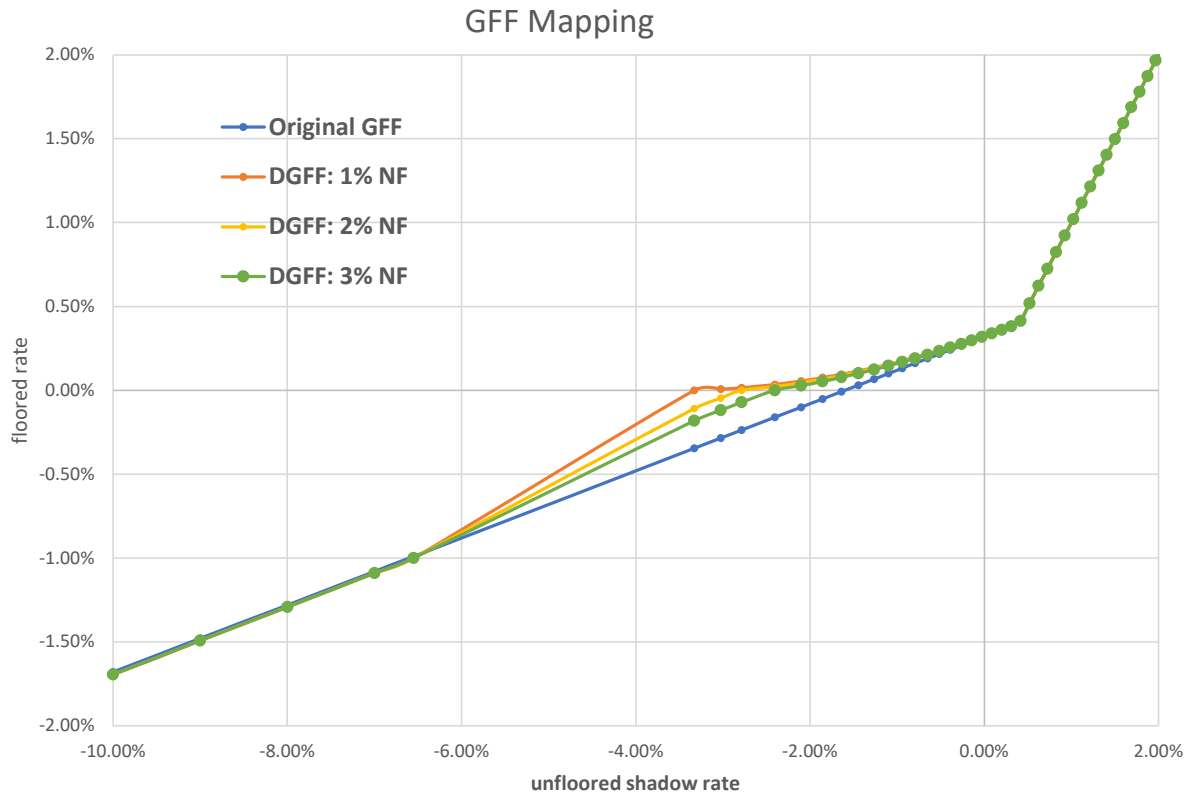


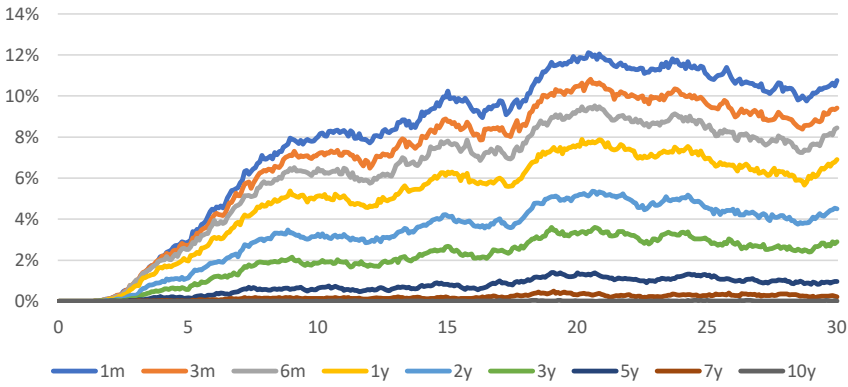
Dynamic GFF Alternatives: impact of flooring



