

UPDATE ON MODEL OFFICE ECONOMIC SCENARIO GENERATOR (ESG) TESTING



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Presentation to Life Actuarial Task Force - March 31, 2022

Update on VA/VM-21 ESG Model Office Testing

Additional scenario testing results



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Agenda for VA Model Office Update

1. Changes since 3/17/22 – new scenario sets added
2. Summary of results
3. Scenario reserve distributions
4. Fund value exhaust year statistics
5. Equity scenario gross wealth factor and cumulative annualized total return comparisons
6. Preliminary conclusions
7. Caveats



VM-21 Model Office – Changes Since 3/17/22

- New model office testing was done for scenario sets recently added:
 1. Conning GEMS with Generalized Fractional Floor (GEMS GFF) as of 12/31/2019 valuation date
 2. An alternative version of the GEMS GFF 12/31/2019 and 12/31/2020 U.S. large cap equity scenarios using a lower equity volatility assumption
 3. No other changes – same product specs, assumptions and investment strategy (1-30 year bonds, no hedging) as 3/17/22 presentation.



Summary of Results – All Scenario Sets

The next slide summarizes the:

- Stochastic CTE70 reserves and
- C3 Phase 2 RBC after-tax Total Assets Required (TAR)
 - both expressed as a percentage of the initial Cash Surrender Value
 - CSV is 100% in the separate account;
 - excess over 100% CSV is the general account portion of reserve (i.e., the CTE70 GPVAD) and TAR

For the following scenario sets tested (yellow highlighted new since 3/17/22):

1. AIRG scenarios, 12/31/2019 and 12/31/2020 valuation dates
2. ACLI reference SLV model (version 1), 12/31/2019 and 12/31/2020
- 3a. Conning GEMS with Generalized Fractional Floor (GFF), 12/31/2019 and 12/31/2020
- 3b. Same as 3a but using lower equity volatility assumption
4. Strommen with Shadow Rate Floor (version 4B), 12/31/2020 valuation date
5. Conning GEMS unfloored 12/31/2020 valuation date scenarios developed in October 2021

In addition, a “hybrid” set of scenarios was tested for 3a above, by replacing the U.S. large cap equity fund scenarios with the AIRG U.S. large cap equity fund scenarios (as an initial rough test to get a feel for impact of removing the equity risk premium linkage to overnight UST scenario rates).



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Summary of Results

VA with GLWB and GMDB		Total reserve and C3P2 RBC post-tax TAR (General account portion is excess over 100%, initial CSV \$92,800)			
		12/31/2019 CTE70 Reserve/CSV	12/31/2020 CTE70 Reserve/CSV	12/31/2019 C3P2 TAR/CSV	12/31/2020 C3P2 TAR/CSV
	Scenario Set (used full 10,000)				
1	Academy Interest Rate Generator (AIRG)	103.3%	106.1%	107.0%	111.1%
2	ACLI Reference Model V1.0	103.6%	106.2%	107.5%	111.2%
3a	Conning with Generalized Fractional Floor (GFF)	109.0%	116.2%	114.5%	122.3%
3b	Conning with GFF, lower equity fund volatility	107.6%	114.5%	112.7%	120.3%
4	Strommen with Shadow Rate Model Floor	TBD	117.4%	TBD	123.1%
5	Conning Oct21 Calibration (Unfloored)	TBD	119.4%	TBD	125.2%
3a hybrid	Conning with GFF, using AIRG equity scens	103.2%	105.0%	107.0%	109.7%
4 hybrid	Strommen with SRF, using AIRG equity scens	TBD	in process	TBD	in process
5 hybrid	Conning Oct 21 unfl, using AIRG equity scens	TBD	in process	TBD	in process

Hybrid scenario results are a rough test to get an initial feel for the impact of removing the equity risk premium linkage to scenario short term overnight UST rates. The bond fund returns and UST rates used are from the corresponding non-hybrid scenario sets.



