LATF Summer National Meeting
Supplemental Packet

LIFE ACTUARIAL (A) TASK FORCE

August 11-12, 2023

NAIC SUMMER NATIONAL MEETING

Hybrid Format

August 11-12, 2023

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Hear a Presentation on Interest Rate
Acceptance Criteria for the Generator of
Economic Scenarios (GOES)

Interest Rates—
Update on proposed Acceptance Criteria

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National Association of Insurance Commissioners (NAIC)
Life Actuarial (A) Task Force (LATF)—August 12, 2023

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Background

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Background   4

LATF asked the Academy to deliver a series of presentations focused on proposing qualitative **Stylized Facts** and quantitative **Acceptance Criteria** for the three major components of an ESG used for statutory reporting purposes: **Interest Rates**, **Equity Returns**, and **Corporate Bond Fund Returns**.

This presentation provides an update on the Academy's work to propose **Acceptance Criteria for Interest Rates**, including both newly developed criteria and minor changes to previously proposed criteria.
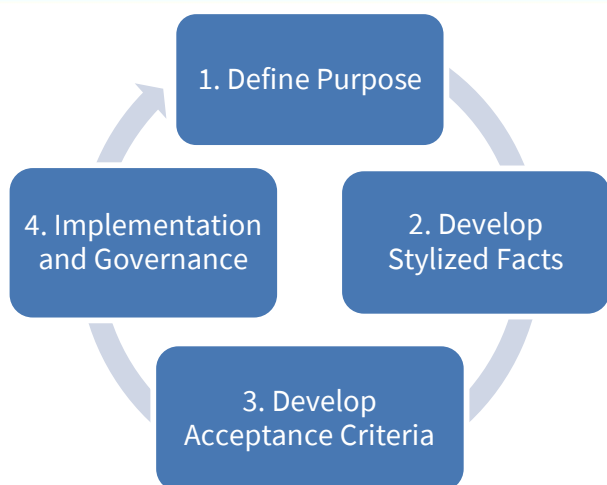
Prior presentations in this series:
- A Framework for Working with ESGs (8/8/22)
- ESG Governance Considerations (8/8/22)
- Equity Returns—Stylized Facts (8/9/22)
- Corporate Credit & Bond Fund Returns—Stylized Facts, Acceptance Criteria, and a Simplified Model (10/27/22)
- Interest Rates—Stylized Facts and Acceptance Criteria (12/11/22)

This and future presentations in this series:
- ➢ **Interest Rates—Update on Proposed Acceptance Criteria (8/12/22)**
- Equity Returns—Acceptance criteria, including criteria for the joint distribution of equity returns and interest rates (TBD)

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A framework for developing, implementing, and evaluating ESGs and the scenario sets they produce

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Diagram (cyclic):
- 1. Define Purpose
- 2. Develop Stylized Facts
- 3. Develop Acceptance Criteria
- 4. Implementation and Governance

"Statistical criteria are important in assessing the quality of an ESG. Statistical calibration criteria are usually numerically specified but can also be qualitative in nature. Statistical criteria belong to one of two broad categories: qualitative features and quantitative measures. The issues one must address in both categories are not amenable to a checklist approach, however, and expert judgment plays a role."

(quote from p. 96 of the 2020 CAS/Conning research paper on ESGs)

1. **Define Purpose**: The intended purpose of the ESG informs the economic variables to be simulated and the relative importance of their "stylized facts."

2. **Develop Stylized Facts**: Stylized facts describe properties of the economic variables to be simulated. They are based on historical market data and economic theory and are prioritized relative to the defined purpose at hand. The establishment of stylized facts is critical for selecting candidate ESG models and a key prerequisite for the development of acceptance criteria.

3. **Develop Acceptance Criteria**: A set of quantitative metrics or target values at different time horizons or in different economic conditions that provide a simplified framework for ensuring sets of scenarios produced by the ESG are consistent with key stylized facts.

4. **Implementation and Governance**: ESG models are selected based on their ability to reflect the stylized facts, then calibrated in accordance with acceptance criteria. Validation reports are produced on each candidate scenario set generated by the ESG. These reports compare scenario set statistics to acceptance criteria and contain other charts and tables useful for evaluation and signoff, which is ultimately a matter of judgement (no automatic "pass" or "fail" based only on acceptance criteria). Implementation is an iterative process. It is important to periodically review and recalibrate the ESG as market conditions change over time.

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2.

Changes to previously proposed criteria

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Rate level
Criteria for the distribution of steady state interest rates
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Percentile	20Y Criteria	1Y Criteria	"Buffers" can provide guidance on "too extreme"
99th	> 13.55%	> 13.86%	[275 bps]
95th	> 9.35%	> 9.02%	[250 bps]
85th	> 7.54%	> 6.22%	[225 bps]
50th	> 3.35% and < 4.88%	> 1.31% and < 3.34%	n/a
15th	< 2.31%	< 0.16%	[70 bps]
5th	< 1.78%	< 0.10%	[80 bps]
1st	< 1.15%	< 0.07%	[90 bps]

- Criteria are based on 15-year half-life PEWs calculated from 1953.04 to 2021.12.
  - Scenarios should be "plausibly more extreme" than the PEWs; however, scenarios that exceed the PEWs by more than a "buffer" may be "too extreme".

- Note, the range for the 50th percentile (Median) is based on the [40th] and [60th] PEW.

- Note, other categories of criteria cover rate dynamics in initial periods.

Changes from 12/11/2022 presentation:

- *Min/Max criteria moved to new criteria focused on bounds and worse-than-history events.*
- *Removed 30th/70th percentile criteria.*
- *Steady state period changed from month [600] to months [961 through 1200] (years [80 through 100]).*

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Rate volatility
Criteria for the standard deviation of monthly yield changes

Bucket	Yield Level (BOM)	1Y volatility		20Y volatility	
		Historical Stat	Desired range for scenario stat	Historical Stat	Desired range for scenario stat
Low	[≤ 3%]	0.59%	0.30% to 0.89%	0.61%	0.31% to 0.92%
Medium	[> 3%, ≤ 8%]	1.16%	0.58% to 1.73%	0.74%	0.37% to 1.12%
High	[> 8%]	3.32%	1.67% to 5.02%	1.54%	0.78% to 2.33%

Changes from 12/11/22 presentation:

- *Steady state period changed from months [600] to months [961] through [1200] (years [80] through [100]). Initial period remains the first [10] years.*

- *A specific buffer of [50%] has been illustrated.*

Notes:

- The relevant statistic is the annualized standard deviation of monthly yield changes across all scenarios, bucketed by the rate level at the beginning of month (BOM).

- Desired ranges use a [50%] buffer on either side of the historical statistic.

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Yield curve slope
Criteria for the shape of the yield curve

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Percentiles of [20Y]-[1Y]	Bucketed by level of [20Y] rate		
	<=[3%]	>[3%] to <=[8%]	>[8%]
99th	2.81% to 3.31%	4.06% to 4.56%	2.76% to 3.26%
95th	2.64% to 3.14%	3.71% to 4.21%	2.41% to 2.91%
90th	2.52% to 3.02%	3.44% to 3.94%	2.05% to 2.55%
85th	2.28% to 2.78%	3.23% to 3.73%	1.94% to 2.44%
15th	-0.01% to 0.49%	-0.56% to -0.06%	-1.46% to -0.96%
10th	-0.11% to 0.39%	-0.71% to -0.21%	-1.79% to -1.29%
5th	-0.23% to 0.27%	-0.97% to -0.47%	-2.06% to -1.56%
1st	-0.32% to 0.18%	-1.73% to -1.23%	-3.43% to -2.93%

Changes from 12/11/22 presentation:
- *Added percentiles further out in the tails.*
- *Steady state period changed from months 600 to months 961 through 1200 (years 80 through 100). Initial period remains the first 10 years.*

Notes:
- Based on historical percentiles using data from [1953.04 to 2021.12] and a [50 bps] buffer.
- Historical statistics are in black.

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3.

Newly proposed criteria

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Description of new categories of acceptance criteria

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- Criteria for upper and lower bounds and worse-than-history frequencies for rate and slope levels

- Criteria for reversion of median rate and slope levels

- Low-for-long criteria

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Criteria for upper and lower bounds and worse-than-history frequencies for rate and slope levels

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	Bucket	Lower Bound	Upper Bound	Historical Min and Max (for reference)[1]	Worse-Than-History Frequencies[2]
Rates:					
1Y	n/a	-0.5% to -1%	20% to 24%	0.05% & 16.97%	0.5% to 1.5%
20Y	n/a	0% to 0.5%	17% to 20%	0.95% & 15.78%	0.5% to 1.5%
Slopes:					
20Y-1Y	20Y <= 3%	-0.5% to -1.5%	3% to 4%	0.02% & 2.85%	0.5% to 2%
20Y-1Y	3% < 20Y <= 8%	-2% to -3.5%	4.5% to 6%	-1.38% & 4.15%	0.5% to 2%
20Y-1Y	8% < 20Y	-4% to -5%	3.5% to 5.5%	-3.36% & 2.90%	0.5% to 2%

[1] *Historical Min and Max determined using monthly observations from 1953.04 to 2021.12.*
[2] *The same Worse-Than-History frequency ranges are proposed for both the left and right tail.*
[3] *These criteria are applied to the steady state period, i.e., months [961] through [1200] (years [80] through [100])*

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Criteria for reversion of median rate and slope levels

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Proposed criteria for interim rate levels is expressed in terms of the length of time it takes for initial rates and slopes to revert 50% of the way to their steady state levels (e.g., half-lives).

The Academy is currently using reference models to further explore potential additional interim criteria.

	Proposed range for half-life of median reversion
Rates:	
1Y	[10] to [20] years
20Y	[10] to [20] years
Slopes:	
20Y-1Y	[2] to [8] years

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Low-for-long criteria for steady state interest rate levels   14

- Proposed *additional, steady state,* low-for-long criteria uses the concept of "sojourn length," i.e., the number of years an interest rate stays within a defined corridor.

  - Criteria for [1Y] rate: During months [961 to 1200] (years [80 to 100]), the 1Y rate stays below [0.5%] for at least [5] consecutive years in at least [X%] of scenarios.

  - Criteria for [20Y] rate: During months [961 to 1200] (years [80 to 100]), the 20Y rate stays below [2%] for at least [5] consecutive years in at least [X%] of scenarios.

- This steady state low-for-long criteria can be combined with the NAIC's current initial period low-for-long criteria to ensure desired low-for-long behavior throughout the simulation. DB0

- Reference models can and should be used to refine the numbers in brackets.

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Discussion and Q&A

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Thank You

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5.

Appendix 1 — Slides from Academy's 12/11/2022 presentation on Interest Rates

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Interest Rates—
Stylized Facts and Acceptance Criteria

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Member, Economic Scenario Generator Work Group (ESGWG)

National Association of Insurance Commissioners (NAIC) Life Actuarial (A) Task Force (LATF)
December 11, 2022

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Agenda—Interest rates

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1. Background
2. Stylized Facts
3. Acceptance Criteria
4. Discussion and Q&A

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1.

Background

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Background

LATF asked the Academy to deliver a series of presentations focused on proposing qualitative **Stylized Facts** and quantitative **Acceptance Criteria** for the three major components of an ESG used for statutory reporting purposes: **Interest Rates**, **Equity Returns**, and **Corporate Bond Fund Returns**.

This presentation proposes **Stylized Facts** and **Acceptance Criteria** for Interest Rates that (a) are independent of any specific ESG model, (b) can be used to identify and evaluate candidate ESG models, and (c) can be used to evaluate a set of stochastic scenarios.

Prior presentations in this series:
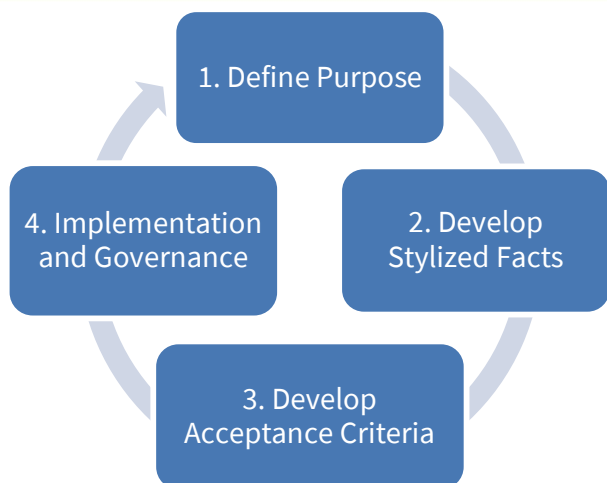- A Framework for Working with ESGs (8/8/22)
- ESG Governance Considerations (8/8/22)
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This and future presentations in this series:
- **Interest Rates—Stylized Facts and Acceptance Criteria**
- Equity Returns—Acceptance Criteria

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A framework for developing, implementing, and evaluating ESGs and the scenario sets they produce

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"Statistical criteria are important in assessing the quality of an ESG. Statistical calibration criteria are usually numerically specified but can also be qualitative in nature. Statistical criteria belong to one of two broad categories: qualitative features and quantitative measures. The issues one must address in both categories are not amenable to a checklist approach, however, and expert judgment plays a role."

(quote from p. 96 of the 2020 CAS/Conning research paper on ESGs)

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Excerpts from the 2020 Casualty Actuarial Society (CAS)/Conning research paper on ESGs

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High-level features of a good ESG:

- ➤ "It produces simulation results that reflect the economic view of the risk manager.
- ➤ Scenarios are consistent with **realistic market dynamics**.
- ➤ A large simulation should produce some **extreme but plausible results** (i.e., the simulation covers and moderately exceeds the benchmark stylized facts).
- ➤ Component models and architecture must have sufficient flexibility to serve in multiple roles.

If one discusses the essential features of a good ESG with a diverse group of ESG experts, those experts' lists of features and the relative importance of those features will vary. However, they will set forth a common core of ideas that can serve as a checklist of best practices."

