Higher MRP

What is this example testing?

Regulators wanted to see the impact of increasing the MRP

Impact on Parameters

Baseline parameters

Model Parameters										Mean Reversion Spee		Long Term Levels		
CIR Process	Theta	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target	Calculatec	Target		Actual	Target
CIR 1	0.2716	5.6773	0.0181	-0.2586	5.3995	5.677311	11.35456	4.67%	4.67%	3.60	3.60	Overnight	2.25%	2.25%
CIR 2	0.0196	0.2520	0.0423	-0.0007	-0.0188	0.259034	0.511067	6.96%	6.96%	3.69	3.69	1-Year	2.50%	2.50%
CIR 3	0.0010	0.0000	0.0390	0.0010	-0.0595	0.055149	0.055164	3.33%	3.33%	16.80	16.80	20-Year	3.50%	3.50%

Time	Shift Function		
0	-0.1271	Diff	0.0%

Alternative parameters

Increasing long-term target levels by 100bps…

Model Parameters										Mean Reversion Spee		Long Term Levels		
CIR Process	Vega	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target	Calculatec	Target		Actual	Target
CIR 1	0.2716	5.6773	0.0181	-0.2585	5.3995	5.677311	11.35456	4.71%	4.71%	3.60	3.60	Overnight	3.25%	3.25%
CIR 2	0.0196	0.2520	0.0423	-0.0012	-0.0188	0.259034	0.511067	6.79%	6.79%	3.69	3.69	1-Year	3.50%	3.50%
CIR 3	0.0010	0.0000	0.0390	0.0017	-0.0595	0.055149	0.055164	4.46%	4.46%	16.80	16.80	20-Year	4.50%	4.50%

Time	Shift Function		
0	-0.1271	Diff	0.0%

Leads to a change in Target States…

Model Parameters										Mean Reversion Spee		Long Term Levels		
CIR Process	Vega	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target	Calculatec	Target		Actual	Target
CIR 1	0.2716	5.6773	0.0181	-0.2585	5.3995	5.677311	11.35456	4.71%	4.71%	3.60	3.60	Overnight	3.25%	3.25%
CIR 2	0.0196	0.2520	0.0423	-0.0012	-0.0188	0.259034	0.511067	6.79%	6.79%	3.69	3.69	1-Year	3.50%	3.50%
CIR 3	0.0010	0.0000	0.0390	0.0017	-0.0595	0.055149	0.055164	4.46%	4.46%	16.80	16.80	20-Year	4.50%	4.50%

Time	Shift Function		
0	-0.1271	Diff	0.0%

Which then leads to new Lambda0 parameters.

Model Parameters

CIR Process	Vega	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target
CIR 1	0.2716	5.6773	0.0181	-0.2585	5.3995	5.677311	11.35456	4.71%	4.71%
CIR 2	0.0196	0.2520	0.0423	-0.0012	-0.0188	0.259034	0.511067	6.79%	6.79%
CIR 3	0.0010	0.0000	0.0390	0.0017	-0.0595	0.055149	0.055164	4.46%	4.46%

Mean Reversion Spee

Calculatec	Target
3.60	3.60
3.69	3.69
16.80	16.80

Long Term Levels

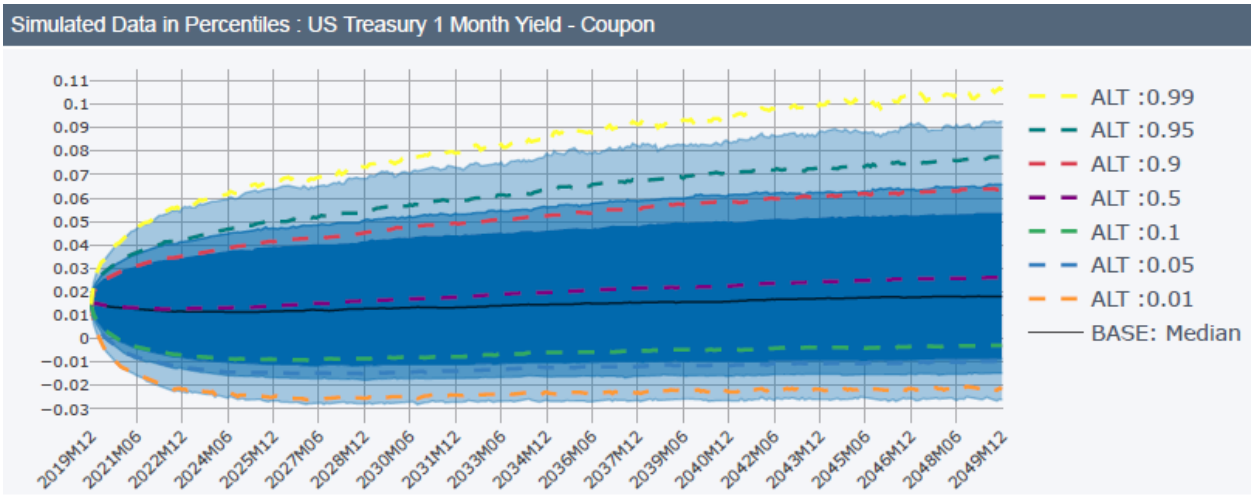
	Actual	Target
Overnight	3.25%	3.25%
1-Year	3.50%	3.50%
20-Year	4.50%	4.50%