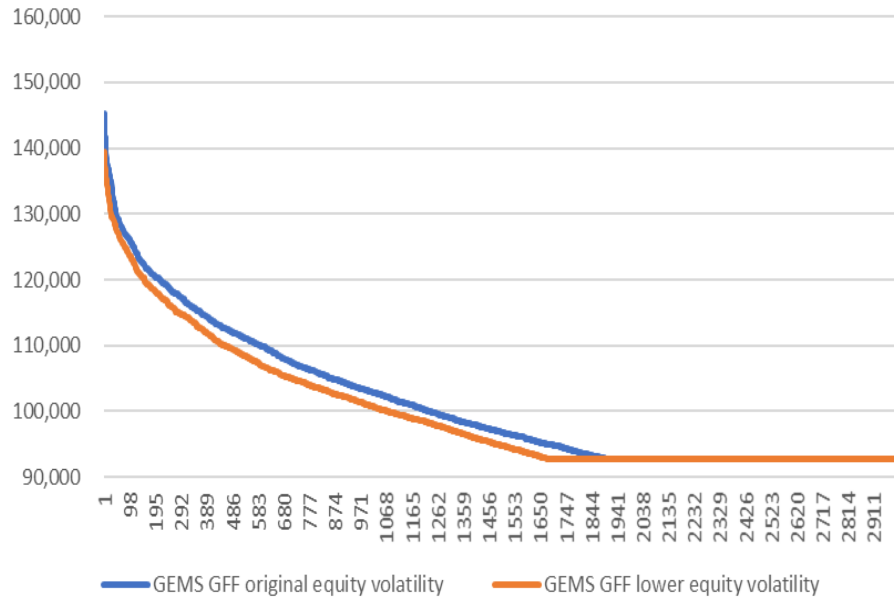
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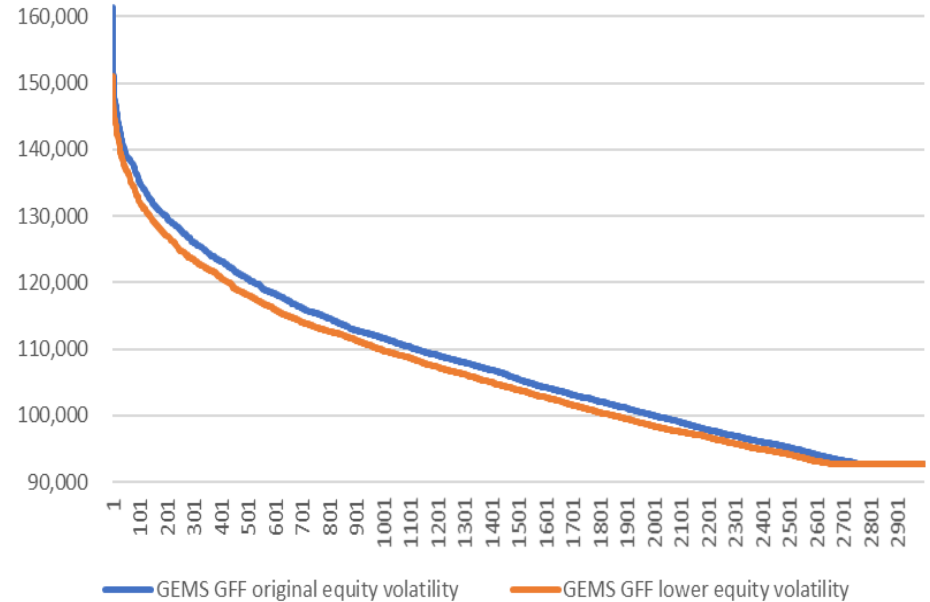
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Scenario Reserve Distributions

GEMS GFF 12/31/2019 highest 30% Scenario reserves



GEMS GFF 12/31/2020 highest 30% Scenario reserves



Fund value exhaustion statistics

For this product and 80/20 equity/bond fund allocation, fund values exhaust during years ~10 to 20 for scenarios requiring general account reserve above CSV to fund future expenses and guaranteed benefits.

Fees in all years and GLWB withdrawals in years 11+ decrease fund values in all scenarios.

Cumulative fund returns (wealth ratios) over the first 20 years are a critical driver of reserve and capital amounts for these tests.