A good ESG:

1. "has a solid methodological foundation for the way the models are built and the way the variables are interrelated, and models are parsimonious, practical, and comprehensive.
2. provides a comprehensive suite of macroeconomic and financial variables and a multi-economy capability.
3. can accommodate many types of calibration views across a wide range of benchmarks.
4. produces simulation results that reflect a relevant view.
5. produces some extreme but plausible outcomes.
6. embeds realistic market dynamics.
7. is computationally efficient and numerically stable.
8. has fast and robust recalibration capabilities.
9. meets the requirements of regulators and auditing firms.
10. produces sufficient simulation detail for extensive validation."

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The NAIC presented LATF with preliminary goals for interest rates on 12/3/20 and preliminary boundary guidance on 2/17/22   24

Preliminary goal	Preliminary boundary guidance
1. The model's starting yield curve should fit the actual starting yield curve as closely as possible. 2. The model should produce a variety of yield curve shapes, and they should change over time.	*Yield curve fit and Yield curve shape (priority 4)* a) Review initial actual vs. fitted spot curve differences for a sampling of 5 dates representing different shapes and rate levels for the entire curve and review fitted curves qualitatively to confirm they stylistically mimic the different actual yield curve shapes b) The frequency of different yield curve shapes in early durations should be reasonable considering the shape of the starting yield curve (e.g., a flatter yield curve leads to more inversions). c) The steady state curve has normal shape (not inverted for short maturities, longer vs shorter maturities, or between long maturities)
3. Interest rates can be negative.	*Negative rates (priority 3)* a) All maturities could experience negative interest rates b) Interest rates may remain negative for multi-year time periods c) Rates should generally not be lower than -1.5%

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The NAIC presented LATF with preliminary goals for interest rates on 12/3/20 and preliminary boundary guidance on 2/17/22 (continued)[25]

Preliminary goal	Preliminary boundary guidance

4. The model should be capable of producing a reasonable range of results for very long simulations.	*High rates (priority 2)*
	
	a) The scenario set should reasonably reflect history, with some allowance for more extreme high and low interest rate environments
	
	b) Upper Bound:
	  i. 20% is >= 99th percentile on the 3M yield fan chart, and no more than 5% of scenarios have 3M yields that go above 20% in the first 30 years
	  ii. 20% is >= 99th percentile on the 10Y yield fan chart, and no more than 5% of scenarios have 10Y yields that go above 20% in the first 30 years

5. The ESG should be capable of producing low interest rates for an extended period of time.	*Low for long (priority 1)* a) For scenarios generated as of 12/31/20, at least **10%** of scenarios should have a **10-year** geometric average of the 20-year US Treasury yield that is below its current level (e.g., 1.45% at 12/31/20) b) For scenarios generated as of 12/31/20, at least **5%** of scenarios should have a **30-year** geometric average of the 20-year US Treasury yield that is below its current level (e.g., 1.45% at 12/31/20)

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The NAIC presented LATF with preliminary goals for interest rates on 12/3/20 and preliminary boundary guidance on 2/17/22 (continued)26

Preliminary goal	Preliminary boundary guidance
6. The model should produce interest rate levels that fluctuate significantly over long periods.	*Volatility (no priority given)* Preliminary boundary guidance not specified
7. The interest rate generator should be arbitrage free.	*Arbitrage free (priority 3)* No longer considered an explicit requirement in the 2/17/22 preliminary boundary guidance since the NAIC's ESG Drafting Group was proposing the use of a generalized fractional floor.
8. The ESG should be calibrated using an appropriate historical period.	*Historical calibration period (no priority given)* Preliminary boundary guidance not specified

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2.

Stylized Facts

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Groupings for stylized facts about interest rates

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Stylized Facts have been grouped into the following three categories:

1. Level of Interest Rates

2. Volatility of Interest Rates

3. Term Structure of Interest Rates (shape of yield curve)

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Stylized Facts
1. Level of Interest Rates

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The level of interest rates (the cost of borrowing money) changes due to a variety of complex and interrelated factors (e.g., supply of and demand for financing, business cycle, GDP, inflation, central bank actions to stimulate the economy or control inflation).

a. Short-term rates (which the Fed has more control of) have generally fallen within a range of 0% to 20% and have most often been within the lower part of that range. Long-term rates have generally been within 300 bps of short-term rates.

b. Negative interest rates are possible (have been observed outside the U.S.) but unlikely due to structural and market differences between the U.S. and other economies.

c. Interest rates can exhibit multi-year trends (e.g., up, down, low-for-long). Interest rates can stay at very low levels for several years. Short-term rates can stay very near their lower bound for several years while higher long-term rates continue to fluctuate.

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Stylized Facts
2. Volatility of Interest Rates

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The volatility of interest rates varies over time, with periods of both high and low volatility.

a. Monthly changes in interest rates are generally limited in size (less than 80 bps) but changes tend to be greater when the level of interest rates is higher.

b. Monthly changes in short-term rates tend to be larger than monthly changes in long-term rates when short-term rates are not near their lower bound, but the opposite relationship tends to hold when short-term rates are near their lower bound.

c. Volatility tends to increase in stressed markets.

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Stylized Facts
3. Term Structure of Interest Rates (shape of yield curve)

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The yield curve embodies the term structure of interest rates and takes a variety of shapes.

a. The normal yield curve shape is upward sloping (long-term rates greater than short-term rates) and concave downward. Normal yield curve shapes can persist for extended periods of time.

b. Non-normal yield curve shapes include inversions (downward sloping), humps, and valleys. Inversions (and other non-normal yield curve shapes) are often associated with key points in the business cycle (e.g., recession indicator) but generally don't persist for extended periods of time.

c. The slope of the yield curve tends to be lower (even negative/inverted) when short-term rates are at relatively high levels.

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3.

Acceptance Criteria

Unless otherwise specified, tables and charts on the following slides are based on two primary data sources:

1. *Historical U.S. Treasury yields from the "Historical Curves" tab of the August 2022 Academy Interest Rate Generator (AIRG) located at https://soa.org/resources/tables-calcs-tools/research-scenario/*

2. *Simulated U.S. Treasury yields from "10000_Path_Set_1a_Conning_GFF_Baseline_Equity_123121" located at https://naic.conning.com/scenariofiles*

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This section discusses acceptance criteria around four key properties of interest rates identified in the stylized facts 33

1. Rate level
   - Includes criteria around high, low, and negative rates.
   - Only **steady state** criteria is being proposed at this point. **Interim** rate level criteria, which depend heavily on initial conditions, are being developed and will be proposed later.

2. Rate volatility
   - Criteria varies by rate level (applies to interim and steady state).

3. Yield curve shape
   - Criteria varies by rate level (applies to interim and steady state).

4. Low-for-long
   - Although the ESGWG has not finalized its proposal for this key property of interest rates, we present our qualitative understanding of low-for-long for discussion and feedback.

Acceptance criteria provide a simplified framework for validating key scenario properties but are only part of a larger validation exercise that includes other charts, statistics, and of course, judgment.

Criteria were developed with the following principles in mind:
- The scenario set should include some extreme but plausible scenarios.
- Pathwise behavior is as important as point-in-time distributions.
- Scenarios should be consistent with realistic market dynamics over both short- and long-term horizons.

"The importance of pathwise model behavior is that it is the simulated path that represents the way an insurance company will experience the evolution of the economy. In other words. The pathwise behavior is the only thing of interest when we want to investigate simulation dynamics. If the overall distribution of returns for an asset class is correct but the pathwise behavior does not correspond to the nature of the fluctuations that we see in the historical record, then there is a potential model issue." (p. 107)

"A good ESG will be capable of being calibrated to coherent targets across multiple simulation horizons." (p. 106)
(quotes from the 2020 CAS/Conning research paper on ESGs)

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Rate level
Historical PEWs (see appendix for additional information on PEWs)   34

- Selected 15-year half-life "Percentiles Exponentially Weighted" (PEWs) on historical month-end interest rates are proposed as steady state acceptance criteria for rate level (high, low, and negative).

  ➤ *Ideally, corresponding percentiles on scenario sets are "plausibly more extreme" than the PEWs.*

- Calculated using data from April 1953, but unlike typical percentiles where data is weighted equally, PEWs give exponentially less weight to older data.

- PEWs are defined by their "half-life." A half-life of 15 years means data that is 15 years older receives half the weight.

- A half-life of 15 years is suggested to give more weight to recent data while not overreacting to short-term fluctuations.

"Stability versus responsiveness: As a common trade-off and concern in general actuarial work, it is important to consider where the happy medium is between a long period of data (enhancing stability) and a recent shorter data period (that promotes responsiveness to more recent conditions)."
(quote from p. 129 of the 2020 CAS/Conning research paper on ESGs)

15-year half-life PEWs at 12/31/21	20Y	1Y
Max	15.52%	16.97%
99th PEW	13.55%	13.86%
95th PEW	9.35%	9.02%
85th PEW	7.54%	6.22%
70th PEW	5.77%	4.88%
60th PEW	4.88%	3.34%
50th PEW	4.33%	2.11%
40th PEW	3.35%	1.31%
30th PEW	2.83%	0.49%
15th PEW	2.31%	0.16%
5th PEW	1.78%	0.10%
1st PEW	1.15%	0.07%
Min	0.98%	0.05%

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Rate level
Criteria for the distribution of steady state interest rates   35

	20Y Criteria	1Y Criteria	"Buffers" could provide guidance on "too extreme"
Max	> 15.52%	> 16.97%	[300 bps]
99th Percentile	> 13.55%	> 13.86%	[275 bps]
95th Percentile	> 9.35%	> 9.02%	[250 bps]
85th Percentile	> 7.54%	> 6.22%	[225 bps]
70th Percentile	> 5.77%	> 4.88%	[200 bps]
50th Percentile	> 3.35% and < 4.88%	> 1.31% and < 3.34%	n/a
30th Percentile	< 2.83%	< 0.49%	[60 bps]
15th Percentile	< 2.31%	< 0.16%	[70 bps]
5th Percentile	< 1.78%	< 0.10%	[80 bps]
1st Percentile	< 1.15%	< 0.07%	[90 bps]
Min	< 0.98%	< 0.05%	[100 bps]

- Criteria is based on 15-year half-life PEWs.
  - Scenarios should be "plausibly more extreme" than the PEWs.
  - But scenarios that exceed the PEWs by more than a "buffer" may be "too extreme".

- Test statistics:
  - Percentiles of the [20Y] and [1Y] rate distributions at month [600] (year [50]).
  - Max and Min of the [20Y] and [1Y] rate distributions are from projection months [480] through [720] (years [40] through [60]).

- Note, the range for the 50th percentile (Median) is based on the 40th and 60th PEW.

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Rate level
Illustrative application of criteria to field test scenario set #1a   36

	20Y Criteria	1Y Criteria	Buffers	20Y Stat	20Y Result	1Y Stat	1Y Result
Max	> 15.52%	> 16.97%	[300 bps]	25.66%	> Buffer (714 bps)	29.60%	> Buffer (963 bps)
99th Percentile	> 13.55%	> 13.86%	[275 bps]	14.39%	In range	15.40%	In range
95th Percentile	> 9.35%	> 9.02%	[250 bps]	10.60%	In range	11.09%	In range
85th Percentile	> 7.54%	> 6.22%	[225 bps]	7.68%	In range	7.41%	In range
70th Percentile	> 5.77%	> 4.88%	[200 bps]	5.76%	< PEW (1 bp)	4.71%	< PEW (17 bps)
50th Percentile	> 3.35% and < 4.88%	> 1.31% and < 3.34%	n/a	4.20%	In range	2.35%	In range
30th Percentile	< 2.83%	< 0.49%	[60 bps]	2.85%	> PEW (2 bps)	0.40%	In range
15th Percentile	< 2.31%	< 0.16%	[70 bps]	1.85%	In range	0.07%	In range
5th Percentile	< 1.78%	< 0.10%	[80 bps]	0.99%	In range	-0.26%	In range
1st Percentile	< 1.15%	< 0.07%	[90 bps]	0.38%	In range	-0.53%	In range
Min	< 0.98%	< 0.05%	[100 bps]	0.22%	In range	-0.79%	In range

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Rate level
Illustrative application of criteria to field test scenario set #1a (continued) 37

Observed Steady State Values vs. Illustrative Acceptance Criteria Ranges: 20Y UST Yields
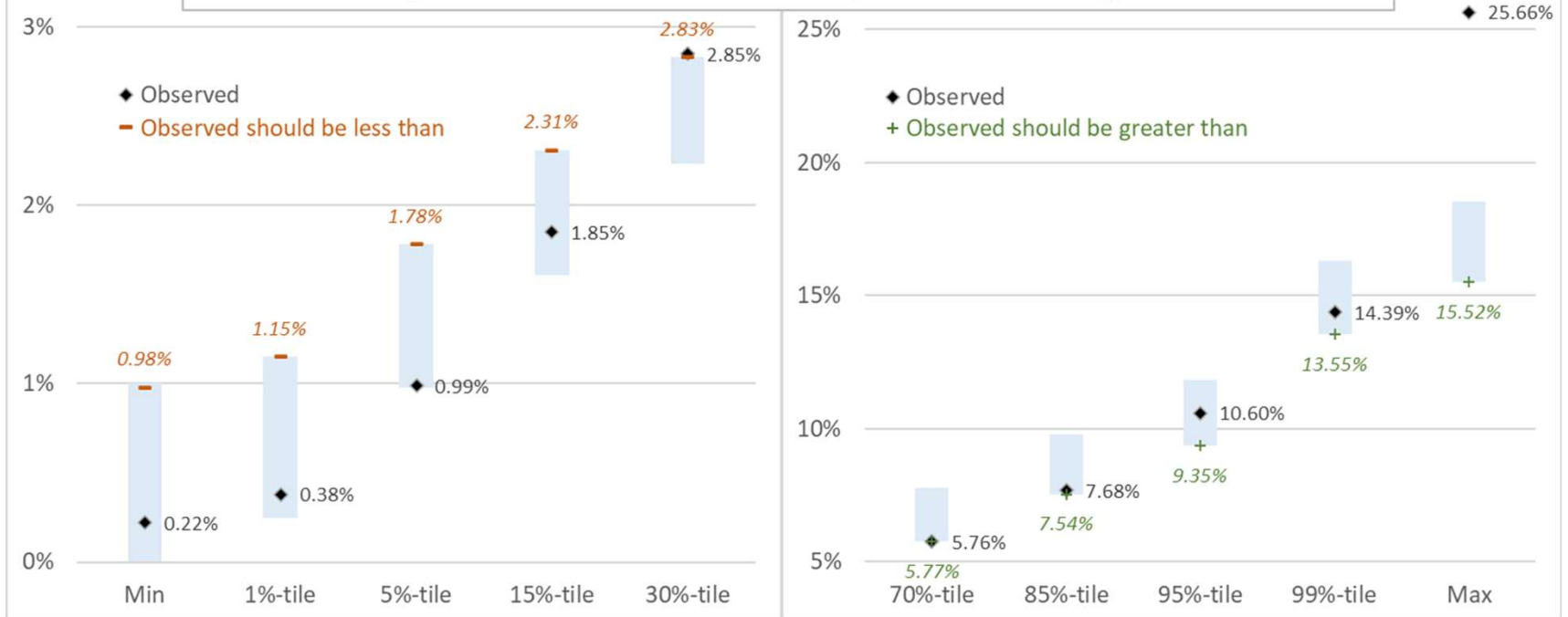
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Rate level
Supplemental chart for evaluating rate levels on consistent basis with PEWs 38

