

ACLI Equity Calibration Proposal

November 15, 2024

Background

- Prior to the 2024 GOES field test (FT2), ACLI identified that equity calibrations were meaningfully more severe for the tail distribution in the longer time horizon than the Academy's criteria
- Specifically, Gross Wealth Factor (GWF) targets at higher durations (20+ years) in the right (low return) tails were lower than targets with monthly returns more severe than history.
- ACLI has concerns developed a calibration as one way to address this issue, while also addressing Conning comments about correlations and jump processes in an early proposal.

Key Enhancements

- Enhanced jump process parametrization, better aligned with historical equity returns (Slide 4)
- Tail short-term (monthly) returns better aligned with historical data (Slides 5-6)
- Tail long-term returns (GWF over 10+ years) better aligned with adopted acceptance criteria (Slide 8)
- ACLI calibration follows a repeatable ground-up process, directly tied to historical data using MLE calibration (Appendix)

Parameter Comparison to GEMS FT2 Baseline

	ACLI Proposed			
	Large	Mid	Small	Aggressive
mu0	0.0723	0.0408	0.0556	0.1233
mu1	0.5744	2.0910	1.5311	-0.2500
alpha	0.0196	0.0307	0.0308	0.0191
beta	0.9519	1.1310	0.9408	0.4800
sigma	0.1254	0.1409	0.1409	0.1587
mu_jump	-0.1500	-0.2184	-0.2355	-0.1990
sigma_jump	0.0584	0.0476	0.0480	0.0678
lambda_jump	4.9442	4.6774	3.8906	3.6347
correlation	-0.4563	-0.6661	-0.6275	-0.3105
initial vol	0.1435	0.1648	0.1809	0.1997
theta	0.0206	0.0272	0.0327	0.0399
Avg. Jump Freq.	0.1019	0.1270	0.1273	0.1449
% Jump Variance	11.4%	18.9%	18.3%	13.8%

	GEMS FT2			
	Large	Mid	Small	Aggressive
mu0	0.0825	0.0882	0.0909	0.1058
mu1	0.0926	0.0020	0.0012	0.0186
alpha	0.0058	0.0048	0.0051	0.0086
beta	0.4627	0.2927	0.3141	0.3303
sigma	0.0747	0.0358	0.0520	0.0408
mu_jump	-0.0525	-0.0420	-0.0696	-0.0504
sigma_jump	0.0575	0.0575	0.0575	0.0595
lambda_jump	139.5882	113.4168	112.9784	128.7243
correlation	-0.4770	-0.5263	-0.4951	-0.4805
initial vol	0.1117	0.1283	0.1272	0.1615
theta	0.0125	0.0164	0.0162	0.0261
Avg. Jump Freq.	1.7419	1.8656	1.8288	3.3580
% Jump Variance	45.8%	36.5%	47.9%	43.9%

Avg. Variance: $\theta = \alpha/\beta$

Est. Jump Freq (annual) = $\theta\lambda$

Est. Variance due to Jumps:

$$V_{jump} = \theta\lambda(\mu_{jump}^2 + \sigma_{jump}^2)$$

% of Variance due to Jumps:

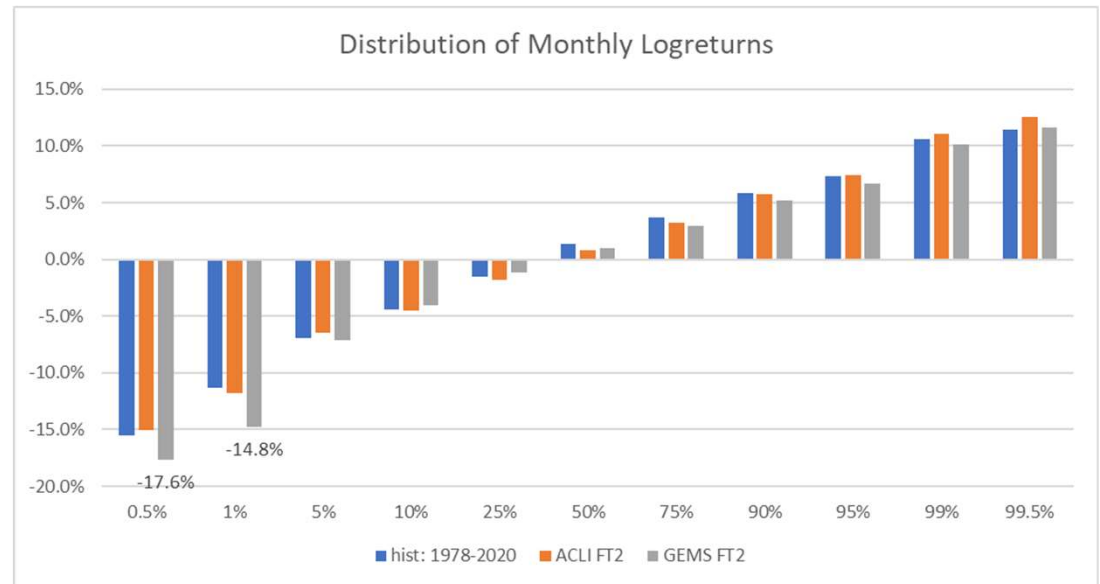
$$\frac{V_{jump}}{\theta + V_{jump}}$$

ACLI calibration key differences vs. GEMS FT2:

- ACLI parameters derived using historical MLE calibration, with subsequent adjustments to alpha and mu0 parameters to align to historical variance and Sharpe ratio of ~28.1% across all indices.
- **Jumps: lower frequency but higher severity, accounting for 10-20% of return variance compared to 40-50% of variance under FT2**
- Variance: higher mean reversion of the variance process
- Risk Premium Coefficient (mu1): larger coefficients and possible negatives.

