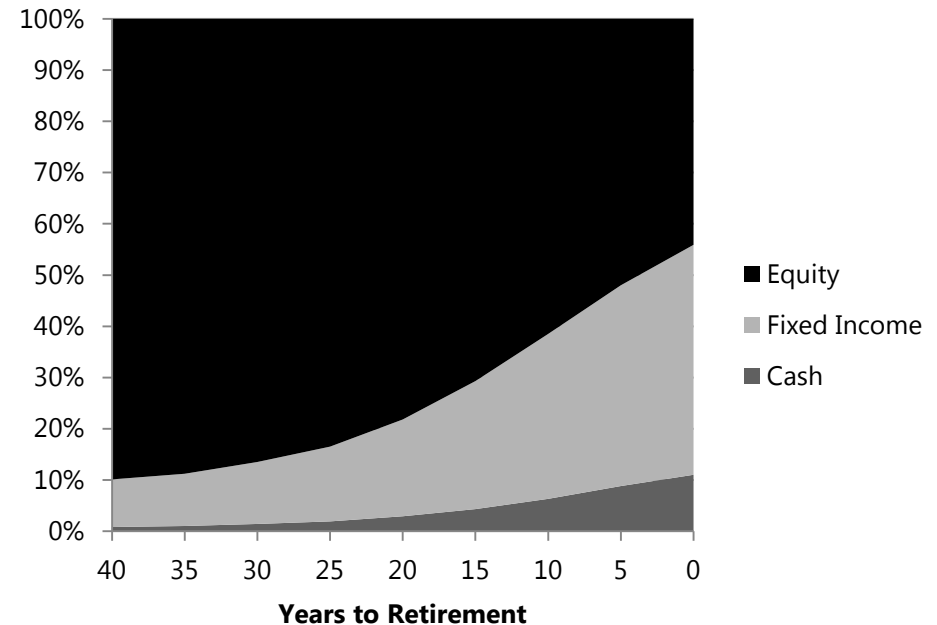


- Corporate DB Plan Assumptions
 - 80% Funded
 - 60/40 Asset Allocation
 - 10 years of contributions under PPA Rules

- DC Plan Assumptions
 - Starting Salary: \$30,000
 - 1% Real Salary Growth
 - 6% EE Contribution, 4% ER Match