Frequency histogram of 20Y UST Yields

Legend:
- Historical (1953.04 - 2021.12; 15-year half-life weighted)
- Field test set #1a (12/31/21; month 600)

20Y UST Yield	Historical (1953.04 - 2021.12)		Field test set #1a (12/31/21; month 600)
	Equally weighted	15-year half-life weighted	
Min	0.98%	0.98%	0.22%
Mean	5.85%	4.77%	4.75%
Median	5.36%	4.33%	4.20%
Max	15.78%	15.78%	25.66%

20Y UST Yield (center of 100 bps interval)
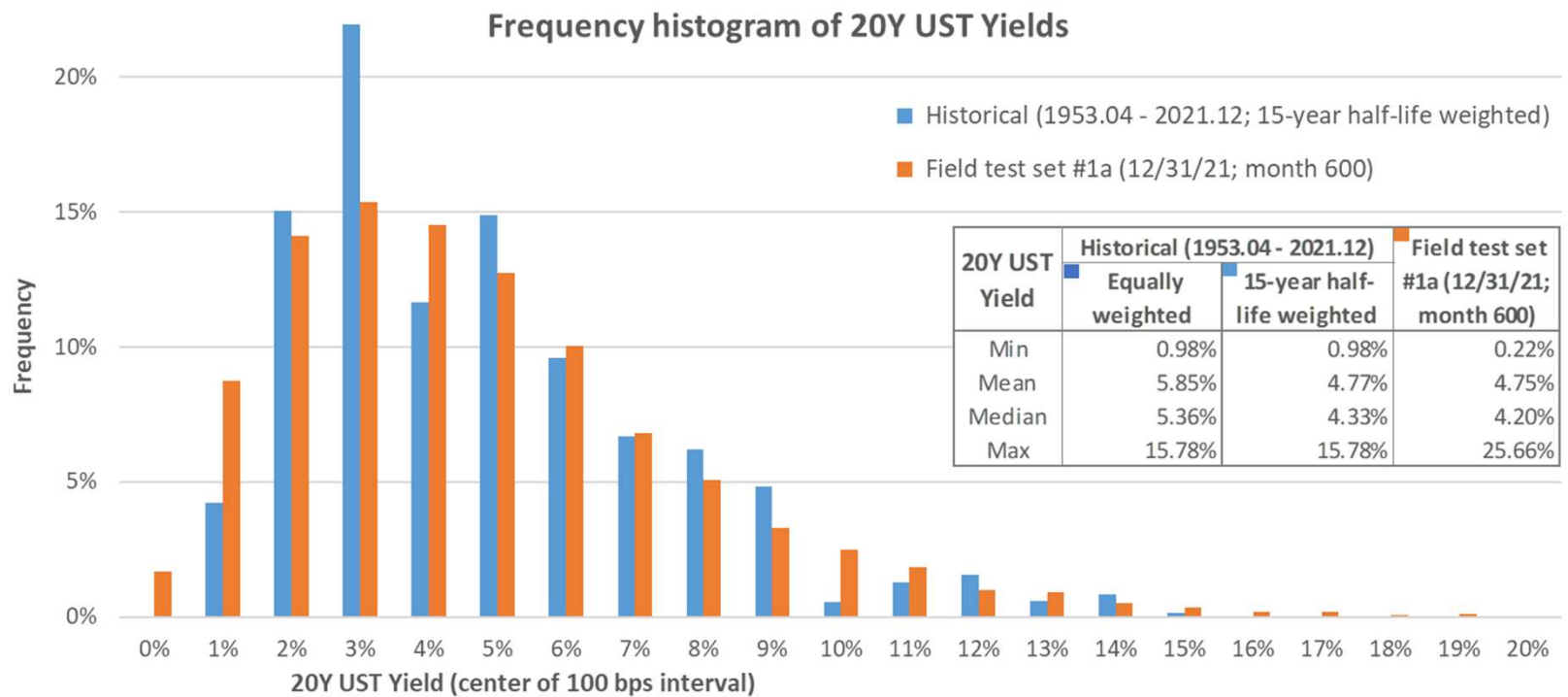
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Rate level
Supplemental chart for evaluating rate levels on consistent basis with PEWs 39

Frequency histogram of 20Y UST Yields

■ Historical (1953.04 - 2021.12; equally weighted)

■ Field test set #1a (12/31/21; month 600)

20Y UST Yield	Historical (1953.04 - 2021.12)		Field test set #1a (12/31/21; month 600)
	Equally weighted	15-year half-life weighted	
Min	0.98%	0.98%	0.22%
Mean	5.85%	4.77%	4.75%
Median	5.36%	4.33%	4.20%
Max	15.78%	15.78%	25.66%

20Y UST Yield (center of 100 bps interval)

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Rate volatility
Background

40
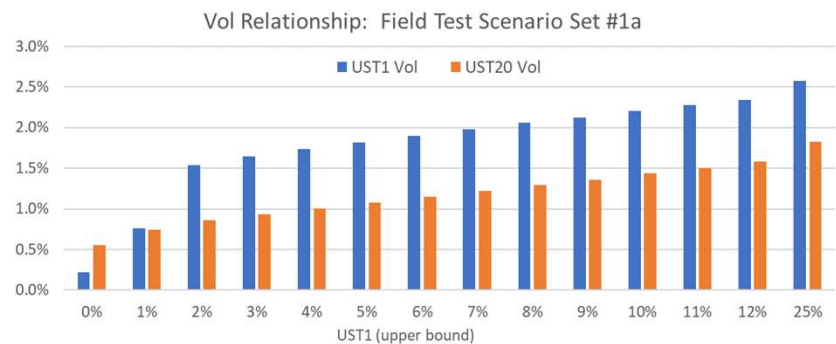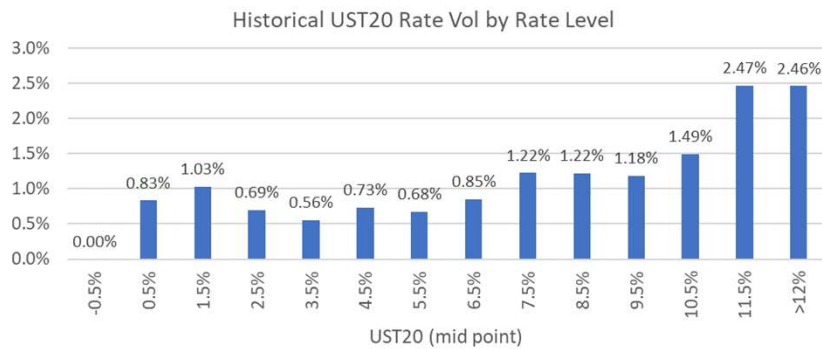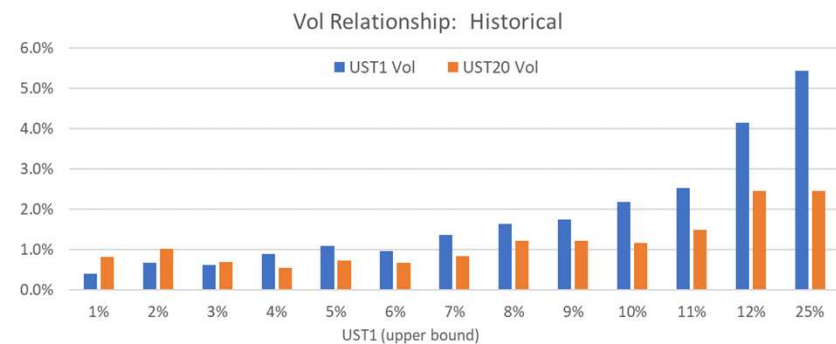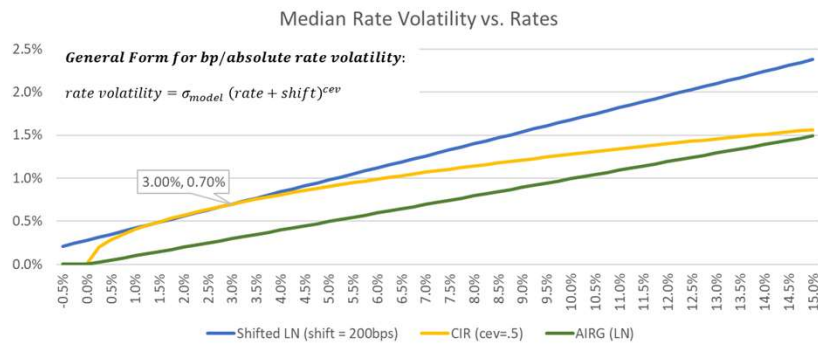
Median Rate Volatility vs. Rates

General Form for bp/absolute rate volatility:

$$rate\ volatility = \sigma_{model}\ (rate + shift)^{cev}$$

3.00%, 0.70%

Shifted LN (shift = 200bps) — CIR (cev=.5) — AIRG (LN)

Vol Relationship: Historical

■ UST1 Vol   ■ UST20 Vol

UST1 (upper bound)

Historical UST20 Rate Vol by Rate Level

0.00% 0.83% 1.03% 0.69% 0.56% 0.73% 0.68% 0.85% 1.22% 1.22% 1.18% 1.49% 2.47% 2.46%

UST20 (mid point)

Vol Relationship: Field Test Scenario Set #1a

■ UST1 Vol   ■ UST20 Vol

UST1 (upper bound)

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Rate volatility
Historical statistics and Criteria

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Historical volatility statistics

Annualized standard deviation of monthly yield changes from 1953.04 to 2021.12, bucketed by yield level at beginning of month (BOM):

Bucket	Yield Level (BOM)	1Y	20Y
Low	[≤ 3%]	0.59%	0.61%
Medium	[> 3%, ≤ 8%]	1.16%	0.74%
High	[> 8%]	3.32%	1.54%

Note that short (1Y) rate volatility tends to exceed long (20Y) rate volatility, except when rates are low.

Volatility criteria

» For the relevant test statistics on the candidate scenario set, calculate the annualized standard deviation of monthly yield changes across all scenarios, bucketed by the rate level at the BOM.

  • Calculate the above test statistics for both the first [10] years and steady state, e.g., years [40] to [60].

» The above test statistics should be "reasonably close" to the historical volatility statistics in the table to the left.

  • For example, the above test statistics should be within [X]% of historical volatility statistics.

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Rate volatility
Illustrative application of rate volatility criteria to field test scenario set #1a   42

Tabular comparison of annualized standard deviation of 1Y and 20Y UST rates to history

				First [10] years		Steady state*	
1Y UST	Bucket	Yield Level (BOM)	History	Simulated	Difference	Simulated	Difference
	Low	[≤ 3%]	0.59%	1.06%	47 bps above	1.05%	46 bps above
	Medium	[> 3%, ≤ 8%]	1.16%	1.88%	72 bps above	1.85%	69 bps above
	High	[> 8%]	3.32%	2.31%	101 bps below	2.31%	101 bps below

	Bucket	Yield Level (BOM)	History	Simulated	Difference	Simulated	Difference
20Y UST	Low	[≤ 3%]	0.61%	0.66%	5 bps above	0.68%	7 bps above
	Medium	[> 3%, ≤ 8%]	0.74%	1.00%	26 bps above	1.11%	37 bps above
	High	[> 8%]	1.54%	1.61%	7 bps above	1.69%	15 bps above

* Years [40] to [60]

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Rate volatility
Illustrative application of rate volatility criteria to field test scenario set #1a

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Graphical comparison of annualized standard deviation of 1Y and 20Y UST rates to history

Observations on Set #1a:

- Initial and steady state volatility are similar

- Volatility is generally higher than history

- In the Low bucket:
  - 1Y volatility roughly double history
  - 20Y volatility roughly equal to history

UST 1Y Volatility: First [10] Years
Historical | Scenario Set #1a

UST 20Y Volatility: First [10] Years
Historical | Scenario Set #1a

UST 1Y Volatility: Steady State*
Historical | Scenario Set #1a

UST 20Y Volatility: Steady State*
Historical | Scenario Set #1a

Years [40] to [60]