Distribution of Monthly Logreturn: Large Cap

	hist: 1978-2020	hist: 1992-2020	ACLI FT2	GEMS FT2	FT1 Run6
min	-24.2%	-18.4%	-62.1%	-69.1%	-52.9%
0.5%	-15.5%	-13.8%	-15.0%	-17.6%	-12.8%
1%	-11.4%	-11.4%	-11.8%	-14.8%	-10.5%
5%	-7.0%	-7.2%	-6.5%	-7.1%	-6.1%
10%	-4.4%	-4.5%	-4.5%	-4.1%	-4.3%
25%	-1.5%	-1.6%	-1.8%	-1.1%	-1.7%
50%	1.4%	1.3%	0.8%	1.0%	0.7%
75%	3.7%	3.4%	3.2%	3.0%	3.0%
90%	5.8%	5.6%	5.7%	5.2%	5.6%
95%	7.3%	7.0%	7.4%	6.7%	7.3%
99%	10.6%	9.2%	11.0%	10.2%	11.1%
99.5%	11.4%	10.4%	12.5%	11.6%	12.6%
max	12.6%	12.1%	33.6%	32.1%	31.6%



- Modeled monthly logreturns based on 10k scenarios and 50yrs of projection.
- FT2 baseline scenarios exaggerate severity of tail monthly returns, which also translate into long term GWF severity (see following slides)
- ACLI calibration amply recovers the distribution of historical monthly returns which includes 1987 Black Monday, Financial Crisis, and the Pandemic of 2020.

Distribution of Monthly Logreturn: All Indices

ACLI Scenarios (estimated)				
	large	mid	small	aggressive
min	-62.1%	-69.7%	-76.0%	-81.1%
0.5%	-15.0%	-21.6%	-23.4%	-23.0%
1%	-11.8%	-15.4%	-16.9%	-18.2%
5%	-6.5%	-7.5%	-8.3%	-9.3%
10%	-4.5%	-5.2%	-5.8%	-6.3%
25%	-1.8%	-2.1%	-2.3%	-2.3%
50%	0.8%	0.9%	1.0%	1.0%
75%	3.2%	3.8%	4.1%	4.1%
90%	5.7%	6.6%	7.3%	7.7%
95%	7.4%	8.5%	9.4%	10.2%
99%	11.0%	12.5%	13.8%	15.9%
99.5%	12.5%	14.2%	15.6%	18.3%
max	33.6%	39.6%	44.6%	56.7%

FT2 Baseline Scenarios				
	large	mid	small	aggressive
min	-69.1%	-53.5%	-70.1%	-63.7%
0.5%	-17.6%	-16.7%	-19.9%	-21.6%
1%	-14.8%	-14.1%	-16.9%	-18.4%
5%	-7.1%	-7.3%	-8.7%	-10.6%
10%	-4.1%	-4.8%	-5.1%	-6.9%
25%	-1.1%	-1.8%	-1.5%	-2.5%
50%	1.0%	1.0%	1.2%	1.3%
75%	3.0%	3.5%	3.6%	4.7%
90%	5.2%	5.9%	6.0%	7.7%
95%	6.7%	7.4%	7.6%	9.7%
99%	10.2%	10.6%	11.0%	13.6%
99.5%	11.6%	12.0%	12.3%	15.2%
max	32.1%	33.7%	30.7%	35.2%

historical 78-2020				
	large	mid	small	aggressive
min	-24.2%	-30.6%	-33.8%	-31.8%
0.5%	-15.5%	-24.0%	-24.0%	-25.2%
1%	-11.4%	-16.8%	-20.1%	-18.9%
5%	-7.0%	-7.5%	-8.2%	-9.7%
10%	-4.4%	-4.8%	-5.8%	-6.6%
25%	-1.5%	-1.7%	-2.1%	-2.2%
50%	1.4%	1.5%	1.7%	1.8%
75%	3.7%	4.2%	4.5%	4.5%
90%	5.8%	6.6%	7.3%	7.6%
95%	7.3%	8.2%	8.5%	10.3%
99%	10.6%	12.9%	13.3%	13.6%
99.5%	11.4%	13.7%	14.4%	15.3%
max	12.6%	15.6%	18.1%	19.9%

ACLI Monthly Logreturn (10k scenarios, 50yrs)				
	large	mid	small	aggressive
mean (annual)	7.3%	8.1%	8.6%	9.1%
st.dev (annual)	15.3%	18.3%	20.0%	21.6%
skew	-0.60	-0.96	-0.90	-0.68
kurtosis	6.48	8.06	7.69	7.17
Sharpe Ratio*	28.1%	28.1%	28.1%	28.2%

* assumes Rf = 3%

GEMS FT2 Monthly Logreturn (10k scenario, 50yrs)				
	large	mid	small	aggressive
mean (annual)	7.2%	7.5%	7.6%	8.3%
st.dev (annual)	15.2%	16.1%	17.7%	21.6%
skew	-1.25	-0.81	-1.25	-0.81
kurtosis	8.29	5.79	7.32	5.14
Sharpe Ratio*	27.9%	28.2%	25.9%	24.8%

* assumes Rf = 3%

Historical Monthly Logreturn (1978-2020)				
	large	mid	small	nasdaq
mean (annual)	11.2%	11.9%	11.6%	10.8%
st.dev (annual)	15.2%	18.2%	19.9%	21.5%
skew	-0.88	-1.18	-1.18	-0.94
kurtosis	6.00	7.84	7.51	6.04
Sharpe Ratio*	34.1%	32.4%	27.9%	22.1%

* assumes Rf = 6%

Index Return Correlations: Realized vs. Historical

ACLI Scenarios (estimated)				
	Large	Mid	Small	Aggrsv.
Large	100%			
Mid	91%	100%		
Small	87%	97%	100%	
Aggrsv.	85%	87%	88%	100%