%ile within worst 3000	GEMS GFF - year fund value exhausts for highest 3,000 scenario reserves				%ile within worst 3000	GEMS GFF - scenario reserves/CSV ratio for highest 3,000 scenario reserves ¹			
	lower vol 12/2019	orig vol 12/2019	lower vol 12/2020	orig vol 12/2020		lower vol 12/2019	orig vol 12/2019	lower vol 12/2020	orig vol 12/2020
min	10.7	10.3	10.5	9.5	max	150.2%	156.6%	162.8%	173.9%
1.0%	12.2	11.7	11.8	11.4	99.0%	139.5%	143.6%	150.2%	152.8%
5.0%	13.7	13.2	13.1	12.6	95.0%	129.6%	131.9%	139.4%	142.0%
10.0%	14.7	14.2	14.0	13.5	90.0%	123.5%	126.2%	133.1%	135.9%
50.0%	18.6	17.9	17.0	16.6	50.0%	102.2%	104.4%	111.9%	113.7%
90.0%	40.0	40.0	20.5	20.3	10.0%	100.0%	100.0%	100.0%	100.5%
95.0%	40.0	40.0	28.6	23.5	5.0%	100.0%	100.0%	100.0%	100.0%
99.0%	40.0	40.0	40.0	40.0	1.0%	100.0%	100.0%	100.0%	100.0%
max	40.0	40.0	40.0	40.0	min	100.0%	100.0%	100.0%	100.0%
mean	22.6	21.6	17.9	17.2	mean	107.6%	109.0%	114.5%	116.2%
						mean is CTE70 reserve			



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1. Right table reserve amount percentiles not an exact match to left table year of fund value exhaustion percentiles, but line up reasonably well.

U.S. Large cap Equity scenario gross wealth factors

% -ile	5 Yr	10 Yr	20 Yr	30 Yr	5 Yr	10 Yr	20 Yr	30 Yr	5 Yr	10 Yr	20 Yr	30 Yr
	GEMS GFF original vol 12/31/2019				GEMS GFF original vol 12/31/2020				Ratio 2020/2019			
Min	0.17	0.08	0.09	0.03	0.13	0.06	0.04	0.05	76%	79%	46%	194%
1.0%	0.49	0.39	0.42	0.47	0.46	0.36	0.39	0.39	93%	91%	91%	83%
2.5%	0.60	0.55	0.63	0.72	0.58	0.48	0.54	0.66	96%	88%	86%	92%
5.0%	0.71	0.70	0.84	1.09	0.68	0.64	0.74	0.96	96%	90%	87%	88%
10.0%	0.85	0.92	1.19	1.73	0.81	0.83	1.05	1.50	95%	90%	88%	87%
25.0%	1.10	1.33	2.08	3.45	1.03	1.21	1.80	2.95	93%	91%	87%	85%
50.0%	1.39	1.90	3.57	7.02	1.29	1.70	3.10	5.88	93%	89%	87%	84%
GEMS GFF new vol 12/31/2019				GEMS GFF new vol 12/31/2020				Ratio 2020/2019				
Min	0.22	0.13	0.15	0.11	0.20	0.11	0.14	0.10	93%	84%	95%	94%
1.0%	0.54	0.46	0.51	0.62	0.50	0.41	0.46	0.55	94%	90%	89%	90%
2.5%	0.64	0.61	0.74	0.95	0.60	0.56	0.66	0.83	94%	91%	89%	87%
5.0%	0.75	0.77	0.99	1.36	0.71	0.70	0.87	1.19	94%	90%	88%	87%
10.0%	0.88	0.96	1.34	2.02	0.82	0.87	1.18	1.74	94%	90%	88%	86%
25.0%	1.11	1.37	2.19	3.73	1.03	1.23	1.90	3.18	93%	90%	87%	85%
50.0%	1.39	1.91	3.67	7.27	1.29	1.70	3.16	6.10	93%	89%	86%	84%
AIRG 12/31/2019				AIRG 12/31/2020 (same as 2019)				Ratio 2020/2019				
Min	0.37	0.36	0.40	0.47	0.37	0.36	0.40	0.47	100%	100%	100%	100%
1.0%	0.61	0.66	0.89	1.23	0.61	0.66	0.89	1.23	100%	100%	100%	100%
2.5%	0.71	0.79	1.12	1.72	0.71	0.79	1.12	1.72	100%	100%	100%	100%
5.0%	0.80	0.92	1.41	2.30	0.80	0.92	1.41	2.30	100%	100%	100%	100%
10.0%	0.93	1.12	1.80	3.09	0.93	1.12	1.80	3.09	100%	100%	100%	100%
25.0%	1.16	1.51	2.77	5.24	1.16	1.51	2.77	5.24	100%	100%	100%	100%
50.0%	1.45	2.11	4.37	8.97	1.45	2.11	4.37	8.97	100%	100%	100%	100%