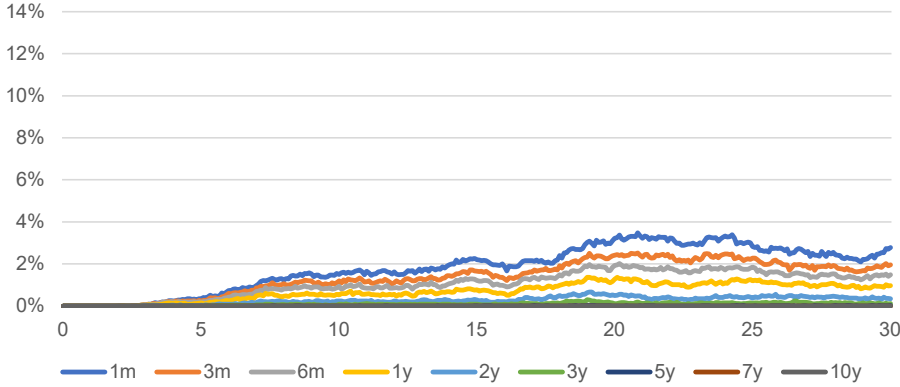
- Original GFF maps unfloored rate of -1.6% to 0%, effectively targeting 6-7% frequency of negative UST1
- Dynamic GFF allows for targeting of any desired frequency of negative UST1 by adjusting the unfloored rate level that maps to 0%
 - 1% frequency: unfloored rate of -3.33%
 - 2% frequency: unfloored rate of -2.79%
 - 3% frequency: unfloored rate of -2.40%
- Resulting flooring gets closer to original GFF as the desired frequency of negative UST1 is increased.

Baseline FT2 Scenarios

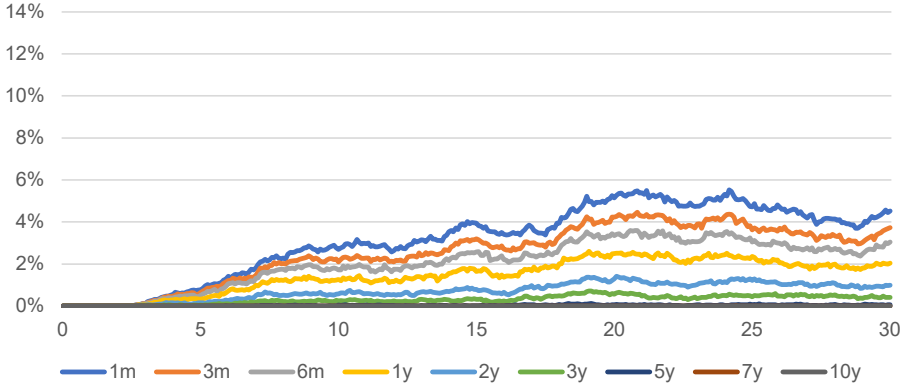
Original GFF



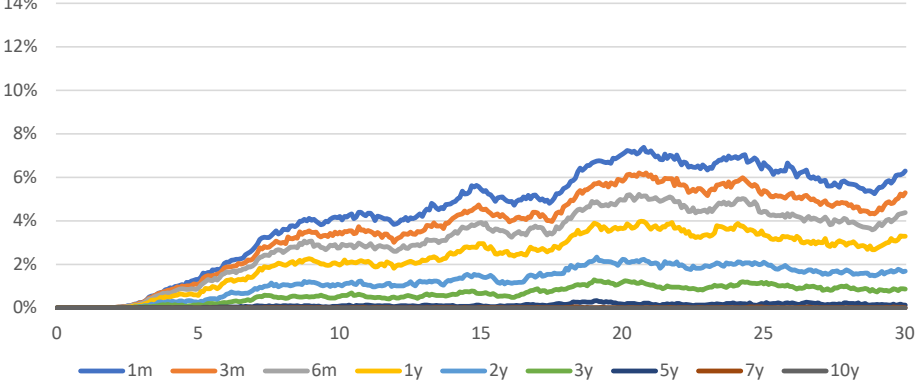
Dynamic GFF: 1% frequency of negative UST1