FT2 Baseline Scenarios				
	Large	Mid	Small	Aggrsv.
Large	100%			
Mid	88%	100%		
Small	87%	92%	100%	
Aggrsv.	81%	80%	80%	100%

Historical 1978-2020				
	Large	Mid	Small	Aggrsv.
Large	100%			
Mid	91%	100%		
Small	87%	98%	100%	
Aggrsv.	86%	89%	90%	100%

Table 10: Historic Correlations for Monthly Log Returns

	S&P500	MSCI-EAFE \$USD	U.S. SmallCap	Aggressive Equity	Money Market	U.S. ITGVT	U.S. LTCORP
S&P500	1						
MSCI-EAFE \$USD	0.560	1					
U.S. SmallCap	0.759	0.447	1				
Aggressive Equity	0.595	0.488	0.579	1			
Money Market	-0.046	-0.059	-0.053	0.002	1		
U.S. ITGVT	0.137	0.091	0.042	-0.064	0.113	1	
U.S. LTCORP	0.280	0.171	0.184	-0.005	0.026	0.822	1

- ACLI realized return correlations reasonably recover historical levels, and exceed those embedded in FT Baseline scenarios
- Both modeled and historical correlation between select indices is high, and well in excess of levels assumed in AIRG (see table to the left). This assumption would reflect a greater severity of systemic equity risk across all indices.

GWF Comparison vs. AAA Criteria: ACLI and FT2 Baseline

ACLI Large Cap							AAA Criteria (Avg. GWF)							ACLI / AAA Criteria						
	1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr
Min	0.49	0.17	0.16	0.19	0.21	0.54	Min	0.46	0.25	0.22	0.25	0.29	0.46	Min	1.07	0.70	0.72	0.73	0.72	1.19
0.5%	0.67	0.51	0.48	0.62	0.89	2.13	0.5%							0.5%						
1.0%	0.70	0.57	0.58	0.76	1.15	2.75	1.0%	0.70	0.58	0.60	0.79	1.15	2.82	1.0%	1.00	0.99	0.97	0.96	1.00	0.97
5.0%	0.82	0.78	0.90	1.36	2.23	6.17	5.0%	0.82	0.80	0.91	1.36	2.20	6.38	5.0%	1.00	0.99	0.98	1.00	1.01	0.97
10.0%	0.88	0.92	1.11	1.82	3.05	9.48	10.0%	0.88	0.93	1.12	1.81	3.08	9.78	10.0%	1.00	1.00	0.99	1.01	0.99	0.97
25.0%	0.98	1.17	1.54	2.81	5.11	18.81	25.0%	0.99	1.18	1.54	2.81	5.26	19.23	25.0%	1.00	1.00	1.00	1.00	0.97	0.98
50.0%	1.09	1.47	2.14	4.44	9.20	39.45	50.0%	1.09	1.48	2.15	4.47	9.23	39.98	50.0%	1.00	1.00	1.00	0.99	1.00	0.99
75.0%	1.19	1.82	2.89	6.92	15.79	79.76	75.0%	1.19	1.82	2.89	6.93	15.88	80.22	75.0%	1.00	1.00	1.00	1.00	0.99	0.99
90.0%	1.29	2.16	3.70	9.99	25.22	148.83	90.0%	1.28	2.15	3.71	10.09	25.20	147.92	90.0%	1.00	1.00	1.00	0.99	1.00	1.01
95.0%	1.34	2.40	4.33	12.50	33.40	209.78	95.0%	1.34	2.37	4.30	12.33	33.19	210.72	95.0%	1.00	1.01	1.00	1.01	1.01	1.00
99.0%	1.47	2.91	5.62	19.04	52.86	415.11	99.0%	1.45	2.82	5.64	18.18	53.74	397.23	99.0%	1.01	1.03	1.00	1.05	0.98	1.05
99.5%	1.51	3.12	6.26	22.26	66.31	512.63	99.5%							99.5%						
Max	1.83	4.70	10.85	43.13	168.19	1,514.65	Max	1.76	4.20	8.98	42.03	140.72	1,676.94	Max	1.04	1.12	1.21	1.03	1.20	0.90

GEMS FT2 Large Cap							AAA Criteria (Avg. GWF)							ACLI / AAA Criteria						
	1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr
Min	0.49	0.21	0.14	0.08	0.17	0.26	Min	0.46	0.25	0.22	0.25	0.29	0.46	Min	1.08	0.87	0.64	0.29	0.57	0.57
0.5%	0.66	0.47	0.42	0.50	0.69	1.45	0.5%							0.5%						
1.0%	0.70	0.55	0.53	0.63	0.93	2.07	1.0%	0.70	0.58	0.60	0.79	1.15	2.82	1.0%	1.00	0.95	0.88	0.79	0.81	0.73
5.0%	0.82	0.79	0.88	1.29	2.02	5.50	5.0%	0.82	0.80	0.91	1.36	2.20	6.38	5.0%	1.00	1.00	0.96	0.95	0.92	0.86
10.0%	0.88	0.92	1.11	1.74	2.93	8.83	10.0%	0.88	0.93	1.12	1.81	3.08	9.78	10.0%	1.00	0.99	0.99	0.96	0.95	0.90
25.0%	0.99	1.18	1.55	2.80	5.17	18.47	25.0%	0.99	1.18	1.54	2.81	5.26	19.23	25.0%	1.00	1.01	1.01	1.00	0.98	0.96
50.0%	1.10	1.49	2.17	4.48	9.28	39.71	50.0%	1.09	1.48	2.15	4.47	9.23	39.98	50.0%	1.01	1.01	1.01	1.00	1.01	0.99
75.0%	1.20	1.83	2.92	6.96	15.89	80.47	75.0%	1.19	1.82	2.89	6.93	15.88	80.22	75.0%	1.01	1.01	1.01	1.00	1.00	1.00
90.0%	1.30	2.17	3.76	9.97	25.08	148.39	90.0%	1.28	2.15	3.71	10.09	25.20	147.92	90.0%	1.01	1.01	1.01	0.99	1.00	1.00
95.0%	1.36	2.39	4.38	12.31	32.53	207.89	95.0%	1.34	2.37	4.30	12.33	33.19	210.72	95.0%	1.01	1.01	1.02	1.00	0.98	0.99
99.0%	1.47	2.83	5.69	17.54	50.60	413.34	99.0%	1.45	2.82	5.64	18.18	53.74	397.23	99.0%	1.01	1.00	1.01	0.96	0.94	1.04
99.5%	1.52	2.99	6.39	19.81	59.40	504.06	99.5%							99.5%						
Max	1.82	4.29	9.32	38.28	120.07	2,292.47	Max	1.76	4.20	8.98	42.03	140.72	1,676.94	Max	1.03	1.02	1.04	0.91	0.85	1.37