U.S. Large cap Equity scenario gross wealth factors

% -ile	5 Yr	10 Yr	20 Yr	30 Yr	5 Yr	10 Yr	20 Yr	30 Yr	5 Yr	10 Yr	20 Yr	30 Yr
	GEMS GFF new vol 12/31/2019				AIRG 12/31/2019				Ratio GEMS/AIRG 2019			
Min	0.22	0.13	0.15	0.11	0.37	0.36	0.40	0.47	58%	37%	37%	23%
1.0%	0.54	0.46	0.51	0.62	0.61	0.66	0.89	1.23	88%	69%	58%	50%
2.5%	0.64	0.61	0.74	0.95	0.71	0.79	1.12	1.72	91%	77%	66%	55%
5.0%	0.75	0.77	0.99	1.36	0.80	0.92	1.41	2.30	94%	84%	70%	59%
10.0%	0.88	0.96	1.34	2.02	0.93	1.12	1.80	3.09	95%	86%	74%	65%
25.0%	1.11	1.37	2.19	3.73	1.16	1.51	2.77	5.24	96%	91%	79%	71%
50.0%	1.39	1.91	3.67	7.27	1.45	2.11	4.37	8.97	96%	91%	84%	81%
% -ile	GEMS GFF new vol 12/31/2020				AIRG 12/31/2020 (same as 2019)				Ratio GEMS/AIRG 2020			
	Min	0.20	0.11	0.14	0.10	0.37	0.36	0.40	0.47	54%	31%	35%
1.0%	0.50	0.41	0.46	0.55	0.61	0.66	0.89	1.23	82%	62%	51%	45%
2.5%	0.60	0.56	0.66	0.83	0.71	0.79	1.12	1.72	85%	71%	59%	49%
5.0%	0.71	0.70	0.87	1.19	0.80	0.92	1.41	2.30	88%	76%	62%	52%
10.0%	0.82	0.87	1.18	1.74	0.93	1.12	1.80	3.09	89%	78%	65%	56%
25.0%	1.03	1.23	1.90	3.18	1.16	1.51	2.77	5.24	89%	81%	69%	61%
50.0%	1.29	1.70	3.16	6.10	1.45	2.11	4.37	8.97	89%	81%	72%	68%

Ratio of GEMS to AIRG wealth factors shows very different equity distributions and changes by year - the question should be whether that makes economic sense for the purpose.



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Equity Scenario cumulative annualized total returns

%ile	5 Yr	10 Yr	20 Yr	30 Yr	5 Yr	10 Yr	20 Yr	30 Yr	5 Yr	10 Yr	20 Yr	30 Yr
	GEMS GFF new vol 12/31/2019				AIRG 12/31/2019				Difference GEMS minus AIRG			
Min	-26.32%	-18.15%	-9.07%	-7.17%	-17.82%	-9.59%	-4.43%	-2.49%	-8.50%	-8.56%	-4.64%	-4.68%
1.0%	-11.70%	-7.55%	-3.27%	-1.60%	-9.40%	-4.01%	-0.56%	0.69%	-2.30%	-3.53%	-2.71%	-2.29%
2.5%	-8.56%	-4.83%	-1.46%	-0.17%	-6.74%	-2.34%	0.58%	1.82%	-1.82%	-2.50%	-2.04%	-1.98%
5.0%	-5.50%	-2.57%	-0.07%	1.03%	-4.35%	-0.87%	1.74%	2.81%	-1.16%	-1.70%	-1.81%	-1.78%
10.0%	-2.50%	-0.39%	1.47%	2.38%	-1.53%	1.12%	2.98%	3.84%	-0.98%	-1.51%	-1.51%	-1.46%
25.0%	2.15%	3.21%	3.99%	4.49%	2.97%	4.23%	5.22%	5.68%	-0.82%	-1.02%	-1.22%	-1.19%
50.0%	6.82%	6.69%	6.72%	6.84%	7.70%	7.75%	7.66%	7.59%	-0.88%	-1.06%	-0.94%	-0.75%
GEMS GFF new vol 12/31/2020				AIRG 12/31/2020 (same as 2019)				Difference GEMS minus AIRG				
Min	-27.45%	-19.56%	-9.32%	-7.36%	-17.82%	-9.59%	-4.43%	-2.49%	-9.63%	-9.97%	-4.89%	-4.87%
1.0%	-12.83%	-8.53%	-3.85%	-1.96%	-9.40%	-4.01%	-0.56%	0.69%	-3.43%	-4.52%	-3.28%	-2.64%
2.5%	-9.73%	-5.68%	-2.05%	-0.61%	-6.74%	-2.34%	0.58%	1.82%	-3.00%	-3.35%	-2.63%	-2.43%
5.0%	-6.71%	-3.56%	-0.69%	0.57%	-4.35%	-0.87%	1.74%	2.81%	-2.37%	-2.69%	-2.43%	-2.24%
10.0%	-3.80%	-1.38%	0.82%	1.87%	-1.53%	1.12%	2.98%	3.84%	-2.28%	-2.50%	-2.16%	-1.97%
25.0%	0.69%	2.10%	3.25%	3.93%	2.97%	4.23%	5.22%	5.68%	-2.28%	-2.14%	-1.97%	-1.75%
50.0%	5.23%	5.47%	5.92%	6.21%	7.70%	7.75%	7.66%	7.59%	-2.48%	-2.28%	-1.74%	-1.37%