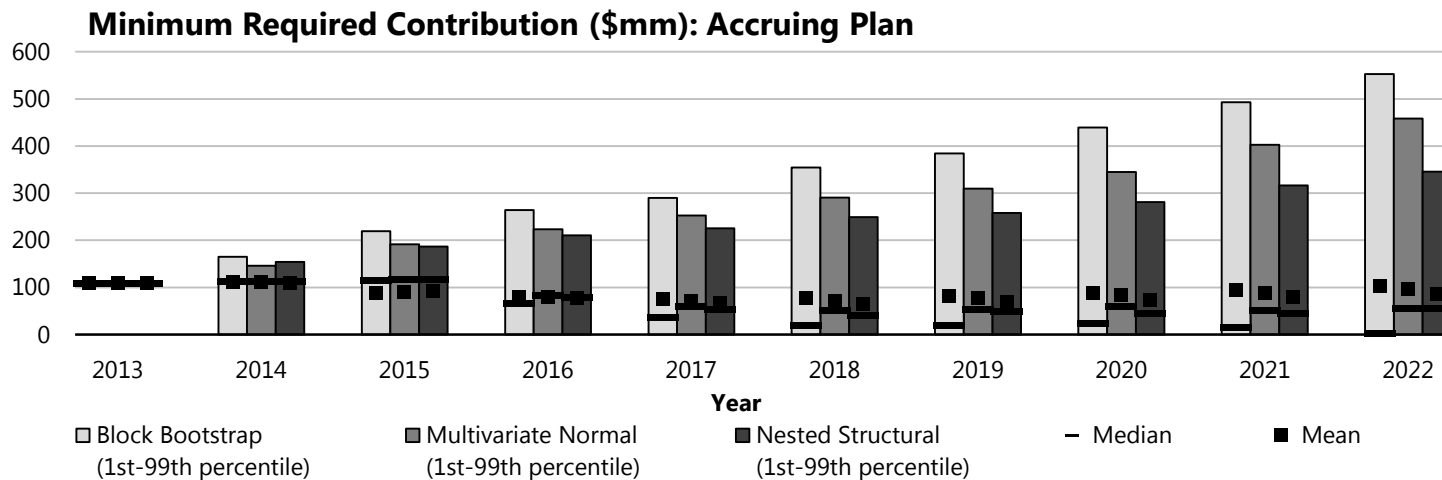
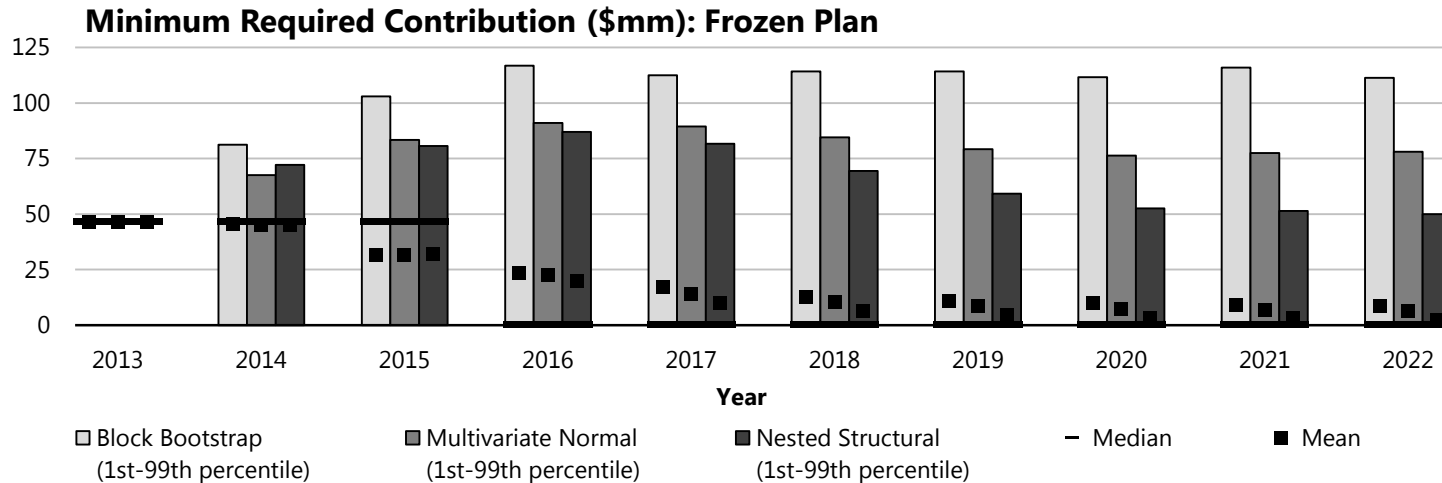
	Frozen plan	Accruing Plan
PV(Liabilities)	\$1.25B	\$1.25B
0-10 yrs	42%	32%
10-20 yrs	35%	36%
20-30 yrs	16%	20%
30+ yrs	7%	12%
Duration of Liabilities	13.8 yrs	16.5 yrs
Normal Cost Pct. Of Liabilities	-	5%

Simplified Market Average DC Glidepath



As of 15 March 2103
 SOURCE: PIMCO, MarketGlide
Hypothetical example for illustrative purposes only.
 Refer to Appendix for additional hypothetical example and portfolio analysis information.