GWF Comparison vs. FT2 Baseline: Large and Mid Cap

Revised ACLI							FT2							Revised ACLI / FT2						
Large Cap							Large Cap							Large Cap						
	1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr
Min	0.49	0.17	0.16	0.19	0.21	0.54	Min	0.49	0.21	0.14	0.08	0.17	0.26	Min	0.99	0.80	1.14	2.47	1.26	2.09
0.5%	0.67	0.51	0.48	0.62	0.89	2.13	0.5%	0.66	0.47	0.42	0.50	0.69	1.45	0.5%	1.02	1.09	1.14	1.24	1.29	1.47
1.0%	0.70	0.57	0.58	0.76	1.15	2.75	1.0%	0.70	0.55	0.53	0.63	0.93	2.07	1.0%	1.00	1.04	1.10	1.21	1.24	1.33
5.0%	0.82	0.78	0.90	1.36	2.23	6.17	5.0%	0.82	0.79	0.88	1.29	2.02	5.50	5.0%	1.00	0.99	1.02	1.06	1.10	1.12
10.0%	0.88	0.92	1.11	1.82	3.05	9.48	10.0%	0.88	0.92	1.11	1.74	2.93	8.83	10.0%	1.00	1.00	1.00	1.05	1.04	1.07
25.0%	0.98	1.17	1.54	2.81	5.11	18.81	25.0%	0.99	1.18	1.55	2.80	5.17	18.47	25.0%	0.99	0.99	0.99	1.00	0.99	1.02
50.0%	1.09	1.47	2.14	4.44	9.20	39.45	50.0%	1.10	1.49	2.17	4.48	9.28	39.71	50.0%	0.99	0.99	0.98	0.99	0.99	0.99
75.0%	1.19	1.82	2.89	6.92	15.79	79.76	75.0%	1.20	1.83	2.92	6.96	15.89	80.47	75.0%	0.99	0.99	0.99	0.99	0.99	0.99
90.0%	1.29	2.16	3.70	9.99	25.22	148.83	90.0%	1.30	2.17	3.76	9.97	25.08	148.39	90.0%	0.99	1.00	0.98	1.00	1.01	1.00
95.0%	1.34	2.40	4.33	12.50	33.40	209.78	95.0%	1.36	2.39	4.38	12.31	32.53	207.89	95.0%	0.99	1.00	0.99	1.02	1.03	1.01
99.0%	1.47	2.91	5.62	19.04	52.86	415.11	99.0%	1.47	2.83	5.69	17.54	50.60	413.34	99.0%	1.00	1.03	0.99	1.09	1.04	1.00
99.5%	1.51	3.12	6.26	22.26	66.31	512.63	99.5%	1.52	2.99	6.39	19.81	59.40	504.06	99.5%	0.99	1.04	0.98	1.12	1.12	1.02
Max	1.83	4.70	10.85	43.13	168.19	1,514.65	Max	1.82	4.29	9.32	38.28	120.07	2,292.47	Max	1.01	1.10	1.16	1.13	1.40	0.66
Mid Cap							Mid Cap							Mid Cap						
	1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr
Min	0.43	0.20	0.13	0.16	0.22	0.56	Min	0.53	0.30	0.20	0.12	0.09	0.19	Min	0.81	0.67	0.66	1.27	2.46	2.88
0.5%	0.59	0.47	0.45	0.60	0.96	2.25	0.5%	0.66	0.51	0.47	0.54	0.75	1.58	0.5%	0.90	0.93	0.96	1.12	1.28	1.43
1.0%	0.65	0.55	0.55	0.78	1.20	3.15	1.0%	0.71	0.57	0.57	0.68	0.97	2.34	1.0%	0.92	0.95	0.97	1.15	1.24	1.35
5.0%	0.79	0.77	0.89	1.45	2.42	8.06	5.0%	0.82	0.78	0.88	1.27	2.08	5.91	5.0%	0.96	0.98	1.01	1.14	1.16	1.36
10.0%	0.86	0.90	1.13	1.94	3.58	12.70	10.0%	0.87	0.91	1.08	1.75	3.01	9.32	10.0%	0.98	0.99	1.04	1.11	1.19	1.36
25.0%	0.98	1.19	1.62	3.19	6.28	26.97	25.0%	0.98	1.16	1.53	2.82	5.41	20.27	25.0%	1.00	1.03	1.06	1.13	1.16	1.33
50.0%	1.11	1.55	2.35	5.29	11.95	60.44	50.0%	1.09	1.49	2.19	4.66	10.01	45.25	50.0%	1.01	1.04	1.07	1.14	1.19	1.34
75.0%	1.23	1.95	3.26	8.53	21.37	131.06	75.0%	1.21	1.88	3.06	7.43	17.70	96.94	75.0%	1.01	1.04	1.06	1.15	1.21	1.35
90.0%	1.33	2.36	4.26	12.86	35.90	253.99	90.0%	1.32	2.29	4.04	11.14	29.41	184.11	90.0%	1.01	1.03	1.05	1.15	1.22	1.38
95.0%	1.38	2.63	5.01	16.24	47.87	379.55	95.0%	1.38	2.56	4.75	14.16	39.00	271.15	95.0%	1.00	1.03	1.05	1.15	1.23	1.40
99.0%	1.50	3.20	6.74	25.05	82.19	774.76	99.0%	1.52	3.11	6.58	21.35	64.22	547.74	99.0%	0.99	1.03	1.02	1.17	1.28	1.41
99.5%	1.55	3.41	7.23	29.42	100.00	996.64	99.5%	1.57	3.27	7.08	24.13	76.76	745.84	99.5%	0.99	1.04	1.02	1.22	1.30	1.34
Max	1.86	4.93	12.60	58.24	352.44	2,777.67	Max	1.88	4.36	10.50	60.24	168.30	1,839.70	Max	0.99	1.13	1.20	0.97	2.09	1.51