Dynamic GFF: 2% frequency of negative UST1

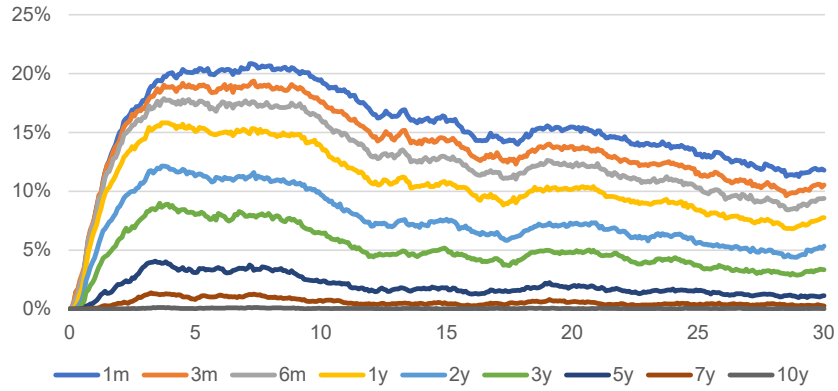


Dynamic GFF: 3% frequency of negative UST1

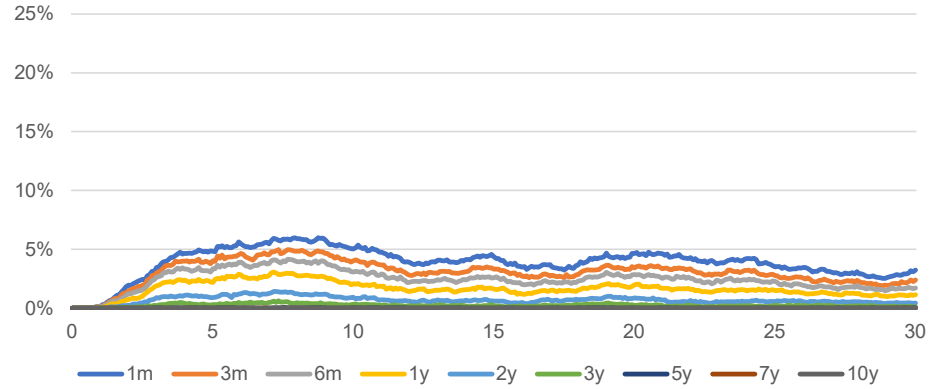


Low Rate FT2 Scenarios

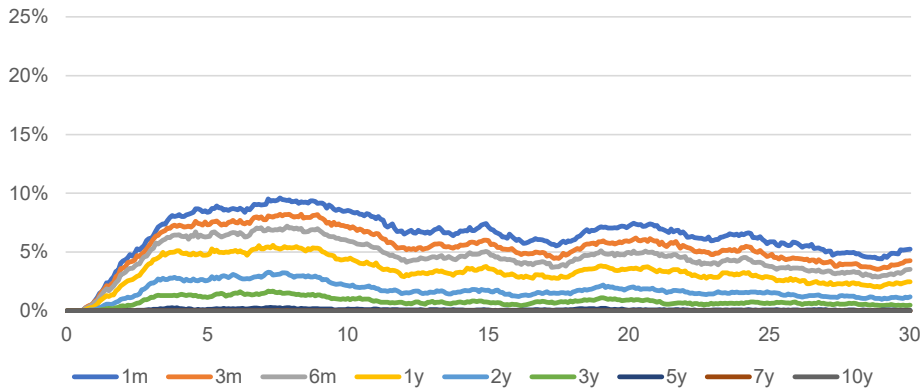
Original GFF



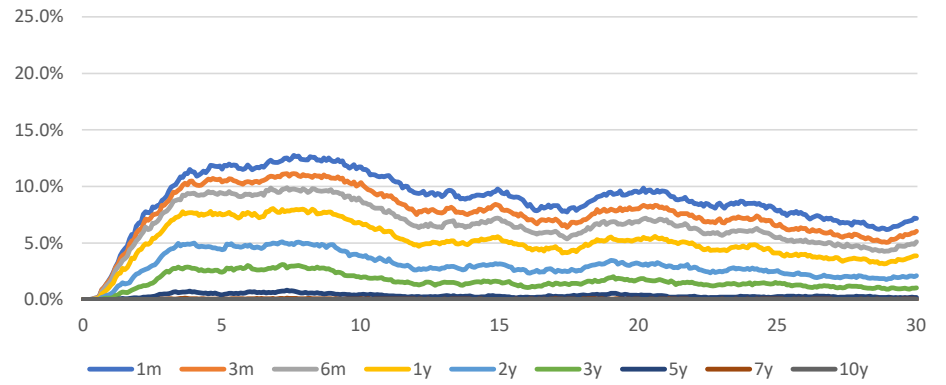
Dynamic GFF: 1% frequency of negative UST1



Dynamic GFF: 2% frequency of negative UST1



Dynamic GFF: 3% frequency of negative UST1



Low Tail Distribution in Steady State (80-100yrs of the projection)