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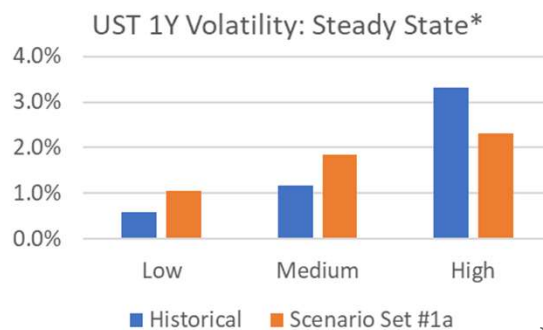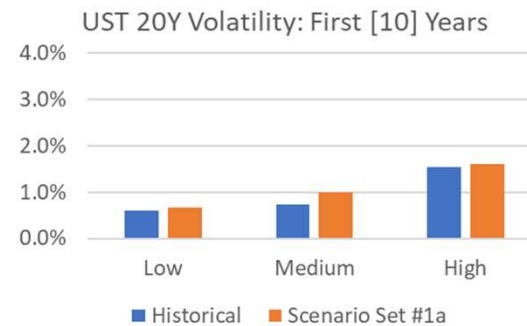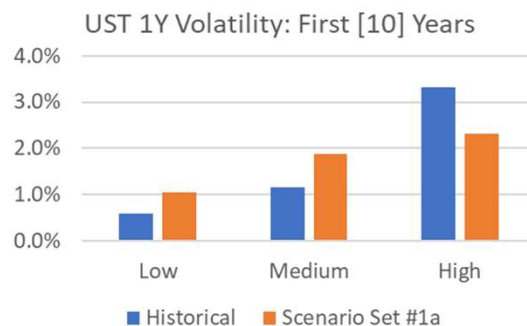
Yield curve slope
Historical statistics   44

Historical yield curve slope statistics

Selected percentiles on the distribution of slope (month-end [20Y] less month-end [1Y] yields) from 1953.04 to 2021.12, bucketed by [20Y] rate:

Bucket	Yield Level (BOM)	% Inverted	Min	5%	**15%**	30%	Median	70%	**85%**	95%	Max
Low	[≤ 3%]	0%	0.0%	0.3%	**0.5%**	1.1%	1.6%	2.0%	**2.3%**	2.6%	2.9%
Medium	[> 3%, ≤ 8%]	17%	-1.4%	-0.5%	**-0.1%**	0.4%	0.9%	1.8%	**3.3%**	3.8%	4.3%
High	[> 8%]	25%	-3.4%	-1.5%	**-0.8%**	0.3%	1.2%	1.8%	**2.1%**	2.7%	3.9%

Criteria

- For the test statistics on the candidate scenario set, calculate selected percentiles on the distribution of slope ([20Y] less [1Y] yield) across all scenarios, bucketed by the level of the [20Y] yield level.

  - Calculate above for both the first [10] years and steady state, e.g., years [40] to [60].

- The [15th] and [85th] percentiles should be "plausibly more extreme" than history.

Historical data indicates the distribution of curve shapes (particularly inversions) varies by rate level.

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Yield curve slope
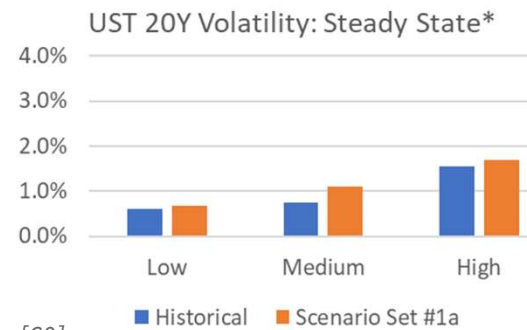## Illustrative application of criteria to field test scenario set #1a

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Historical

Bucket	Inv %	Min	5%	15%	30%	Median	70%	85%	95%	Max
Low	0%	0.0%	0.3%	**0.5%**	1.1%	1.6%	2.0%	**2.3%**	2.6%	2.9%
Medium	17%	-1.4%	-0.5%	**-0.1%**	0.4%	0.9%	1.8%	**3.3%**	3.8%	4.3%
High	25%	-3.4%	-1.5%	**-0.8%**	0.3%	1.2%	1.8%	**2.1%**	2.7%	3.9%

Field test #1a *(first [10] years)*

Bucket	Inv %	Min	5%	15%	30%	Median	70%	85%	95%	Max
Low	6%	-4.5%	-0.2%	**0.6%**	1.0%	1.3%	1.6%	**1.9%**	2.2%	3.1%
Medium	35%	-9.2%	-2.6%	**-1.3%**	-0.3%	0.7%	1.5%	**2.3%**	3.0%	4.5%
High	62%	-10.0%	-5.2%	**-3.4%**	-2.0%	-0.7%	0.5%	**1.3%**	2.2%	3.7%

Difference *(field test #1a less historical)*

Bucket	Inv %	Min	5%	15%	30%	Median	70%	85%	95%	Max
Low	6%	-4.6%	-0.5%	**0.1%**	-0.2%	-0.3%	-0.5%	**-0.4%**	-0.4%	0.2%
Medium	18%	-7.9%	-2.1%	**-1.2%**	-0.6%	-0.3%	-0.3%	**-1.0%**	-0.8%	0.3%
High	37%	-6.7%	-3.7%	**-2.5%**	-2.3%	-1.9%	-1.3%	**-0.8%**	-0.5%	-0.2%

Notes:

- Slope = [20Y] less [1Y] yield

- Bucketed by [20Y] yield

- Buckets:
  - Low [≤ 3%]
  - Medium [> 3%, ≤ 8%]
  - High [> 8%]

- The [15th] percentile is more extreme than history if the difference is negative.

- The [85th] percentile is more extreme than history if the difference is positive.

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Yield curve slope
Illustrative application of criteria to field test scenario set #1a

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Historical

Bucket	Inv %	Min	5%	15%	30%	Median	70%	85%	95%	Max
Low	0%	0.0%	0.3%	0.5%	1.1%	1.6%	2.0%	2.3%	2.6%	2.9%
Medium	17%	-1.4%	-0.5%	-0.1%	0.4%	0.9%	1.8%	3.3%	3.8%	4.3%
High	25%	-3.4%	-1.5%	-0.8%	0.3%	1.2%	1.8%	2.1%	2.7%	3.9%

Field test #1a *(steady state, e.g., years [40] to [60])*

Bucket	Inv %	Min	5%	15%	30%	Median	70%	85%	95%	Max
Low	4%	-4.5%	0.3%	0.9%	1.2%	1.6%	2.0%	2.3%	2.6%	3.1%
Medium	19%	-10.5%	-2.0%	-0.4%	0.7%	1.7%	2.5%	3.1%	3.5%	4.6%
High	39%	-11.3%	-3.6%	-1.8%	-0.5%	0.6%	1.5%	2.2%	2.8%	4.2%

Difference *(field test #1a less historical)*

Bucket	Inv %	Min	5%	15%	30%	Median	70%	85%	95%	Max
Low	4%	-4.5%	0.0%	0.4%	0.1%	0.0%	0.0%	0.0%	0.0%	0.2%
Medium	2%	-9.2%	-1.5%	-0.3%	0.4%	0.8%	0.8%	-0.2%	-0.3%	0.4%
High	14%	-8.0%	-2.0%	-1.0%	-0.8%	-0.6%	-0.3%	0.1%	0.1%	0.3%

Notes:

- Slope = [20Y] less [1Y] yield

- Bucketed by [20Y] yield

- Buckets:
  - Low [≤ 3%]
  - Medium [> 3%, ≤ 8%]
  - High [> 8%]

- The [15th] percentile is more extreme than history if the difference is negative.

- The [85th] percentile is more extreme than history if the difference is positive.

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Yield curve slope
Supplemental chart for evaluating rate yield curve slope

Scatter Plot of 1Y vs 20Y UST Yields

- Field test set #1a (12/31/21; month 600) †
- Historical (1953.04 - 2021.12) ‡
- Flat (points below = inversions)

† 825 random scenarios (from set of 10K)
‡ 825 historical month-end observations
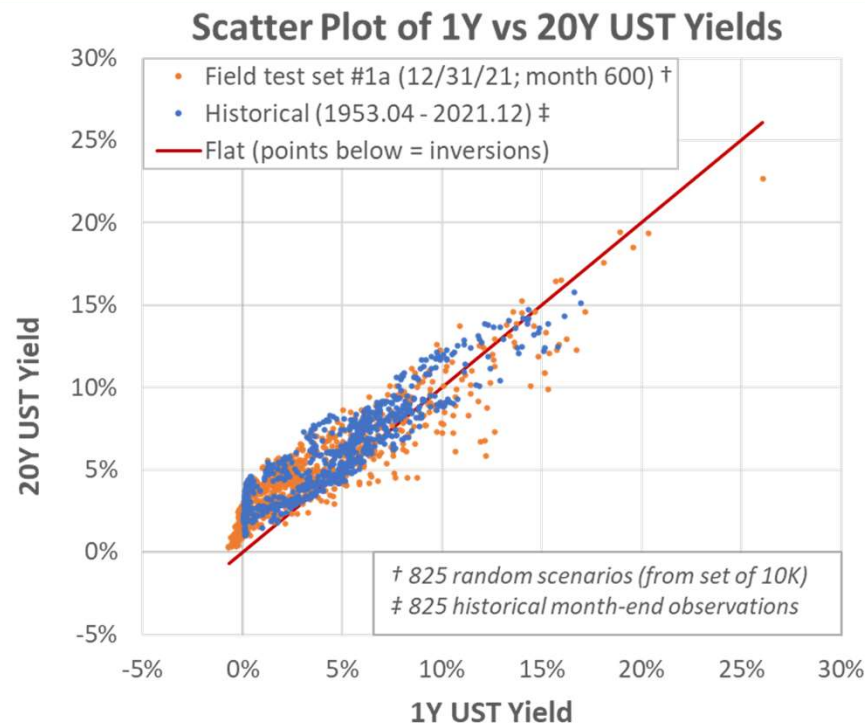
Statistics

Historical (1953.04 - 2021.12)
- Min spread = -336 bps
- Mean spread = 122 bps
- Max spread = 425 bps
- StDev spread = 132 bps
- Inversion freq. = 16%
- Mean inversion = -63 bps

Field test set #1a (12/31/21; month 600) *
- Min spread = -926 bps
- Mean spread = 129 bps
- Max spread = 448 bps
- StDev spread = 159 bps
- Inversion freq. = 17%
- Mean inversion = -146 bps

* Stats based on all 10K scenarios

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Yield curve slope
Supplemental chart for evaluating rate yield curve slope

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Scen #1a (Months 1-600): UST 20Y - UST 1Y Slopes by Rate Bucket
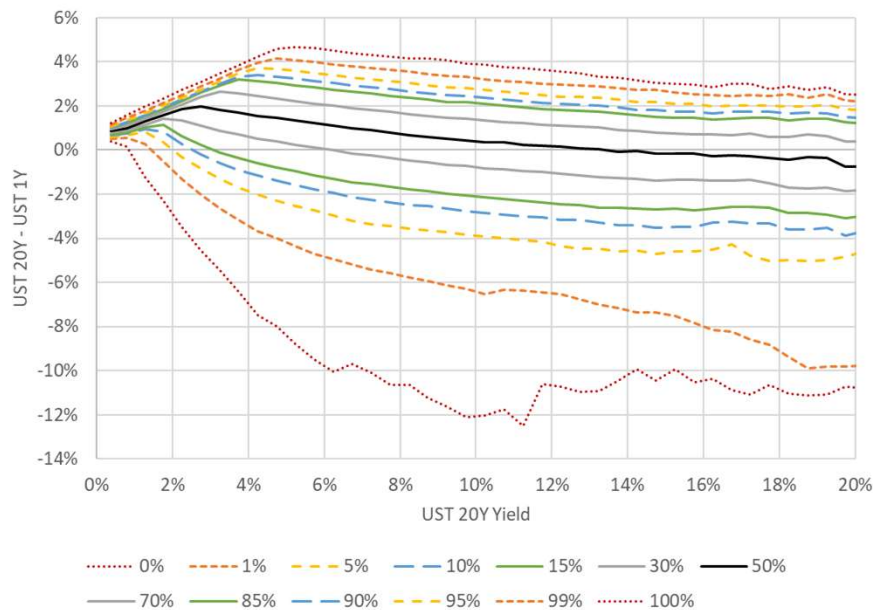
Historical (4/1953-12/2021): UST 20Y - UST 1Y Slopes by Rate Bucket
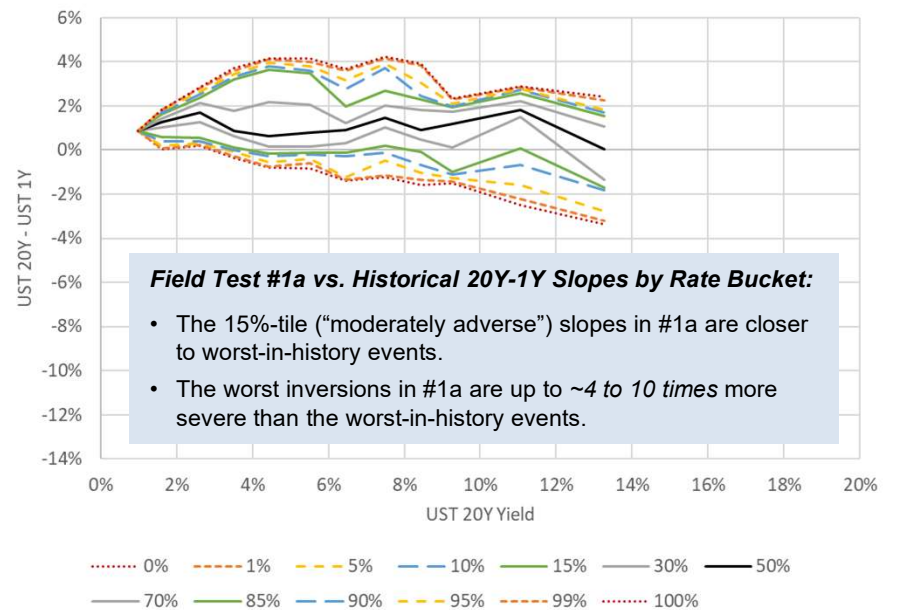
Field Test #1a vs. Historical 20Y-1Y Slopes by Rate Bucket:

- The 15%-tile ("moderately adverse") slopes in #1a are closer to worst-in-history events.

- The worst inversions in #1a are up to *~4 to 10 times* more severe than the worst-in-history events.