GWF Comparison vs. FT2 Baseline: Small Cap and Aggressive

Revised ACLI							FT2							Revised ACLI / FT2						
Small Cap							Small Cap							Small Cap						
	1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr
Min	0.39	0.15	0.10	0.12	0.21	0.39	Min	0.45	0.16	0.12	0.07	0.07	0.16	Min	0.86	0.95	0.86	1.82	3.11	2.41
0.5%	0.57	0.41	0.40	0.53	0.80	1.90	0.5%	0.61	0.42	0.38	0.38	0.56	1.02	0.5%	0.93	0.98	1.05	1.38	1.43	1.87
1.0%	0.62	0.49	0.49	0.70	1.12	2.85	1.0%	0.66	0.52	0.48	0.50	0.72	1.54	1.0%	0.94	0.93	1.02	1.41	1.55	1.85
5.0%	0.76	0.73	0.85	1.39	2.40	8.13	5.0%	0.79	0.72	0.79	1.13	1.67	4.63	5.0%	0.97	1.00	1.07	1.23	1.44	1.76
10.0%	0.84	0.87	1.09	1.92	3.54	13.60	10.0%	0.85	0.87	1.02	1.58	2.63	8.09	10.0%	0.99	1.00	1.07	1.21	1.35	1.68
25.0%	0.97	1.19	1.63	3.30	6.78	30.89	25.0%	0.97	1.15	1.51	2.72	5.14	19.31	25.0%	1.00	1.04	1.08	1.21	1.32	1.60
50.0%	1.11	1.59	2.46	5.86	13.84	78.25	50.0%	1.10	1.51	2.23	4.71	10.22	46.50	50.0%	1.01	1.05	1.10	1.24	1.35	1.68
75.0%	1.25	2.06	3.57	9.99	26.65	184.34	75.0%	1.23	1.94	3.18	7.90	19.41	108.70	75.0%	1.02	1.07	1.13	1.26	1.37	1.70
90.0%	1.36	2.56	4.82	15.81	48.08	397.94	90.0%	1.34	2.36	4.28	12.30	32.48	222.35	90.0%	1.02	1.08	1.13	1.29	1.48	1.79
95.0%	1.43	2.89	5.82	20.92	66.09	609.89	95.0%	1.41	2.66	5.11	15.62	43.45	324.38	95.0%	1.02	1.09	1.14	1.34	1.52	1.88
99.0%	1.57	3.57	7.99	33.97	118.70	1,352.69	99.0%	1.54	3.30	6.96	23.83	76.17	713.21	99.0%	1.02	1.08	1.15	1.43	1.56	1.90
99.5%	1.63	3.84	8.84	39.59	140.37	1,740.91	99.5%	1.58	3.52	7.61	27.12	90.62	936.46	99.5%	1.03	1.09	1.16	1.46	1.55	1.86
Max	1.91	5.57	15.56	94.36	680.18	5,728.16	Max	1.84	5.99	15.46	56.38	183.63	3,135.58	Max	1.04	0.93	1.01	1.67	3.70	1.83
Aggressive							Aggressive							Aggressive						
	1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr
Min	0.37	0.07	0.04	0.04	0.02	0.01	Min	0.42	0.24	0.12	0.05	0.06	0.10	Min	0.88	0.29	0.31	0.81	0.31	0.05
0.5%	0.56	0.31	0.24	0.28	0.37	0.77	0.5%	0.59	0.39	0.33	0.33	0.44	0.88	0.5%	0.94	0.80	0.74	0.85	0.86	0.88
1.0%	0.60	0.38	0.33	0.40	0.56	1.32	1.0%	0.63	0.45	0.41	0.45	0.62	1.31	1.0%	0.94	0.83	0.79	0.90	0.90	1.00
5.0%	0.74	0.63	0.68	1.03	1.70	5.34	5.0%	0.76	0.66	0.72	0.99	1.59	4.48	5.0%	0.98	0.94	0.95	1.04	1.07	1.19
10.0%	0.82	0.81	0.96	1.65	2.92	10.73	10.0%	0.82	0.81	0.95	1.50	2.54	8.36	10.0%	1.00	1.00	1.02	1.10	1.15	1.28
25.0%	0.96	1.18	1.61	3.30	6.91	31.97	25.0%	0.95	1.12	1.48	2.81	5.51	22.91	25.0%	1.01	1.05	1.09	1.17	1.25	1.40
50.0%	1.11	1.65	2.66	6.79	16.57	101.05	50.0%	1.11	1.56	2.39	5.49	12.74	67.17	50.0%	1.01	1.05	1.11	1.24	1.30	1.50
75.0%	1.27	2.22	4.10	12.80	37.38	303.97	75.0%	1.27	2.13	3.77	10.49	28.50	191.25	75.0%	1.00	1.04	1.09	1.22	1.31	1.59
90.0%	1.42	2.83	5.82	21.68	73.93	741.62	90.0%	1.43	2.80	5.55	17.95	56.55	470.39	90.0%	1.00	1.01	1.05	1.21	1.31	1.58
95.0%	1.51	3.26	7.22	29.39	107.63	1,237.20	95.0%	1.52	3.26	6.88	24.71	80.40	808.50	95.0%	0.99	1.00	1.05	1.19	1.34	1.53
99.0%	1.70	4.40	10.52	53.22	215.88	3,004.52	99.0%	1.71	4.33	10.21	43.81	164.57	2,022.47	99.0%	1.00	1.02	1.03	1.21	1.31	1.49
99.5%	1.83	4.80	12.01	68.58	271.59	3,958.46	99.5%	1.77	4.71	11.99	51.65	206.30	2,855.67	99.5%	1.03	1.02	1.00	1.33	1.32	1.39
Max	2.62	9.91	24.87	158.33	1,000.18	20,311.70	Max	2.24	7.32	22.45	120.23	540.32	22,014.52	Max	1.17	1.35	1.11	1.32	1.85	0.92