Original GFF										Dynamic GFF: 2% frequency of negative UST1									
	1m	3m	6m	1y	2y	3y	5y	7y	10y		1m	3m	6m	1y	2y	3y	5y	7y	10y
min	-1.3%	-1.2%	-1.1%	-1.0%	-0.8%	-0.7%	-0.5%	-0.4%	-0.2%	min	-1.3%	-1.2%	-1.1%	-1.0%	-0.8%	-0.6%	-0.3%	-0.1%	0.0%
0.5%	-0.6%	-0.6%	-0.5%	-0.4%	-0.3%	-0.2%	-0.1%	0.1%	0.2%	0.5%	-0.4%	-0.4%	-0.3%	-0.2%	-0.1%	0.0%	0.1%	0.1%	0.2%
1%	-0.5%	-0.5%	-0.4%	-0.3%	-0.2%	-0.1%	0.0%	0.1%	0.3%	1%	-0.3%	-0.2%	-0.2%	-0.1%	0.0%	0.0%	0.1%	0.2%	0.3%
2%	-0.4%	-0.3%	-0.3%	-0.2%	-0.1%	0.0%	0.1%	0.2%	0.3%	2%	-0.2%	-0.1%	-0.1%	0.0%	0.0%	0.1%	0.2%	0.2%	0.3%
3%	-0.3%	-0.3%	-0.2%	-0.2%	-0.1%	0.0%	0.2%	0.3%	0.4%	3%	-0.1%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.4%
4%	-0.3%	-0.2%	-0.2%	-0.1%	0.0%	0.1%	0.2%	0.3%	0.6%	4%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.6%
5%	-0.2%	-0.2%	-0.1%	-0.1%	0.0%	0.1%	0.3%	0.4%	0.7%	5%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.4%	0.7%
6%	-0.2%	-0.1%	-0.1%	0.0%	0.1%	0.2%	0.3%	0.4%	0.9%	6%	0.0%	0.0%	0.1%	0.1%	0.1%	0.2%	0.3%	0.4%	0.9%
7%	-0.1%	-0.1%	0.0%	0.0%	0.1%	0.2%	0.3%	0.5%	1.1%	7%	0.0%	0.1%	0.1%	0.1%	0.2%	0.2%	0.3%	0.5%	1.1%
8%	-0.1%	0.0%	0.0%	0.1%	0.2%	0.2%	0.4%	0.7%	1.2%	8%	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	0.4%	0.7%	1.2%
9%	0.0%	0.0%	0.0%	0.1%	0.2%	0.3%	0.4%	0.8%	1.3%	9%	0.1%	0.1%	0.1%	0.2%	0.2%	0.3%	0.4%	0.8%	1.3%
10%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.5%	0.9%	1.4%	10%	0.1%	0.1%	0.1%	0.2%	0.2%	0.3%	0.5%	0.9%	1.4%

Dynamic GFF: 1% frequency of negative UST1										Dynamic GFF: 3% frequency of negative UST1									
	1m	3m	6m	1y	2y	3y	5y	7y	10y		1m	3m	6m	1y	2y	3y	5y	7y	10y
min	-1.3%	-1.2%	-1.1%	-1.0%	-0.8%	-0.6%	-0.3%	-0.1%	0.0%	min	-1.3%	-1.2%	-1.1%	-1.0%	-0.8%	-0.6%	-0.4%	-0.2%	0.0%
0.5%	-0.4%	-0.3%	-0.2%	-0.2%	0.0%	0.0%	0.1%	0.1%	0.2%	0.5%	-0.5%	-0.4%	-0.4%	-0.3%	-0.2%	-0.1%	0.0%	0.1%	0.2%
1%	-0.3%	-0.2%	-0.1%	-0.1%	0.0%	0.0%	0.1%	0.2%	0.3%	1%	-0.4%	-0.3%	-0.3%	-0.2%	-0.1%	0.0%	0.1%	0.2%	0.3%
2%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.1%	0.2%	0.2%	0.3%	2%	-0.2%	-0.2%	-0.1%	-0.1%	0.0%	0.1%	0.1%	0.2%	0.3%
3%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.4%	3%	-0.2%	-0.1%	-0.1%	0.0%	0.0%	0.1%	0.2%	0.3%	0.4%
4%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.2%	0.3%	0.6%	4%	-0.1%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.6%
5%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.4%	0.7%	5%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.4%	0.7%
6%	0.0%	0.0%	0.1%	0.1%	0.1%	0.2%	0.3%	0.4%	0.9%	6%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.4%	0.9%
7%	0.0%	0.1%	0.1%	0.1%	0.2%	0.2%	0.3%	0.5%	1.1%	7%	0.0%	0.0%	0.1%	0.1%	0.2%	0.2%	0.3%	0.5%	1.1%
8%	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	0.4%	0.7%	1.2%	8%	0.0%	0.1%	0.1%	0.1%	0.2%	0.2%	0.4%	0.7%	1.2%
9%	0.1%	0.1%	0.1%	0.2%	0.2%	0.3%	0.4%	0.8%	1.3%	9%	0.1%	0.1%	0.1%	0.1%	0.2%	0.3%	0.4%	0.8%	1.3%
10%	0.1%	0.1%	0.1%	0.2%	0.2%	0.3%	0.5%	0.9%	1.4%	10%	0.1%	0.1%	0.1%	0.2%	0.2%	0.3%	0.5%	0.9%	1.4%