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4. Low-for-long
Qualitative understanding

Although the ESGWG has not finalized its proposal for this key property of interest rates, we present our qualitative understanding of low-for-long for discussion and feedback.

Historical observations on low-for-long interest rate behavior:

1. (a) The long rate [20Y] stays below a threshold [3%] for an extended period of time [5+ years]. (b) During this time, the long rate continues to fluctuate as usual.

2. (a) The short rate [1Y] is "stuck" in a very narrow range [50bps] above zero. (b) During this time, short rate volatility (which normally exceeds long rate volatility) drops to near zero.

3. Low-for-long is a relatively recent phenomenon (post-2000 in the US; limited historical data).
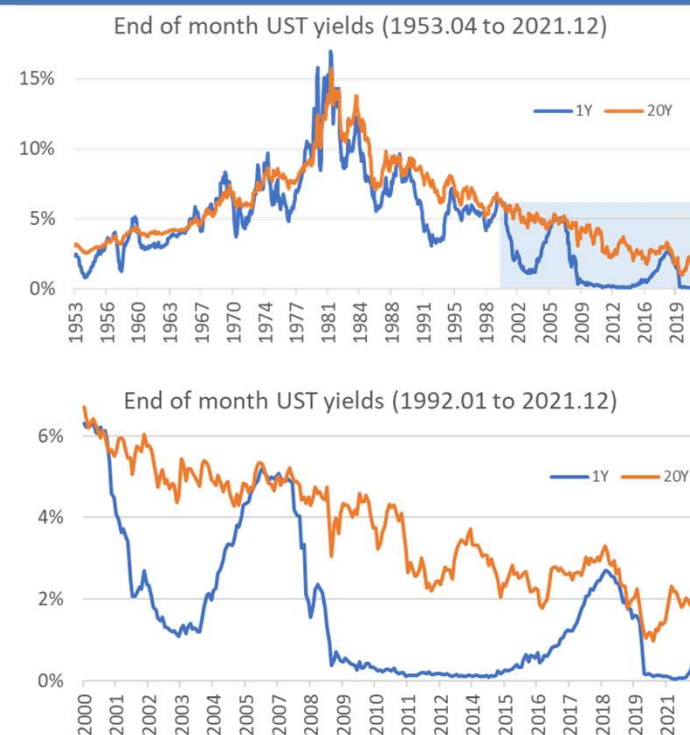
End of month UST yields (1953.04 to 2021.12)

End of month UST yields (1992.01 to 2021.12)

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4.

Discussion and Q&A

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Thank You

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Appendix

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PEWs
Additional information on Percentiles Exponentially Weighted (PEWs) 53

The development of historical statistics for economic variables such as interest rates and equity rates involves subjective decisions such as how much history to include. One way to make use of all available data, but to focus more heavily on more recent data, is to develop exponentially weighted averages and percentiles.

An AWE is an Average Weighted Exponentially, with parameter Alpha. The most recent historical period, typically a month, gets an initial weight of 100%. Each prior historical period gets (1-α) times the weight of the next most recent period. Based on the number of historical periods of available data, the weights are then normalized so that their sum is 100%. The AWE is simply the weighted average of all the available or selected data. The "half-life" is then the period of time for which the cumulative weight reaches 50%.

PEWs apply the same concept to develop exponentially weighted percentiles. The historical values are unchanged, but their relative weight is dependent on when they occurred. Values are rank-ordered, with percentiles based on the sum of the relative weights up to the particular value. It may be desirable to assign percentiles at the center of each value's weight range, especially if extreme values are important or statistical distributions will be fitted to the percentiles.

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PEWs
Historical UST 20Y PEWs at different half-lives (12/31/2021)   54

	Equally Weighted	20Yr Half-Life	15Yr Half-Life	10Yr Half-Life	5Yr Half-Life
Maximum	15.52 %	15.52 %	15.52 %	15.52 %	15.52 %
99th PEW	13.92 %	13.63 %	13.55 %	12.49 %	8.11 %
95th PEW	11.70 %	10.44 %	9.35 %	8.59 %	5.78 %
85th PEW	8.48 %	7.94 %	7.54 %	6.47 %	4.47 %
70th PEW	7.09 %	6.20 %	5.77 %	4.87 %	3.08 %
50th PEW	5.36 %	4.64 %	4.33 %	3.31 %	2.66 %
30th PEW	4.06 %	3.05 %	2.83 %	2.63 %	2.20 %
15th PEW	2.95 %	2.47 %	2.31 %	2.08 %	1.85 %
5th PEW	2.31 %	1.85 %	1.78 %	1.45 %	1.23 %
1st PEW	1.43 %	1.18 %	1.15 %	1.05 %	1.05 %
Minimum	0.98 %	0.98 %	0.98 %	0.98 %	0.98 %
Max minus Min	14.54 %	14.54 %	14.54 %	14.54 %	14.54 %
99th minus 1st	12.48 %	12.45 %	12.40 %	11.44 %	7.06 %
95th minus 5th	9.39 %	8.59 %	7.57 %	7.14 %	4.55 %
85th minus 15th	5.53 %	5.47 %	5.23 %	4.39 %	2.62 %
70th minus 30th	3.03 %	3.15 %	2.94 %	2.24 %	0.88 %

* Historical 20 year Treasury rates are from: 1) 1953.04 - 1977.01 - monthly average rates from Fed H15 monthly history report;
2) 1977.02 - 1993.09 - estimated month-end 20 year rates by averaging 10 year and 30 year; 3) 1993.10 - current: actual month end rates.

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PEWs
Chart of UST 20Y PEWs at different half-lives (12/31/2021)   55

20Yr Treasury Cumulative Distribution Function
1953.04 - 2021.12

Legend: Equally Weighted — 15Yr Half-Life PEW — 5Yr Half-Life PEW — Conning at Projection Yr 50

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PEWs
Historical movement in 15-year half-life PEWs

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	PEWs from April 1953 through:						
	1971.12	1991.12	2001.12	2011.12	2016.12	2020.12	2021.12
	(50 years ago)	(30 years ago)	(20 years ago)	(10 years ago)	(5 years ago)	(1 year ago)	Current
Maximum	7.34 %	15.52 %	15.52 %	15.52 %	15.52 %	15.52 %	15.52 %
99th PEW	7.24 %	14.32 %	14.03 %	13.88 %	13.63 %	13.55 %	13.55 %
95th PEW	6.85 %	13.28 %	12.48 %	11.45 %	10.64 %	10.04 %	9.35 %
85th PEW	6.18 %	11.19 %	9.18 %	8.34 %	8.01 %	7.60 %	7.54 %
Mean (AWE)	4.60 %	8.03 %	7.38 %	6.24 %	5.46 %	4.91 %	4.77 %
50th PEW	4.20 %	8.11 %	7.05 %	5.68 %	4.91 %	4.47 %	4.33 %
15th PEW	3.30 %	4.25 %	5.46 %	4.19 %	2.77 %	2.49 %	2.31 %
5th PEW	2.86 %	3.49 %	3.96 %	3.61 %	2.31 %	1.78 %	1.78 %
1st PEW	2.60 %	2.80 %	2.93 %	2.66 %	1.90 %	1.15 %	1.15 %
Minimum	2.57 %	2.57 %	2.57 %	2.57 %	1.78 %	0.98 %	0.98 %
99th minus 1st	4.64 %	11.52 %	11.10 %	11.22 %	11.73 %	12.40 %	12.40 %
95th minus 5th	3.99 %	9.79 %	8.52 %	7.84 %	8.33 %	8.26 %	7.57 %
85th minus 15th	2.88 %	6.94 %	3.72 %	4.15 %	5.24 %	5.11 %	5.23 %

* Percentiles Exponentially Weighted (PEW) are determined by the specified alpha
* Historical 20 year Treasury rates are from: 1) 1953.04 - 1977.01 - monthly average rates from Fed H15 monthly history report;
2) 1977.02 - 1993.09 - estimated month-end 20 year rates by averaging 10 year and 30 year; 3) 1993.10 - current: actual month end rates.
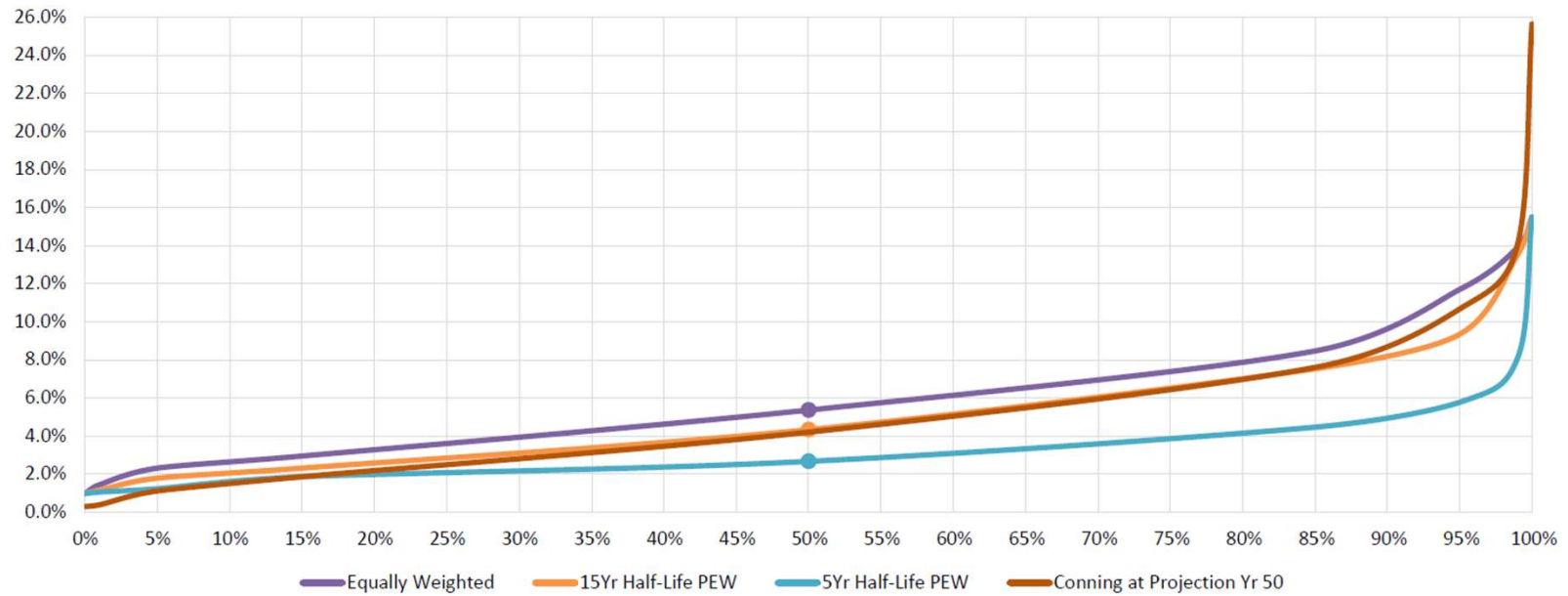
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PEWs
Chart of historical movement in 15-year half-life PEWs

20 year Treasury rates and PEWs
with 15 Year Half-Life Alpha (α = 0.38%)

Legend: Historical, 100%, 99%, 95%, 85%, 50%, 15%, 5%, 1%, 0%

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Rate level
Supplemental chart for evaluating rate levels on consistent basis with PEWs
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Frequency histogram of 20Y UST Yields

Legend:
- Historical (1953.04 - 2021.12; equally weighted)
- Historical (1953.04 - 2021.12; 15-year half-life weighted)
- Field test set #1a (12/31/21; month 600)

20Y UST Yield	Historical (1953.04 - 2021.12)		Field test set #1a (12/31/21; month 600)
	Equally weighted	15-year half-life weighted	
Min	0.98%	0.98%	0.22%
Mean	5.85%	4.77%	4.75%
Median	5.36%	4.33%	4.20%
Max	15.78%	15.78%	25.66%

20Y UST Yield (center of 100 bps interval)

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Yield curve slope (bucketed by 20Y rate) Historical Slope Data (4/1953 - 12/2020)

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Observations:

- No inversions for UST 20-year yields below 3%

- Severity of inversions generally increases with rate levels

- Other variations in curve steepness by rate level

- Recommend slope criteria based on simplified Low / Medium / High 20Y yield buckets to capture historical dynamics while not being overly constraining