GWF Comparison vs. FT1 Run 6: Large and Mid Cap

Revised ACLI							FT1 Run 6							Revised ACLI / FT1 Run 6						
Large Cap							Large Cap							Large Cap						
	1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr
Min	0.49	0.17	0.16	0.19	0.21	0.54	Min	0.43	0.14	0.13	0.31	0.23	0.54	Min	1.12	1.24	1.23	0.60	0.92	1.01
0.5%	0.67	0.51	0.48	0.62	0.89	2.13	0.5%	0.67	0.50	0.51	0.66	0.95	2.22	0.5%	1.00	1.04	0.95	0.94	0.93	0.96
1.0%	0.70	0.57	0.58	0.76	1.15	2.75	1.0%	0.71	0.57	0.59	0.79	1.20	2.97	1.0%	0.99	0.99	1.00	0.96	0.96	0.92
5.0%	0.82	0.78	0.90	1.36	2.23	6.17	5.0%	0.83	0.80	0.92	1.41	2.32	6.91	5.0%	0.99	0.98	0.97	0.97	0.96	0.89
10.0%	0.88	0.92	1.11	1.82	3.05	9.48	10.0%	0.89	0.94	1.14	1.85	3.20	10.25	10.0%	0.99	0.98	0.97	0.99	0.95	0.92
25.0%	0.98	1.17	1.54	2.81	5.11	18.81	25.0%	0.99	1.19	1.58	2.90	5.41	19.96	25.0%	0.99	0.98	0.98	0.97	0.94	0.94
50.0%	1.09	1.47	2.14	4.44	9.20	39.45	50.0%	1.09	1.50	2.17	4.55	9.49	41.20	50.0%	1.00	0.98	0.99	0.97	0.97	0.96
75.0%	1.19	1.82	2.89	6.92	15.79	79.76	75.0%	1.19	1.82	2.90	6.83	15.89	80.13	75.0%	1.00	1.00	1.00	1.01	0.99	1.00
90.0%	1.29	2.16	3.70	9.99	25.22	148.83	90.0%	1.28	2.15	3.66	9.85	24.35	144.23	90.0%	1.01	1.01	1.01	1.01	1.04	1.03
95.0%	1.34	2.40	4.33	12.50	33.40	209.78	95.0%	1.33	2.34	4.22	12.01	31.70	198.49	95.0%	1.01	1.03	1.03	1.04	1.05	1.06
99.0%	1.47	2.91	5.62	19.04	52.86	415.11	99.0%	1.43	2.75	5.37	17.19	52.06	349.38	99.0%	1.03	1.06	1.05	1.11	1.02	1.19
99.5%	1.51	3.12	6.26	22.26	66.31	512.63	99.5%	1.47	2.94	5.97	19.75	61.17	455.82	99.5%	1.03	1.06	1.05	1.13	1.08	1.12
Max	1.83	4.70	10.85	43.13	168.19	1,514.65	Max	1.79	3.97	9.38	33.26	135.23	1,089.03	Max	1.02	1.18	1.16	1.30	1.24	1.39
Mid Cap							Mid Cap							Mid Cap						
	1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr
Min	0.43	0.20	0.13	0.16	0.22	0.56	Min	0.36	0.07	0.10	0.21	0.17	0.49	Min	1.18	2.72	1.35	0.74	1.26	1.12
0.5%	0.59	0.47	0.45	0.60	0.96	2.25	0.5%	0.59	0.47	0.49	0.61	0.91	2.42	0.5%	1.00	1.00	0.93	0.99	1.05	0.93
1.0%	0.65	0.55	0.55	0.78	1.20	3.15	1.0%	0.65	0.53	0.57	0.77	1.18	3.40	1.0%	1.00	1.03	0.97	1.01	1.02	0.93
5.0%	0.79	0.77	0.89	1.45	2.42	8.06	5.0%	0.80	0.77	0.90	1.47	2.56	8.37	5.0%	0.98	0.99	1.00	0.99	0.94	0.96
10.0%	0.86	0.90	1.13	1.94	3.58	12.70	10.0%	0.87	0.93	1.15	2.00	3.64	13.33	10.0%	0.99	0.97	0.98	0.97	0.98	0.95
25.0%	0.98	1.19	1.62	3.19	6.28	26.97	25.0%	0.99	1.22	1.66	3.25	6.58	28.51	25.0%	0.99	0.98	0.98	0.98	0.95	0.95
50.0%	1.11	1.55	2.35	5.29	11.95	60.44	50.0%	1.11	1.56	2.37	5.39	12.23	63.08	50.0%	1.00	0.99	0.99	0.98	0.98	0.96
75.0%	1.23	1.95	3.26	8.53	21.37	131.06	75.0%	1.22	1.95	3.26	8.62	21.73	132.37	75.0%	1.00	1.00	1.00	0.99	0.98	0.99
90.0%	1.33	2.36	4.26	12.86	35.90	253.99	90.0%	1.32	2.33	4.26	12.57	35.30	256.01	90.0%	1.01	1.01	1.00	1.02	1.02	0.99
95.0%	1.38	2.63	5.01	16.24	47.87	379.55	95.0%	1.38	2.60	4.95	15.66	46.52	369.93	95.0%	1.00	1.01	1.01	1.04	1.03	1.03
99.0%	1.50	3.20	6.74	25.05	82.19	774.76	99.0%	1.49	3.09	6.36	23.02	77.92	752.74	99.0%	1.01	1.04	1.06	1.09	1.05	1.03
99.5%	1.55	3.41	7.23	29.42	100.00	996.64	99.5%	1.53	3.40	6.98	26.70	90.74	945.65	99.5%	1.01	1.00	1.04	1.10	1.10	1.05
Max	1.86	4.93	12.60	58.24	352.44	2,777.67	Max	1.81	4.38	9.80	44.43	281.03	3,564.58	Max	1.03	1.13	1.29	1.31	1.25	0.78