These are annual effective rates that accumulate over the given period to the gross wealth ratios on prior slides. GEMS cumulative annualized equity returns lower than AIRG, driving higher reserves, which are most sensitive to cumulative returns over 20 years (returns after 20 years not as relevant for this product and fund allocation due to fund value exhaustion).

Differences significantly more negative for 12/31/2020, increasing reserves relative to 12/31/2019.



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Equity Scenario cumulative annualized total returns

% -ile	5 Yr	10 Yr	20 Yr	30 Yr	5 Yr	10 Yr	20 Yr	30 Yr	5 Yr	10 Yr	20 Yr	30 Yr
	GEMS GFF original vol 12/31/2019				GEMS GFF original vol 12/31/2020				Difference 2020 minus 2019 returns			
Min	-29.99%	-22.44%	-11.51%	-11.50%	-33.78%	-24.27%	-14.89%	-9.53%	-3.79%	-1.82%	-3.38%	1.97%
1.0%	-13.15%	-9.02%	-4.19%	-2.47%	-14.48%	-9.83%	-4.65%	-3.08%	-1.32%	-0.81%	-0.46%	-0.61%
2.5%	-9.71%	-5.82%	-2.30%	-1.09%	-10.46%	-7.02%	-3.04%	-1.36%	-0.76%	-1.20%	-0.73%	-0.27%
5.0%	-6.68%	-3.45%	-0.84%	0.28%	-7.44%	-4.41%	-1.52%	-0.14%	-0.77%	-0.97%	-0.67%	-0.42%
10.0%	-3.15%	-0.86%	0.88%	1.84%	-4.22%	-1.85%	0.24%	1.36%	-1.07%	-0.99%	-0.64%	-0.49%
25.0%	1.97%	2.90%	3.72%	4.22%	0.51%	1.90%	2.98%	3.67%	-1.47%	-1.00%	-0.74%	-0.55%
50.0%	6.83%	6.63%	6.57%	6.71%	5.28%	5.45%	5.81%	6.08%	-1.55%	-1.18%	-0.76%	-0.63%
	GEMS GFF new vol 12/31/2019				GEMS GFF new vol 12/31/2020				Difference 2020 minus 2019 returns			
Min	-26.32%	-18.15%	-9.07%	-7.17%	-27.45%	-19.56%	-9.32%	-7.36%	-1.13%	-1.41%	-0.24%	-0.19%
1.0%	-11.70%	-7.55%	-3.27%	-1.60%	-12.83%	-8.53%	-3.85%	-1.96%	-1.13%	-0.98%	-0.57%	-0.35%
2.5%	-8.56%	-4.83%	-1.46%	-0.17%	-9.73%	-5.68%	-2.05%	-0.61%	-1.17%	-0.85%	-0.59%	-0.44%
5.0%	-5.50%	-2.57%	-0.07%	1.03%	-6.71%	-3.56%	-0.69%	0.57%	-1.21%	-0.99%	-0.62%	-0.46%
10.0%	-2.50%	-0.39%	1.47%	2.38%	-3.80%	-1.38%	0.82%	1.87%	-1.30%	-0.99%	-0.65%	-0.51%
25.0%	2.15%	3.21%	3.99%	4.49%	0.69%	2.10%	3.25%	3.93%	-1.46%	-1.11%	-0.74%	-0.56%
50.0%	6.82%	6.69%	6.72%	6.84%	5.23%	5.47%	5.92%	6.21%	-1.59%	-1.22%	-0.80%	-0.62%
	AIRG 12/31/2019				AIRG 12/31/2020 (same as 2019)				Difference 2020 minus 2019 returns			
Min	-17.82%	-9.59%	-4.43%	-2.49%	-17.82%	-9.59%	-4.43%	-2.49%	0.00%	0.00%	0.00%	0.00%
1.0%	-9.40%	-4.01%	-0.56%	0.69%	-9.40%	-4.01%	-0.56%	0.69%	0.00%	0.00%	0.00%	0.00%
2.5%	-6.74%	-2.34%	0.58%	1.82%	-6.74%	-2.34%	0.58%	1.82%	0.00%	0.00%	0.00%	0.00%
5.0%	-4.35%	-0.87%	1.74%	2.81%	-4.35%	-0.87%	1.74%	2.81%	0.00%	0.00%	0.00%	0.00%
10.0%	-1.53%	1.12%	2.98%	3.84%	-1.53%	1.12%	2.98%	3.84%	0.00%	0.00%	0.00%	0.00%
25.0%	2.97%	4.23%	5.22%	5.68%	2.97%	4.23%	5.22%	5.68%	0.00%	0.00%	0.00%	0.00%
50.0%	7.70%	7.75%	7.66%	7.59%	7.70%	7.75%	7.66%	7.59%	0.00%	0.00%	0.00%	0.00%