- Also considers alignment with volatility buckets

ALL Spreads

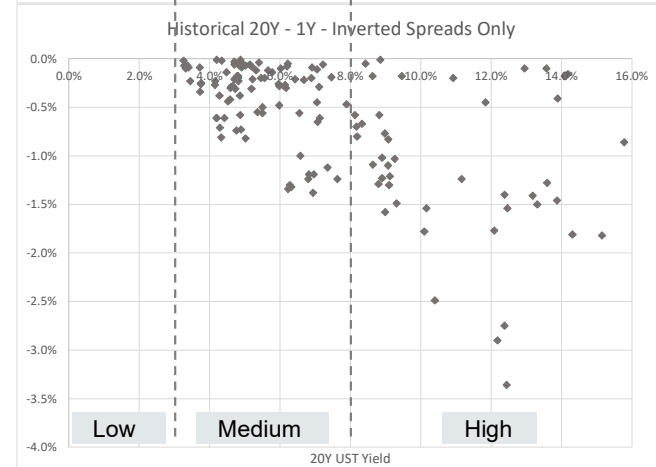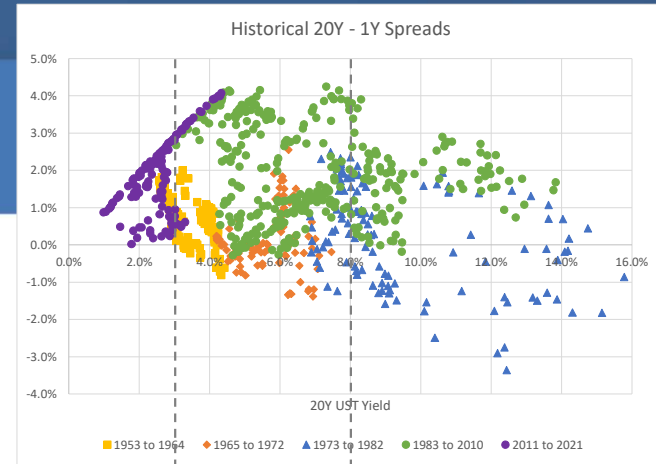| Rate Bucket (20Y)	Inverted Months	Total Months	% Inverted	Min Spread	15%	50%	85%	Max Spread	Avg Spread
[0%, 1%)	0	1	0%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%
[1%, 2%)	0	23	0%	0.0%	0.6%	1.3%	1.6%	1.8%	1.2%
[2%, 3%)	0	107	0%	0.2%	0.5%	1.7%	2.4%	2.9%	1.6%
[3%, 4%)	11	102	11%	-0.3%	0.1%	0.9%	3.2%	3.7%	1.4%
[4%, 5%)	32	146	22%	-0.8%	-0.2%	0.6%	3.6%	4.1%	1.2%
[5%, 6%)	18	89	20%	-0.8%	-0.1%	0.8%	3.5%	4.2%	1.3%
[6%, 7%)	18	93	19%	-1.4%	-0.1%	0.9%	2.0%	3.7%	0.9%
[7%, 8%)	10	82	12%	-1.2%	0.2%	1.5%	2.7%	4.3%	1.5%
[8%, 9%)	14	79	18%	-1.6%	-0.1%	0.9%	2.3%	3.9%	1.1%
[9%, 10%)	7	29	24%	-1.5%	-1.0%	1.2%	1.9%	2.3%	0.8%
> 10%	24	74	32%	-3.4%	-1.5%	1.4%	2.2%	2.9%	0.7%
All	**134**	**825**	**16%**	**-3.4%**	**-0.1%**	**1.1%**	**2.7%**	**4.3%**	**1.2%**

INVERTED Spreads Only

Rate Bucket (20Y)	Inverted Months	Total Months	% Inverted	Most Negative Spread	15%	50%	85%	Least Negative Spread	Avg Spread
[0%, 1%)	0	1	0%	n/a	n/a	n/a	n/a	n/a	n/a
[1%, 2%)	0	23	0%	n/a	n/a	n/a	n/a	n/a	n/a
[2%, 3%)	0	107	0%	n/a	n/a	n/a	n/a	n/a	n/a
[3%, 4%)	11	102	11%	-0.3%	-0.3%	-0.1%	-0.1%	0.0%	-0.1%
[4%, 5%)	32	146	22%	-0.8%	-0.6%	-0.3%	-0.1%	0.0%	-0.3%
[5%, 6%)	18	89	20%	-0.8%	-0.5%	-0.2%	-0.1%	0.0%	-0.3%
[6%, 7%)	18	93	19%	-1.4%	-1.3%	-0.4%	-0.1%	0.0%	-0.7%
[7%, 8%)	10	82	12%	-1.2%	-1.0%	-0.5%	-0.1%	-0.1%	-0.5%
[8%, 9%)	14	79	18%	-1.6%	-1.2%	-0.7%	-0.2%	0.0%	-0.8%
[9%, 10%)	7	29	24%	-1.5%	-1.3%	-1.1%	-0.8%	-0.2%	-1.0%
> 10%	24	74	32%	-3.4%	-2.2%	-1.4%	-0.2%	-0.1%	-1.4%
All	**134**	**825**	**16%**	**-3.4%**	**-1.3%**	**-0.4%**	**-0.1%**	**0.0%**	**-0.6%**

Historical 20Y - 1Y Spreads

Legend: 1953 to 1964, 1965 to 1972, 1973 to 1982, 1983 to 2010, 2011 to 2021

Historical 20Y - 1Y - Inverted Spreads Only

Low | Medium | High

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Yield curve slope (bucketed by 1Y rate)
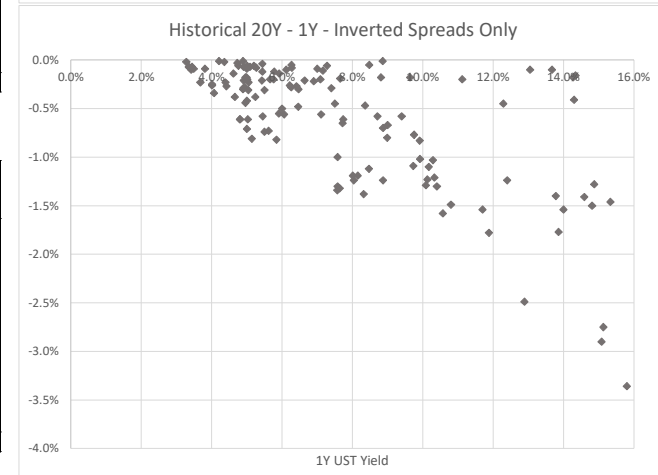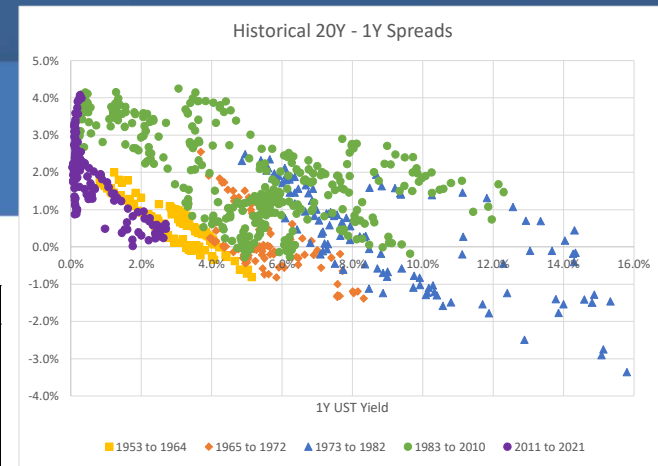## Historical Slope Data (4/1953 - 12/2020)

Observations:

- No inversions for UST 1-year yields below 3%

- Severity of inversions generally increases with rate levels

- Other variations in curve steepness by rate level

- Recommend slope criteria based on simplified Low / Medium / High yield buckets to capture historical dynamics while not being overly constraining

- May bucket by 20Y instead of 1Y yields based on preference

ALL Spreads

Rate Bucket (1Y)	Inverted Months	Total Months	% Inverted	Min Spread	15%	50%	85%	Max Spread	Avg Spread
[0%, 1%)	0	128	0%	0.5%	1.6%	2.5%	3.6%	4.1%	2.5%
[1%, 2%)	0	69	0%	0.0%	1.0%	1.6%	3.6%	4.2%	2.1%
[2%, 3%)	0	71	0%	0.1%	0.4%	0.9%	3.0%	3.6%	1.3%
[3%, 4%)	8	103	8%	-0.2%	0.2%	0.8%	2.8%	4.3%	1.2%
[4%, 5%)	22	89	25%	-0.6%	-0.2%	0.5%	1.7%	3.9%	0.8%
[5%, 6%)	26	116	22%	-0.8%	-0.1%	0.9%	1.8%	3.0%	0.8%
[6%, 7%)	12	76	16%	-0.6%	0.0%	1.2%	1.9%	2.5%	1.1%
[7%, 8%)	14	56	25%	-1.3%	-0.3%	0.7%	1.9%	2.9%	0.8%
[8%, 9%)	13	38	34%	-1.4%	-0.9%	0.5%	1.8%	2.8%	0.5%
[9%, 10%)	7	26	27%	-1.1%	-0.7%	1.5%	2.1%	2.5%	0.9%
> 10%	32	53	60%	-3.4%	-1.6%	-0.4%	1.5%	2.0%	-0.3%
All	134	825	16%	-3.4%	-0.1%	1.1%	2.7%	4.3%	1.2%

INVERTED Spreads Only

Rate Bucket (1Y)	Inverted Months	Total Months	% Inverted	Most Negative Spread	15%	50%	85%	Least Negative Spread	Avg Spread
[0%, 1%)	0	128	0%	n/a	n/a	n/a	n/a	n/a	n/a
[1%, 2%)	0	69	0%	n/a	n/a	n/a	n/a	n/a	n/a
[2%, 3%)	0	71	0%	n/a	n/a	n/a	n/a	n/a	n/a
[3%, 4%)	8	103	8%	-0.2%	-0.1%	-0.1%	-0.1%	0.0%	-0.1%
[4%, 5%)	22	89	25%	-0.6%	-0.4%	-0.2%	0.0%	0.0%	-0.2%
[5%, 6%)	26	116	22%	-0.8%	-0.7%	-0.2%	-0.1%	0.0%	-0.3%
[6%, 7%)	12	76	16%	-0.6%	-0.5%	-0.3%	-0.1%	0.0%	-0.3%
[7%, 8%)	14	56	25%	-1.3%	-1.3%	-0.5%	-0.1%	-0.1%	-0.6%
[8%, 9%)	13	38	34%	-1.4%	-1.2%	-0.8%	-0.2%	0.0%	-0.8%
[9%, 10%)	7	26	27%	-1.1%	-1.0%	-0.8%	-0.5%	-0.2%	-0.7%
> 10%	32	53	60%	-3.4%	-1.8%	-1.4%	-0.3%	-0.1%	-1.3%
All	134	825	16%	-3.4%	-1.3%	-0.4%	-0.1%	0.0%	-0.6%

Historical 20Y - 1Y Spreads

1953 to 1964 ● 1965 to 1972 ▲ 1973 to 1982 ● 1983 to 2010 ● 2011 to 2021

Historical 20Y - 1Y - Inverted Spreads Only

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Agenda Item 7

Hear a Presentation on the C-3 Phase I
GOES Field Test Results

SEATTLE

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NAIC Economic Scenario Generator Field Test: C3 Phase I Quantitative Results

Scott O'Neal, FSA, MAAA

August 11, 2023

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Agenda

1. Background and Purpose
2. Limitations
3. Field Test Participation
4. High-Level Observations
5. Quantitative Results
   A. Baseline Comparisons
   B. Valuation Date Comparisons
   C. Additional Metrics
6. Next Steps

Appendix: Field Test Run Descriptions

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Background and Purpose

- The purpose of this presentation is to summarize quantitative information from the C3 Phase I field test participants to:

  - Understand the impact on capital,

  - Review the range of results across field test participants,

  - Compare the stability of results over time,

  - Evaluate the use of alternative metrics, and

  - Inform regulator decision-making on model and calibration choices.

C3 Phase I Background

Calculation Details

- Cash flow models that are used for asset adequacy analysis (or other consistent models) are used. The greatest present value of a deficiency at any point in the projection is calculated for each scenario.
- 50 or 12 interest rate scenarios generated from an older version of the Academy Interest Rate Generator (AIRG) are used in the calculations. The 50 or 12 scenarios are selected from a larger 200 set and are meant to contain the most adverse scenarios so that a tail measure metric can be calculated with a smaller number of scenarios.
- This version of the AIRG has a 6.55% interest rate mean reversion parameter (MRP) which does not change, compared with the current version of the AIRG which has a dynamic MRP that resets annually based on a weighted average of past interest rate levels.
- From the 50-scenario set, a weighted average centered around the 95th percentile scenario is determined, and that is the C3 RBC amount.
- In the C3 Phase I RBC worksheet, the scenario level and final results are also shown as a "C3 Factor" percentage, which is the capital amount divided by the statutory reserve at the start of the projection.

Product Scope

Deferred and Immediate Annuities

Guaranteed Separate Accounts*

Guaranteed Investment Contracts

Single Premium Life

Excludes Indexed and Variable Products

* excluding guaranteed indexed separate accounts following a Class II investment strategy

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Limitations

- The NAIC took steps to review the quantitative results for reasonableness, including reviewing qualitative survey responses, sending questions to participants, and asking participants to confirm that the NAIC compilations matched their intended result submission. However, the accuracy and reliability of the results are ultimately dependent on the quality of participant submissions.

- The field test analytics (average C3 Factors, range of impacts, etc.) can be strongly dependent on a subset of the participants. Results shown today for the different field test runs will include varying numbers of participants corresponding to the levels of participation for that run. The lack of participation in some of the runs will limit their applicability to the overall industry.

- There are two basic types of comparisons of the field test results in this presentation; 1) comparisons of field test runs to their respective baseline run, and 2) comparisons of field test runs across the two tested valuation dates. These comparisons are limited to the participation of whichever run had the least participation. For example, as Baseline 2 (as of 12/31/19 + 200 BP) had significantly lower participation than run 2A, many of the 2A results will not be included in the baseline comparison.

- Some participants mentioned that they would assess the need for changes to their assumptions prior to implementation of the new Generator of Economic Scenarios (GOES) but had not done so for the field test.

- The C3 Phase I portion of the qualitative survey did not ask companies to specifically comment on the drivers of their results as was done for VM-21/C3 Phase II. Most participants did not comment on the drivers of their results.

- Detailed information on the products included in the C3 Phase I results was not asked for in the qualitative survey data. Therefore, it is not fully understood exactly what products were included in each participant's C3 Phase I submission.

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Field Test Participation

- Looking at overall numbers for the industry, at the end of 2021 there were 752 legal entities that reported using the Life RBC blank. Of those 752, 613 legal entities reported industry C3 Phase I capital (line 33, LR027) less than or equal to $1. That group of 613 companies includes both legal entities that are in scope for C3 Phase I (and determined their C3 Phase I capital to be zero) as well as companies that do not have products that are in scope for C3 Phase I.
- The total amount of industry C3 Phase I capital was approximately $3 billion at the end of 2021. The largest ten legal entities (by C3 Phase I capital amount) accounted for over $2 billion of this total. Of those ten legal entities, two of them participated in the field test.
- The chart below shows the number of legal entities that submitted C3 Phase I GOES Field Test results. It also shows the share of the 12/31/21 total industry C3 Phase I capital (line 33, LR027) that is reflective of the participation in each field test.
- C3 Phase I results will be shown for 24 legal entities that represent approximately 19% of the industry when looking at their share of the 2021 industry C3 Phase I capital.