GWF Comparison vs. FT1 Run 6: Small Cap and Aggressive

Revised ACLI							FT1 Run 6							Revised ACLI / FT1 Run 6						
Small Cap							Small Cap							Small Cap						
	1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr
Min	0.39	0.15	0.10	0.12	0.21	0.39	Min	0.30	0.04	0.05	0.11	0.16	0.29	Min	1.32	3.53	2.06	1.08	1.32	1.34
0.5%	0.57	0.41	0.40	0.53	0.80	1.90	0.5%	0.56	0.38	0.39	0.47	0.72	1.87	0.5%	1.02	1.08	1.02	1.13	1.11	1.02
1.0%	0.62	0.49	0.49	0.70	1.12	2.85	1.0%	0.61	0.47	0.46	0.65	1.03	2.82	1.0%	1.01	1.04	1.08	1.09	1.08	1.01
5.0%	0.76	0.73	0.85	1.39	2.40	8.13	5.0%	0.77	0.73	0.85	1.37	2.43	8.05	5.0%	1.00	1.00	1.00	1.02	0.99	1.01
10.0%	0.84	0.87	1.09	1.92	3.54	13.60	10.0%	0.85	0.90	1.12	1.93	3.57	13.73	10.0%	0.99	0.97	0.97	0.99	0.99	0.99
25.0%	0.97	1.19	1.63	3.30	6.78	30.89	25.0%	0.98	1.22	1.68	3.36	7.01	31.57	25.0%	0.99	0.98	0.97	0.98	0.97	0.98
50.0%	1.11	1.59	2.46	5.86	13.84	78.25	50.0%	1.12	1.61	2.48	5.86	13.85	77.20	50.0%	1.00	0.99	0.99	1.00	1.00	1.01
75.0%	1.25	2.06	3.57	9.99	26.65	184.34	75.0%	1.24	2.03	3.51	9.72	25.82	171.67	75.0%	1.01	1.01	1.02	1.03	1.03	1.07
90.0%	1.36	2.56	4.82	15.81	48.08	397.94	90.0%	1.35	2.47	4.61	14.55	43.08	346.14	90.0%	1.01	1.04	1.05	1.09	1.12	1.15
95.0%	1.43	2.89	5.82	20.92	66.09	609.89	95.0%	1.41	2.73	5.41	18.50	58.08	515.80	95.0%	1.01	1.06	1.08	1.13	1.14	1.18
99.0%	1.57	3.57	7.99	33.97	118.70	1,352.69	99.0%	1.53	3.40	7.06	27.78	99.82	1,082.56	99.0%	1.02	1.05	1.13	1.22	1.19	1.25
99.5%	1.63	3.84	8.84	39.59	140.37	1,740.91	99.5%	1.59	3.73	7.76	32.36	118.72	1,473.17	99.5%	1.03	1.03	1.14	1.22	1.18	1.18
Max	1.91	5.57	15.56	94.36	680.18	5,728.16	Max	1.93	5.23	12.00	66.21	449.09	4,322.95	Max	0.99	1.07	1.30	1.43	1.51	1.33
Aggressive							Aggressive							Aggressive						
	1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr		1 Yr	5 Yr	10 Yr	20 Yr	30 Yr	50 Yr
Min	0.37	0.07	0.04	0.04	0.02	0.01	Min	0.27	0.04	0.04	0.04	0.02	0.06	Min	1.36	1.64	0.93	0.99	1.05	0.08
0.5%	0.56	0.31	0.24	0.28	0.37	0.77	0.5%	0.54	0.28	0.22	0.21	0.31	0.57	0.5%	1.03	1.12	1.10	1.34	1.19	1.35
1.0%	0.60	0.38	0.33	0.40	0.56	1.32	1.0%	0.60	0.35	0.30	0.32	0.43	1.01	1.0%	0.99	1.08	1.09	1.27	1.30	1.31
5.0%	0.74	0.63	0.68	1.03	1.70	5.34	5.0%	0.74	0.61	0.63	0.93	1.58	4.82	5.0%	1.00	1.03	1.07	1.11	1.07	1.11
10.0%	0.82	0.81	0.96	1.65	2.92	10.73	10.0%	0.82	0.79	0.93	1.50	2.73	10.29	10.0%	1.00	1.02	1.04	1.10	1.07	1.04
25.0%	0.96	1.18	1.61	3.30	6.91	31.97	25.0%	0.97	1.17	1.59	3.22	6.72	32.53	25.0%	0.99	1.01	1.01	1.03	1.03	0.98
50.0%	1.11	1.65	2.66	6.79	16.57	101.05	50.0%	1.12	1.67	2.69	6.83	16.71	103.80	50.0%	1.00	0.99	0.99	0.99	0.99	0.97
75.0%	1.27	2.22	4.10	12.80	37.38	303.97	75.0%	1.27	2.29	4.26	13.29	39.46	324.43	75.0%	1.00	0.97	0.96	0.96	0.95	0.94
90.0%	1.42	2.83	5.82	21.68	73.93	741.62	90.0%	1.41	2.92	6.24	23.51	79.89	862.78	90.0%	1.00	0.97	0.93	0.92	0.93	0.86
95.0%	1.51	3.26	7.22	29.39	107.63	1,237.20	95.0%	1.50	3.42	7.59	32.14	120.89	1,449.71	95.0%	1.01	0.95	0.95	0.91	0.89	0.85
99.0%	1.70	4.40	10.52	53.22	215.88	3,004.52	99.0%	1.67	4.37	11.21	55.41	252.27	3,687.17	99.0%	1.02	1.01	0.94	0.96	0.86	0.81
99.5%	1.83	4.80	12.01	68.58	271.59	3,958.46	99.5%	1.75	4.68	12.92	68.95	320.91	4,996.51	99.5%	1.04	1.03	0.93	0.99	0.85	0.79
Max	2.62	9.91	24.87	158.33	1,000.18	20,311.70	Max	2.25	9.52	23.82	219.21	1,104.92	24,015.57	Max	1.17	1.04	1.04	0.72	0.91	0.85