Preliminary Conclusions

- AAA equity scenario ESG compared to GEMS:
 - AIRG ESG has no formulaic linkage between the equity returns and Treasury yields.
 - There is an implicit expected equity risk premium in the long term / steady state if you consider expected equity returns vs. the mean reversion interest rate parameter
 - The AIRG was calibrated to specific targets, and given its structure and inputs, it will continue to meet those targets at all future points in time
 - Equity scenario distribution does not change based on initial market conditions
 - GEMS links expected equity return to current short Treasury Yield. Initially and at every node, the expected equity return is the overnight rate plus a fixed equity risk premium.
 - Therefore the short-term expected equity return is constantly changing based on changes in the simulated overnight rate, produces different expected equity returns across start dates, and makes the equity returns impacted by Treasury model's mean reversion.
 - Actual scenario total returns also impacted by structural model differences and calibration parameter choices (i.e., the choice made to not update certain Conning Standard Calibration equity parameters and instead accept left tail returns that are significantly lower)
 - GEMS equity return wealth ratios are more volatile and pro-cyclical, and these model office results for this product design and fund allocation indicate this translates to reserves and capital being more volatile and pro-cyclical (at least for unhedged results).



Preliminary Conclusions (continued)

- For this product design and fund allocation, the impact to reserves is very large under the 3 Conning ESG scenario sets tested (GFF, Strommen SRF, GEMS unfloored) relative to current AIRG or ACLI reference model
 - Ratios of reserves and TAR to CSV are significantly higher - general account reserves are more than double the AIRG & ACLI reserves for GEMS GFF and Strommen SRF, and more than triple using the GEMS unfloored set
 - Primary driver is more severe (lower) cumulative equity return distributions in the first ~20 years for the GEMS scenario sets (though this is in part driven by the form of the linkage to interest rates).
 - Secondary driver is the “low for long” interest rate requirements, which are not present in the current AIRG. More work in process to understand these drivers.
 - At 12/31/2020 the short term rates more than 100bp lower than at 12/31/2020, producing higher reserves.
- Form of linkage of expected equity returns to short term interest rates may drive artificial volatility in reserves and capital.
- May cause non-intuitive risk management decisions/hedging (e.g., suggests that companies may need to hedge more overnight rates or hold more capital for the stat volatility for changes in overnight rates even if the liabilities and assets do not have an inherent dependence on overnight rates).
- The “hybrid” scenario results shown (using Conning GEMS GFF interest rate and LT corporate bond fund returns but using AIRG equity returns) have reserve and TAR amounts that are very similar to the AIRG and ACLI reference model results.



Caveats

- Intended as an illustrative single data point (single representative model point issued on valuation date; no future sales; not an in-force block) for assessing materiality and relative impact to reserve levels and volatility from a change to the scenarios
 - ▣ No hedging reflected in results – company results may vary depending on hedging strategy.
 - ▣ Companies should consider testing their own products using their own models.

- Not intended to:
 - ▣ Cover wide variety of products available on the market
 - ▣ Reflect a full distribution of issue ages / genders within the given product
 - ▣ Reflect different starting in-force block conditions (guaranteed benefit moneyiness, etc.)
 - ▣ Thoroughly test all the underlying assumptions
 - ▣ Be used as a basis for assessing appropriateness of an Economic Scenario Generator



Questions?

- Please contact Devin Boerm at boerm@actuary.org