C3 Phase I RBC Statistics (2021)

Total # of Life RBC Blank Filers	752
Life RBC Filers with Line 33 of LR027 <= $1	613
Total Industry Amount of C3 Phase I Capital	~$3 billion
Total C3 Phase I Capital: Top Ten Filers	~$2 billion
# of Top Ten Filers that Participated in GOES Field Test	2/10

Category	Baseline 1*	Baseline 2	1A*	1B*	2A*	2B*	7
Number of Participants (Legal Entities)	24	10	24	22	22	22	16
Share of Industry C3 Phase I Capital	19%	13%	19%	19%	19%	19%	14%

Valuation Dates: 12/31/21 12/31/19 + 200 BP   ***Required Run**

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High-Level Observations

- The field test results for the scenario sets produced from the Conning economic scenario generator (1A, 2A, 1B, 2B) showed significant increases on average compared to the respective 12/31/21 or 12/31/19 + 200 BP baseline. However, many of the field test participants held little to no C3 Phase I capital in their baseline runs.
- The participant results for field test 7 (200 scenarios from the latest version of the AIRG prescribed in VM-20 and VM-21) were mixed, with increases for some companies mostly offset by decreases for others.
- When producing capital results using a limited number of scenarios, outlier scenarios that are included in the scenario sets can have an outsized impact on the results – particularly with scenario sets that have increased volatility/broader distributions (e.g. 1A, 2A).

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12/31/21 Baseline Comparisons

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Field Test 1A: US Treasury Overview

- Field Test 1A (as of 12/31/21) included a recalibration of the Conning GEMS® US Treasury model that was designed to meet the acceptance criteria related to low for long, the prevalence of high interest rates, upper and lower bounds, initial yield curve fit, and yield curve shape. The frequency and severity of negative interest rates were controlled using a generalized fractional floor.
- The 1A UST scenario set as of 12/31/21 had a much higher prevalence of low UST rates, including negative interest rates, compared to the scenarios produced by the C3 Phase I Generator.
- The 1A UST scenario set included a frequency and severity of high 1-yr UST rates that was comparable at certain percentiles and projection periods but deviated in others. The limited number of scenarios typically used among field test participants for B1 and 1A may not be fully reflective of the distribution produced by either scenario generator with a greater number of scenarios.

Baseline 1 (B1): 50 C3 Phase I AIRG 1-yr UST Scenarios: Percentiles by Projection Month

Percentile	12	60	120	240	360
Min	0.42%	0.39%	0.40%	0.62%	0.65%
1%	0.43%	0.40%	0.43%	0.64%	0.71%
10%	0.47%	0.48%	0.59%	1.65%	1.37%
25%	0.52%	1.00%	0.89%	2.90%	3.17%
50%	0.81%	2.19%	2.86%	4.61%	5.05%
75%	1.49%	4.27%	5.69%	6.98%	7.92%
95%	3.04%	6.88%	7.94%	10.06%	12.61%
99%	3.30%	7.60%	8.67%	12.58%	14.26%
Max	3.44%	7.98%	9.04%	13.98%	14.35%

1A: 200 Conning w/ GFF 1-yr UST Scenarios: Percentiles by Projection Month

Percentile	12	60	120	240	360
Min	-0.20%	-0.58%	-0.72%	-0.69%	-0.75%
1%	-0.19%	-0.54%	-0.58%	-0.36%	-0.40%
10%	0.07%	-0.16%	-0.21%	-0.10%	-0.04%
25%	0.24%	0.11%	0.09%	0.20%	0.32%
50%	0.62%	0.75%	1.14%	1.62%	1.83%
75%	1.70%	2.95%	3.42%	4.34%	4.44%
95%	3.09%	5.59%	9.28%	9.10%	8.98%
99%	3.72%	7.50%	11.93%	10.35%	13.72%
Max	4.29%	14.36%	14.57%	15.71%	14.39%

1A – B1

Percentile	12	60	120	240	360
Min	-0.62%	-0.97%	-1.12%	-1.31%	-1.40%
1%	-0.62%	-0.94%	-1.01%	-1.00%	-1.11%
10%	-0.40%	-0.65%	-0.80%	-1.75%	-1.41%
25%	-0.28%	-0.89%	-0.81%	-2.70%	-2.85%
50%	-0.19%	-1.45%	-1.72%	-2.99%	-3.22%
75%	0.22%	-1.32%	-2.27%	-2.64%	-3.47%
95%	0.05%	-1.29%	1.34%	-0.96%	-3.64%
99%	0.42%	-0.09%	3.26%	-2.23%	-0.54%
Max	0.85%	6.38%	5.53%	1.73%	0.04%

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Field Test 1B: US Treasury Overview

- Field Test 1B (as of 12/31/21) included a calibration of the Conning GEMS® US Treasury model that was designed to meet regulator acceptance criteria but placed additional emphasis on maintaining realistic term premiums throughout the projection. Towards that end, there was a significantly lower frequency of inversions (e.g.~5% of 1B scenarios had 10 year/2year UST inversions at the end of year 30 compared to ~12% seen in 1A). The average level of inversion was also significantly lower (e.g. in 1B 10 year/2 year UST inversions average ~30 BP at the end of year 30, compared to ~90 BP average inversion level for 1A).
- The 1B UST scenario set as of 12/31/21 had a much higher prevalence of low UST rates, including negative interest rates, compared to the scenarios produced by the C3 Phase I Generator.
- The 1B UST scenario set included a frequency and severity of high 1-yr UST rates that was typically lower than that produced by the C3 Phase I scenario generator.

Baseline 1 (B1): 50 C3 Phase I AIRG 1-yr UST Scenarios: Percentiles by Projection Month

Percentile	12	60	120	240	360
Min	0.42%	0.39%	0.40%	0.62%	0.65%
1%	0.43%	0.40%	0.43%	0.64%	0.71%
10%	0.47%	0.48%	0.59%	1.65%	1.37%
25%	0.52%	1.00%	0.89%	2.90%	3.17%
50%	0.81%	2.19%	2.86%	4.61%	5.05%
75%	1.49%	4.27%	5.69%	6.98%	7.92%
95%	3.04%	6.88%	7.94%	10.06%	12.61%
99%	3.30%	7.60%	8.67%	12.58%	14.26%
Max	3.44%	7.98%	9.04%	13.98%	14.35%

1B: 200 Alternative w/ Shadow Floor 1-yr UST Scenarios: Percentiles by Projection

Percentile	12	60	120	240	360
Min	-0.33%	-0.80%	-0.69%	-0.85%	-0.95%
1%	-0.08%	-0.48%	-0.54%	-0.58%	-0.78%
10%	0.22%	-0.01%	-0.08%	-0.03%	0.08%
25%	0.41%	0.30%	0.30%	0.34%	0.57%
50%	0.63%	0.67%	0.74%	0.84%	1.37%
75%	0.82%	0.98%	1.87%	2.38%	3.55%
95%	1.61%	3.16%	4.20%	6.24%	7.25%
99%	2.02%	4.15%	5.39%	7.93%	10.13%
Max	2.34%	5.62%	9.36%	10.24%	14.31%

1B – B1

Percentile	12	60	120	240	360
Min	-0.75%	-1.19%	-1.09%	-1.47%	-1.60%
1%	-0.52%	-0.88%	-0.97%	-1.22%	-1.49%
10%	-0.25%	-0.50%	-0.67%	-1.68%	-1.29%
25%	-0.11%	-0.70%	-0.60%	-2.57%	-2.60%
50%	-0.18%	-1.53%	-2.12%	-3.78%	-3.68%
75%	-0.67%	-3.29%	-3.82%	-4.60%	-4.36%
95%	-1.43%	-3.72%	-3.74%	-3.82%	-5.37%
99%	-1.28%	-3.44%	-3.28%	-4.65%	-4.13%
Max	-1.10%	-2.36%	0.32%	-3.74%	-0.04%

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Field Test 7: US Treasury Overview

- Field Test 7 (as of 12/31/21) was a C3 Phase I specific test designed to use the current version of the AIRG (prescribed in VM-20 and VM-21) to understand what the impact would be of moving to the latest version of the AIRG with a mean reversion parameter that is dynamic based upon historical data. For 12/31/21, the latest version of the AIRG had a mean reversion parameter of 3.25% compared to 6.55% for the C3 Phase I ESG.
- The field test 7 UST scenario set as of 12/31/21 had a much higher prevalence of low UST rates, but the current version of the AIRG has a soft floor of 1 BP, effectively eliminating negative interest rates.
- The field test 7 UST scenario set included a frequency and severity of high 1-yr UST rates that was much lower than those produced by the C3 Phase I generator, particularly at the later projection periods.

Baseline 1 (B1): 50 C3 Phase I AIRG 1-yr UST Scenarios: Percentiles by Projection Month

Percentile	12	60	120	240	360
Min	0.42%	0.39%	0.40%	0.62%	0.65%
1%	0.43%	0.40%	0.43%	0.64%	0.71%
10%	0.47%	0.48%	0.59%	1.65%	1.37%
25%	0.52%	1.00%	0.89%	2.90%	3.17%
50%	0.81%	2.19%	2.86%	4.61%	5.05%
75%	1.49%	4.27%	5.69%	6.98%	7.92%
95%	3.04%	6.88%	7.94%	10.06%	12.61%
99%	3.30%	7.60%	8.67%	12.58%	14.26%
Max	3.44%	7.98%	9.04%	13.98%	14.35%

7: 200 VM-20 AIRG 1-yr UST Scenarios: Percentiles by Projection Month

Percentile	12	60	120	240	360
Min	0.01%	0.17%	0.01%	0.01%	0.17%
1%	0.01%	0.40%	0.28%	0.57%	0.32%
10%	0.25%	0.71%	0.77%	1.02%	1.06%
25%	0.43%	0.89%	1.22%	1.55%	1.41%
50%	0.69%	1.23%	1.65%	2.04%	2.07%
75%	0.90%	1.72%	2.31%	2.79%	2.95%
95%	1.24%	2.27%	3.35%	3.98%	4.69%
99%	1.54%	2.97%	4.27%	5.39%	5.99%
Max	1.57%	4.01%	5.28%	7.45%	6.95%

7 - B1

Percentile	12	60	120	240	360
Min	-0.41%	-0.22%	-0.39%	-0.61%	-0.49%
1%	-0.42%	0.00%	-0.16%	-0.07%	-0.39%
10%	-0.22%	0.23%	0.19%	-0.63%	-0.31%
25%	-0.09%	-0.11%	0.32%	-1.35%	-1.76%
50%	-0.12%	-0.96%	-1.21%	-2.57%	-2.98%
75%	-0.59%	-2.55%	-3.37%	-4.19%	-4.96%
95%	-1.81%	-4.61%	-4.59%	-6.08%	-7.92%
99%	-1.75%	-4.62%	-4.40%	-7.19%	-8.27%
Max	-1.87%	-3.97%	-3.76%	-6.53%	-7.40%

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Change in Capital Amount by Legal Entity – 12/31/21

Field Test	B1	1A	1B	7
Wtd. Average C3 Phase I Factor	0.14%	1.29%	0.92%	0.17%
Average % Change*		817%	512%	15%
# of Participants	24	24	22	16

C3 Phase I Factor: Range and Percentile Statistics
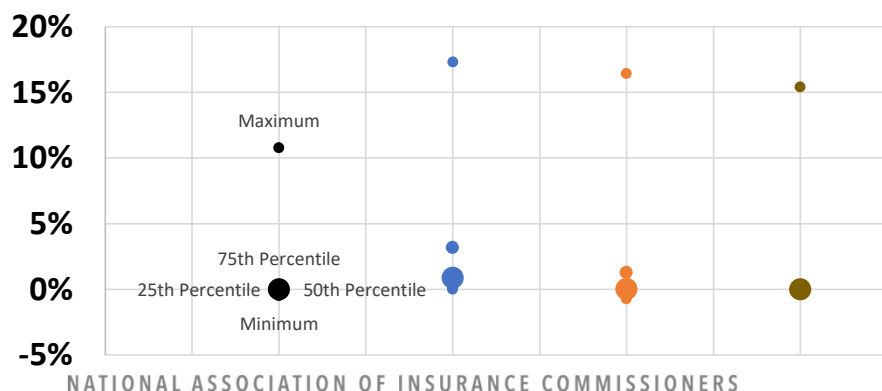
- For the 12/31/21 Baseline 1 (B1) field test run, approximately half of the participants had C3P1 RBC amounts (C3 factor * statutory reserve) close to zero. The 75th percentile for the Baseline 1 C3 factor was 0.23%, and the average C3 factor (weighted by statutory reserve) was 0.14%.
- For each of the 12/31/21 field test runs shown, there was an increase to the average C3 Factor, with 1A (Conning calibration with GFF) coming in at the highest followed by the 1B (Alternative with Shadow Floor).
- Both 1A and 1B saw a larger proportion of the field test participants with non-zero C3 Factors.
- Field test run 7 (200 Scenario VM-20 AIRG) had a small average C3 factor increase, with some participants seeing higher, lower, or no changes at all to their capital.

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*Note, each of the Average % Change value is specific to the cohort that completed both the baseline and the respective field test run.

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12/31/19 + 200 BP Baseline Comparisons

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Field Test 2A: US Treasury Overview

- Field Test 2A (as of 12/31/19 + 200 BP) used the same calibration as 1A (Conning Calibration with a Generalized Fractional Floor) but with a 12/31/19 starting yield curve modified using a 200 BP increase across all maturities.
- Compared to the C3 Phase I generator with a 12/31/19 + 200 BP starting interest environment, the 2A scenario set has a much greater frequency and severity of low (and negative) UST rates. The 2A scenario set has a comparable severity of high 1-yr UST rates at the 95th percentile, but somewhat higher 1-yr UST rates at the 99th percentile.