Low Tail Distribution in Steady State (80-100yrs of the projection)

FT2 Baseline Scenarios				
# of scenarios out of 10,000 where 1yr Rate turns negative in the first 360 months				
	GFF	Dynamic GFF 1%	Dynamic GFF 2%	Dynamic GFF 3%
negative rates are observed	4,807	1,405	2,356	3,087
at least 12 negative rates	3,127	586	1,153	1,724
at least 24 negative rates	2,357	355	729	1,146
at least 36 negative rates	1,787	224	473	786
at least 60 negative rates	1,063	67	231	396
at least 120 negative rates	254	5	23	56
at least 240 negative rates	7	-	-	-

FT2 Low Rate Scenarios				
# of scenarios out of 10,000 where 1yr Rate turns negative in the first 360 months				
	GFF	Dynamic GFF 1%	Dynamic GFF 2%	Dynamic GFF 3%
negative rates are observed	7,526	2,941	4,390	5,496
at least 12 negative rates	5,619	1,411	2,511	3,459
at least 24 negative rates	4,514	835	1,711	2,494
at least 36 negative rates	3,698	512	1,186	1,887
at least 60 negative rates	2,459	218	568	1,006
at least 120 negative rates	784	21	90	210
at least 240 negative rates	30	-	-	3

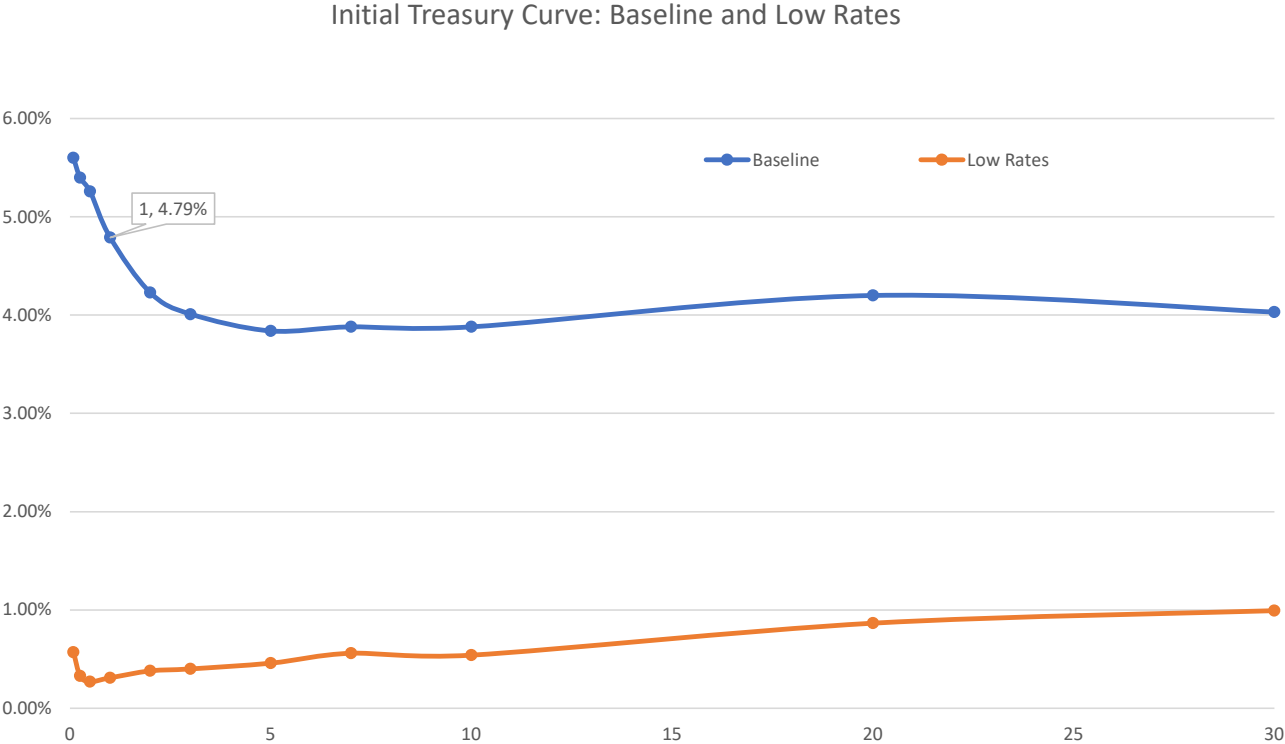
Original GFF results in significant proportion of scenarios where 1yr rate turns negative for extended period of time:

- 48% of Baseline scenarios produce 3% negative rates in the first 360 months of the projection
- 10% of Baseline scenarios produce 60+ months of negative rates in the first 360 months of the projection
- 24% of Low Rate scenarios produce 60+ months of negative rates in the first 360 months of the projection
- 7% of Low Rate scenarios produce 120+ months of negative rates in the first 360 months of the projection

Dynamic GFF targeting 1-3% of negative rates in the steady-state “cross-cut” distribution produces robust proportion of scenarios that exhibit negative rates. For instance, Dynamic GFF targeting 2% shows:

- 23% of Baseline scenarios and 44% of Low Rate scenarios with negative rates
- 2% of Baseline scenarios produce 60+ months of negative rates
- 6% of Low Rate scenarios produce 60+ months of negative rates, and ~1% of scenarios show 120+ months of negative rates

Initial UST Treasury Curves: FT2 Baseline and Low Rates



Tail Distribution of 1yr Spot Rate under FT2 GEMS Scenarios

percentile	Floored (GFF)	Unfloored
min	-0.99%	-6.55%
1%	-0.35%	-3.33%
2%	-0.24%	-2.79%
3%	-0.16%	-2.40%
4%	-0.10%	-2.11%
5%	-0.05%	-1.86%
6%	-0.01%	-1.64%
7%	0.03%	-1.45%
8%	0.07%	-1.27%
9%	0.10%	-1.10%
10%	0.13%	-0.94%

- Steady state distribution of 1yr Spot rate based on baseline FT2 GEMS scenarios, and years 80 to 100 of the projection.
- Unfloored/Shadow rates calculated by inverting the GFF formula to solve for the implied unfloored rates.
- Unfloored rates at given severity can be used directly to target the frequency of negative rates in the distribution.
- Example: to target 2% negative rate frequency in the steady state, set parameter $s_0 = -2.79\%$

Appendix: Formula for Dynamic GFF

The GFF approach can be extended and made more flexible by making the fraction parameter rate dependent and effectively replacing a constant m with $m(s)$ as a function of the unfloored/shadow rate.

$$rate(s) = \max(\kappa + m(s)(s - \kappa), s)$$

The dynamic GFF fraction parameter can be defined as follows:

$$m(s) = m_0 + \max(\min(s, \kappa) - s_0, 0) R_0 - \max(s_0 - \max(s, s_{min}), 0) R_{min}$$

where:

\bar{m} is the terminal fraction level that applies when $s = \kappa$

$m_0 = \frac{\kappa}{\kappa - s_0}$ is the fraction that ensures $rate(s_0) = 0$

$$R_0 = \frac{\bar{m} - m_0}{\kappa - s_0}$$

$m_{min} = \frac{\kappa - rate_{min}}{\kappa - s_{min}}$ is the fraction that ensures $rate(s_{min}) = rate_{min}$

$$R_{min} = \frac{m_0 - m_{min}}{s_0 - s_{min}}$$

Illustrative parameters for Dynamic GFF that ensure 1.5% negative 1yr Spot frequency in the steady state:

Initial slope/fraction: $\bar{m} = 2$ (original GFF parameter)

Threshold rate below which flooring is applied: $\kappa = 0.004$ (original GFF parameter)

Shadow rate that maps to 0% when floored to target frequency of negative rates: $s_0 = 0.0303$

Shadow rate that maps to the minimum 1yr spot in the steady state: $s_{min} = -0.0655$