Appendix

Appendix A: Calibration and Parameters

	Large	Mid	Small	Aggressive
mu0	0.0723	0.0408	0.0556	0.1233
mu1	0.5744	2.0910	1.5311	-0.2500
alpha	0.0196	0.0307	0.0308	0.0191
beta	0.9519	1.1310	0.9408	0.4800
sigma	0.1254	0.1409	0.1409	0.1587
mu_jump	-0.1500	-0.2184	-0.2355	-0.1990
sigma_jump	0.0584	0.0476	0.0480	0.0678
lambda_jump	4.9442	4.6774	3.8906	3.6347
correlation	-0.4563	-0.6661	-0.6275	-0.3105
initial vol	0.1435	0.1648	0.1809	0.1997
theta	0.0206	0.0272	0.0327	0.0399
Avg. Jump Freq.	0.1019	0.1270	0.1273	0.1449
% Jump Variance	11.4%	18.9%	18.3%	13.8%
MLE Sum LL	914	838	788	756
MLE Avg. LL	1.8	1.7	1.6	1.5

Equity return assumed to be independent of short rate, i.e. follows constant mean return, implying the short rate as part of total return is effectively set to zero.

Model parameters calibrated to monthly historical data using generalized MLE:

- Large Cap: S&P total return index from 8/1978 to 12/2020, based on data provided by Link Richardson from a combination of sources
- Mid Cap: Willshire Mid Cap from 8/1978 to 12/2020, sourced from FRED
- Small Cap: Willshire Small Cap from 8/1978 to 12/2020, sourced from FRED
- Aggressive: NASDAQ Composite from 3/1971 to 12/2020, sourced from FRED

Adjustments / Targeting

- MLE calibration included a 12% cap on jump frequency, to better align with historical correlations. Note that this frequency was subject to variance adjustment below.
- Large Cap drift coefficient, mu0, was adjusted by -.0383 to align with 8.75% average target proposed by NAIC in the original AIRG specification
- Mid, Small, and Aggressive alpha (variance target) parameter was adjusted to align with historical relationship to Large Cap returns
- Mid, Small and Aggressive, had mu0 adjusted to align with the Sharpe Ratio of 28.1% implied in the Large Cap scenarios, and assuming a risk-free rate of 3%.

Appendix B: Constructing the Correlation Matrix

	Large Var	Large Ret	Mid Var	Mid Ret	Small Var	Small Ret	Aggr. Var	Aggr. Ret
Large Var	1.0000							
Large Ret	-0.4563	1.0000						
Mid Var	0.8172	-0.5429	1.0000					
Mid Ret	-0.4995	0.9405	-0.6661	1.0000				
Small Var	0.7667	-0.4927	0.9642	-0.6193	1.0000			
Small Ret	-0.4840	0.9004	-0.6505	0.9816	-0.6275	1.0000		
Aggr. Var	0.7889	-0.3309	0.8026	-0.3917	0.7996	-0.3890	1.0000	
Aggr. Ret	-0.3857	0.8931	-0.4965	0.9196	-0.4713	0.9276	-0.3105	1.0000

Correlation matrix based on historical data from 8/1978 to 12/2020:

- Variance/Return, or skew, correlation for each individual index based on each specific MLE
- Cross index Variance/Variance explicitly calculated using filtered historical Heston variance based on calibrated parameters
- Cross-skew correlation computed based on same filtered variances as above, but scaled to align with MLE-based correlation coefficients
- Cross index Return/Return explicitly calculated based on historical data, and subsequently adjusted by +3% for all coefficients except Mid/Small to adjust for the noise from the jump process.

Appendix C: Notes on Proposed Calibration

- ACLI proposal calibrated to the history by using Maximum Likelihood Estimation (MLE) with additional adjustments to make sure appropriate relationship across model indices.
- Equity returns do not reflect explicit linkage to short rates, and the returns/volatilities have been adjusted to reflect reasonable historical relationships. No additional adjustments are required.
- Modeled ACLI results are based on externally implemented GEMS proxy model based on publicly disclosed model details. Proposed parameters must be run directly through GEMS software to confirm intended outcomes and for possible minor refinements.