Baseline 2 (B2): 50 C3 Phase I AIRG 1-yr UST Scenarios: Percentiles by Projection Month

Percentile	12	60	120	240	360
Min	0.81%	0.67%	0.73%	0.59%	0.64%
1%	0.85%	0.69%	0.78%	0.60%	0.70%
10%	1.90%	1.38%	1.61%	1.75%	2.35%
25%	3.23%	2.69%	2.76%	3.06%	3.85%
50%	3.82%	3.81%	3.94%	4.42%	5.49%
75%	4.64%	4.80%	6.30%	5.81%	7.77%
95%	5.81%	7.46%	9.29%	8.88%	10.14%
99%	6.03%	11.09%	11.53%	9.85%	11.39%
Max	6.18%	12.29%	13.42%	9.91%	11.88%

2A: 200 Conning w/ GFF 1-yr UST Scenarios: Percentiles by Projection Month

Percentile	12	60	120	240	360
Min	-0.01%	-0.72%	-0.50%	-0.74%	-0.70%
1%	0.30%	-0.10%	-0.30%	-0.56%	-0.57%
10%	1.48%	0.26%	-0.01%	0.02%	-0.02%
25%	2.47%	0.76%	0.42%	0.49%	0.37%
50%	3.53%	2.89%	2.68%	2.48%	2.51%
75%	4.65%	5.30%	5.45%	5.59%	5.29%
95%	6.55%	8.68%	10.02%	11.22%	10.88%
99%	7.68%	10.55%	12.97%	14.28%	13.77%
Max	9.12%	12.16%	14.50%	15.29%	23.43%

2A – B2

Percentile	12	60	120	240	360
Min	-0.82%	-1.39%	-1.23%	-1.33%	-1.34%
1%	-0.55%	-0.79%	-1.08%	-1.16%	-1.27%
10%	-0.42%	-1.12%	-1.63%	-1.73%	-2.37%
25%	-0.76%	-1.93%	-2.34%	-2.56%	-3.48%
50%	-0.29%	-0.93%	-1.26%	-1.95%	-2.98%
75%	0.01%	0.50%	-0.86%	-0.22%	-2.48%
95%	0.74%	1.22%	0.73%	2.35%	0.74%
99%	1.66%	-0.54%	1.44%	4.43%	2.38%
Max	2.94%	-0.13%	1.08%	5.38%	11.55%

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Field Test 2B: US Treasury Overview

- Field Test 2B (as of 12/31/19 + 200 BP) used the same calibration as 1A (Conning Calibration with a Generalized Fractional Floor) but with a 12/31/19 starting yield curve modified using a 200 BP increase across all maturities
- Compared to the C3 Phase I generator with a 12/31/19 + 200 BP starting interest environment, the 2B scenario set has a much greater frequency and severity of low (and negative) UST rates. The 2B scenario set has a comparable severity of high 1-yr UST rates at the 95th percentile but has higher or lower severity depending on the projection period at the 99th percentile level.

Baseline 2 (B2): 50 C3 Phase I AIRG 1-yr UST Scenarios: Percentiles by Projection Month

Percentile	12	60	120	240	360
Min	0.81%	0.67%	0.73%	0.59%	0.64%
1%	0.85%	0.69%	0.78%	0.60%	0.70%
10%	1.90%	1.38%	1.61%	1.75%	2.35%
25%	3.23%	2.69%	2.76%	3.06%	3.85%
50%	3.82%	3.81%	3.94%	4.42%	5.49%
75%	4.64%	4.80%	6.30%	5.81%	7.77%
95%	5.81%	7.46%	9.29%	8.88%	10.14%
99%	6.03%	11.09%	11.53%	9.85%	11.39%
Max	6.18%	12.29%	13.42%	9.91%	11.88%

2B: 200 Conning w/ GFF 1-yr UST Scenarios: Percentiles by Projection Month

Percentile	12	60	120	240	360
Min	0.34%	-0.10%	-0.25%	-0.30%	-0.49%
1%	0.70%	0.23%	-0.07%	-0.27%	-0.40%
10%	1.44%	0.71%	0.47%	0.32%	0.34%
25%	2.22%	1.32%	0.92%	0.90%	0.93%
50%	3.25%	2.76%	2.78%	2.57%	2.54%
75%	4.04%	4.36%	4.60%	5.28%	5.41%
95%	5.53%	6.58%	9.26%	9.50%	9.61%
99%	6.28%	7.74%	11.19%	10.58%	13.54%
Max	6.93%	10.41%	12.18%	18.69%	19.49%

2B – B2

Percentile	12	60	120	240	360
Min	-0.47%	-0.77%	-0.98%	-0.89%	-1.13%
1%	-0.15%	-0.47%	-0.85%	-0.87%	-1.10%
10%	-0.46%	-0.67%	-1.15%	-1.44%	-2.01%
25%	-1.01%	-1.37%	-1.84%	-2.16%	-2.92%
50%	-0.57%	-1.05%	-1.16%	-1.85%	-2.96%
75%	-0.60%	-0.45%	-1.70%	-0.53%	-2.36%
95%	-0.28%	-0.88%	-0.03%	0.63%	-0.53%
99%	0.25%	-3.35%	-0.34%	0.73%	2.15%
Max	0.75%	-1.88%	-1.24%	8.78%	7.61%

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Change in Capital Amount by Legal Entity – 12/31/19 + 200 BP

Field Test	B2	2A	2B
Wtd. Average C3 Phase I Factor	0.46%	1.50%	0.93%
Average % Change		226%	103%
# of Participants	10	10	10
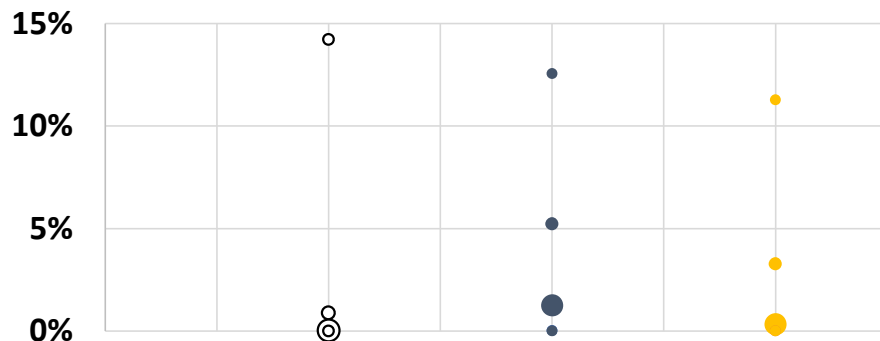
**C3 Phase I Factor: Range and Percentile Statistics**

- There was more limited participation for the optional Baseline 2 run.
- For the 12/31/19 + 200 BP Baseline 2 (B2) field test run, approximately half of the participants had C3P1 RBC amounts (C3 factor * statutory reserve) close to zero. The 75th percentile for the Baseline 2 C3 factor was 0.87%, and the average C3 factor (weighted by statutory reserve) was 0.46%.
- A similar pattern to the 12/31/21 field test runs holds for the 12/31/19 + 200 BP field test baseline comparisons, where the Conning Calibration w/ GFF (2A) has the largest increase to capital from the baseline with the Alternative Calibration with a Shadow Floor (2B) representing a significant but smaller increase.
- Both 2A and 2B saw a larger proportion of the field test participants with non-zero C3 Factors.

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Valuation Date Comparisons

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Change in Capital Amount by Legal Entity – 12/31/19 + 200 BP compared to 12/31/21

Field Test	B1	B2	1A	2A	1B	2B
Wtd. Average C3 Phase I Factor	0.14%	0.46%	1.35%	1.72%	1.01%	1.15%
Average % Change		229%		28%		15%
# of Participants	10	10	22	22	20	20
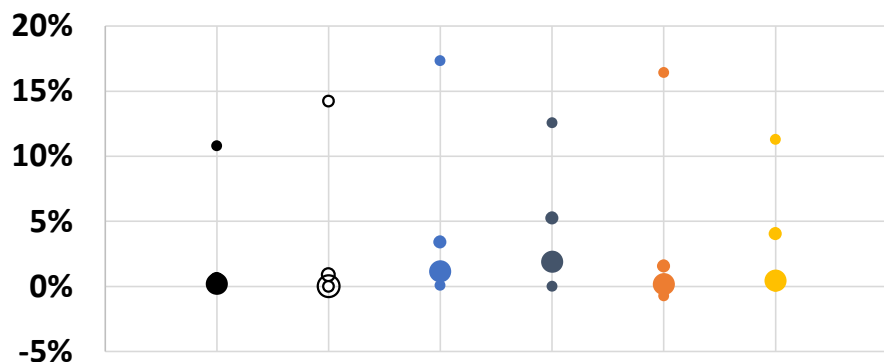
C3 Phase I Factor: Range and Percentile Statistics

- For each of the valuation date comparisons, the average C3 Factor increased from 12/31/21 (low interest environment) to 12/31/19 + 200 BP (higher interest environment).
- There was more limited participation for the optional Baseline 2 run, limiting the comparison between valuation dates. The average % change in the C3 Factor between valuation dates was the greatest for the baseline runs.
- Of the field test runs, the Conning calibration w/ GFF showed a higher average % change between valuation dates (28%), compared to the smaller (15%) change for the alternative calibration with shadow floor.
- Because of the large difference in legal entity cohorts between the baseline and field test runs, it is hard to conclude that the field test scenario sets produce more stable results than the C3 Phase I generator used in the baseline runs.

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Additional Metrics

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Additional C3 Phase I Metrics

- The table below shows the range statistics and weighted average of the legal entity results for C3 Phase I factors (C3 Phase I Capital Amount/Statutory Reserve) computed using different metrics.
- The results for the "C3 Phase I Weighted Average" are for 24 legal entities, whereas the results shown for the other metrics are only for 23 legal entities. One of the legal entities was removed due to one scenario out of their C3 Phase I calculation producing a very large C3 Phase I factor (e.g. 3,000%) that distorted the metrics. This scenario result was not included in the C3 Phase I weighted average or the range statistics.
- Once the outlier was removed, the CTE 90 metric had very similar results to the C3 Phase I metric. However, the 25% * (CTE 98 – CTE 70) metric produced smaller C3 Factors overall.

Range Statistic/Average	C3 Phase I Metric		CTE90		Mean Factor		Max Factor		25% * (CTE98 – CTE70)	
	B1	1A	B1	1A	B1	1A	B1	1A	B1	1A
Minimum	-0.49%	0.00%	-0.34%	0.00%	-0.62%	-0.62%	0.00%	0.00%	0.00%	0.00%
25th Percentile	0.00%	0.11%	0.00%	0.02%	0.00%	0.00%	0.00%	0.33%	0.00%	0.02%
Median	0.00%	0.87%	0.00%	1.14%	0.00%	0.13%	0.13%	3.56%	0.04%	0.67%
75th Percentile	0.23%	3.18%	0.36%	3.09%	0.15%	0.85%	1.27%	4.60%	0.15%	0.68%
Maximum	10.78%	17.32%	10.80%	17.82%	10.52%	15.85%	11.09%	29.91%	0.70%	0.80%
Wtd. Average Factor	**0.14%**	**1.29%**	**0.20%**	**1.39%**	**0.08%**	**0.63%**	**0.62%**	**8.35%**	**0.03%**	**0.40%**

(a) For the 50 scenario set, the C-3 scores are multiplied by the following series of weights:

C3 Phase I Metric ⟶

-------------------------------- Weighting Table --------------------------------

Scenario Rank:	17	16	15	14	13	12	11	10	9	8	7	6	5
Weight:	0.02	0.04	0.06	0.08	0.10	0.12	0.16	0.12	0.10	0.08	0.06	0.04	0.02

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Next Steps

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Next Steps

- The Generator of Economic Scenarios (GOES) (A) Subgroup will develop recommendations to LATF for reserve and capital framework-specific implementation issues and a GOES model governance framework.
- A more comprehensive set of GOES acceptance criteria will be reviewed by regulators and exposed in September. Once regulators decide on a new set of acceptance criteria, additional candidate scenario sets will be produced that are designed to meet the acceptance criteria.
- Regulators and the NAIC are considering how model office testing can supplement and/or replace components of industry field testing to efficiently evaluate the new scenario sets. A second-round industry field test of the new scenarios would occur no sooner than Spring of 2024.

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Appendix: Field Test Run Descriptions

Field Test Run Descriptions

Note: Bold = Required Run

Run #	Description	Purpose of Run
Baseline #1	Scenario set(s) the company used for 12/31/21 statutory reporting	Baseline used as comparative basis for 12/31/21 runs
Baseline #2	ESG the company used for 12/31/21 statutory reporting of reserves and RBC, but modified to produce scenario sets with a 12/31/19 yield curve modified using a 200 BP increase across all maturities	Baseline used as comparative basis for 12/31/19 + 200 BP runs
Test #1a	GEMS Baseline Equity and Corporate model scenarios as of 12/31/21, and Conning Treasury model calibration with generalized fractional floor as of 12/31/21	Tests Conning Treasury model w/ GFF and Baseline Equity at YE 2021
Test #1b	Same as Test #1a, but with Alternative Treasury model calibration with shadow floor as of 12/31/21	Tests Alternative Treasury model with shadow floor and Baseline Equity at YE 2021
Test #2a	Same as Test #1a, but with Equity, Corporate, and Treasury models with a 12/31/19 starting yield curve modified using a 200 BP increase across all maturities. All other initial market conditions are unchanged. The Equity model parameters would be adjusted from #1a so that the year 30 median Large Cap Equity gross wealth factors remain consistent with #1a.	Stresses the starting Treasury rates using the same calibration as 1a to evaluate whether the model produces appropriate results in different economic environments
Test #2b	Same as Test #2a, but with the Alternative Treasury model calibration with shadow floor instead of the Conning Treasury model calibration with generalized fractional floor	Same as 2a, but designed to stress the 1b calibration
Test #7	12/31/21 scenarios from the ESG prescribed in VM-20 with a Mean Reversion Parameter (MRP) set to 3.25%	Attribution analysis to understand the impact of moving from the current C3 Phase I MRP of 6.55% to a lower MRP that incorporates recent UST history.