Simulation Results: DB Plan

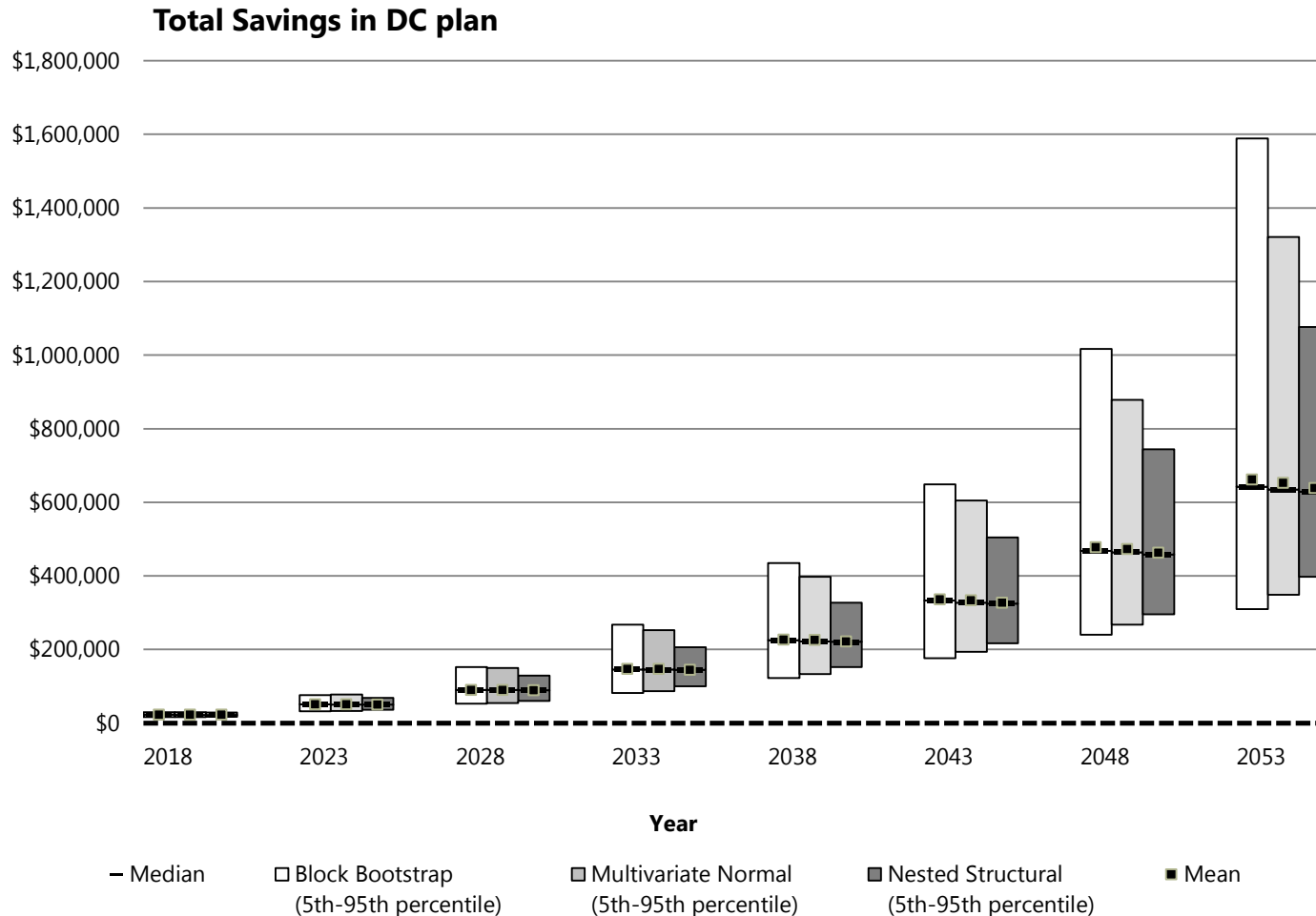


As of 15 March 2103
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Simulation Results: DC Glidepath



As of 15 March 2103
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Final Thoughts



- Interesting Preliminary Results, but much room for further development
 - Inclusion of Knightian/Bayesian Parameter Uncertainty
 - Extensions to Multiple Economies
 - Inclusion of Broader Menu of Asset Classes
- Broad Array of Potential Applications
 - Evaluate dynamic/conditional Asset Allocation strategies
 - Examine value/role of Options-based hedging strategies
 - Evaluate Product Design across business cycles
 - Examine interplay of asset allocation and non-linear filters and constraints



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