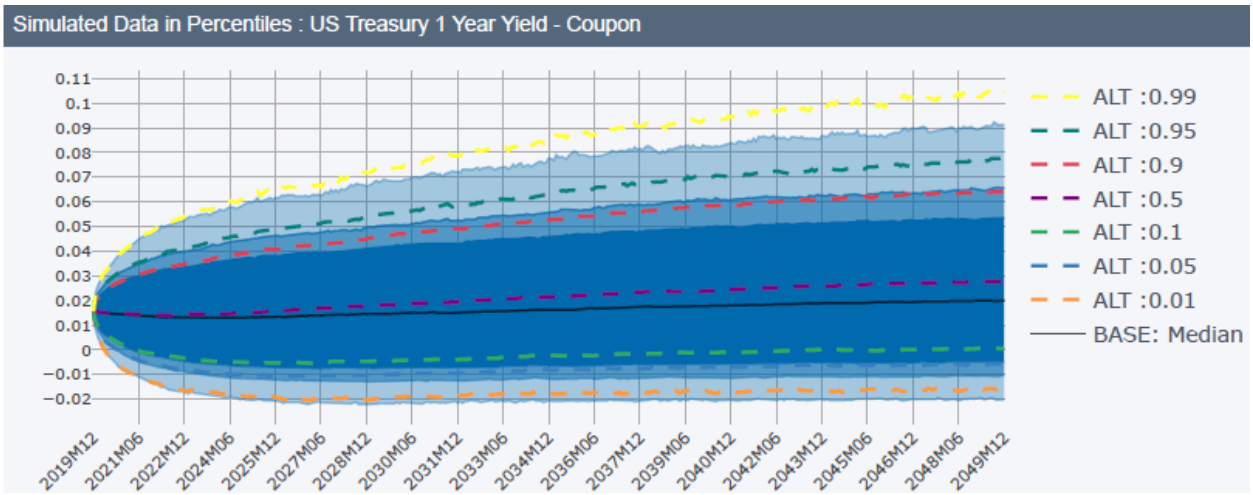
Time	Shift Function
0	-0.1271

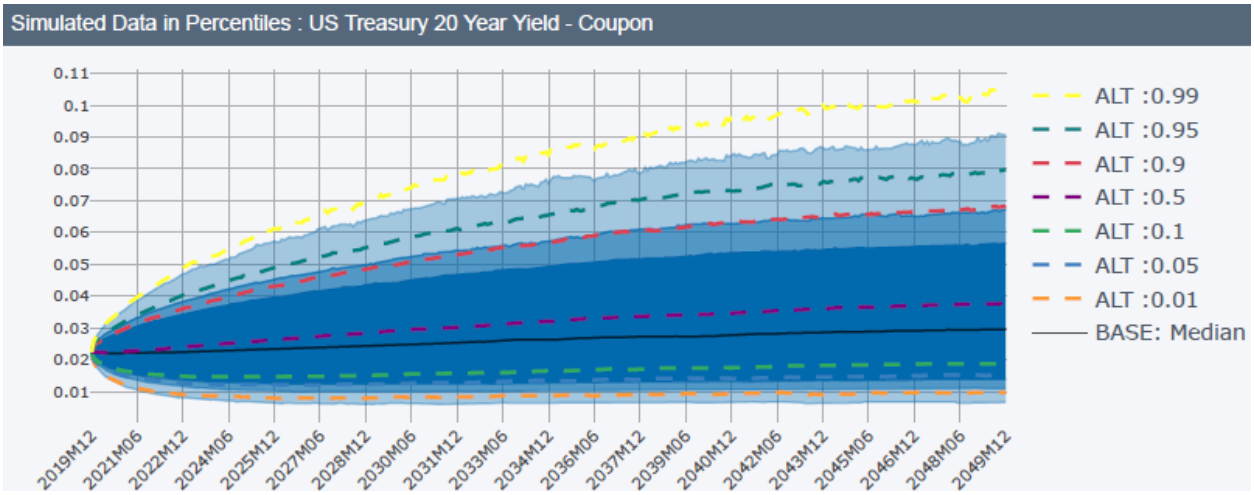
Diff 0.0%

Note: These last two adjustments are formulaic in the current spreadsheet. Although, the new Target State variables must be solved for.

Impact on Results







The distributions for all points along the curve increase by about 100 bps across the 30-year simulation. The results are slightly wider since volatility increases with level.

Lower MRP

What is this example testing?

Regulators wanted to see the impact of decreasing the MRP

Impact on Parameters

Baseline parameters

Model Parameters										Mean Reversion Spee		Long Term Levels		
CIR Process	Theta	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target	Calculatec	Target		Actual	Target
CIR 1	0.2716	5.6773	0.0181	-0.2586	5.3995	5.677311	11.35456	4.67%	4.67%	3.60	3.60	Overnight	2.25%	2.25%
CIR 2	0.0196	0.2520	0.0423	-0.0007	-0.0188	0.259034	0.511067	6.96%	6.96%	3.69	3.69	1-Year	2.50%	2.50%
CIR 3	0.0010	0.0000	0.0390	0.0010	-0.0595	0.055149	0.055164	3.33%	3.33%	16.80	16.80	20-Year	3.50%	3.50%

Time	Shift Function		
0	-0.1271	Diff	0.0%

Alternative parameters

Reducing long-term target levels by 100bps…

Model Parameters										Mean Reversion Spee		Long Term Levels		
CIR Process	Vega	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target	Calculatec	Target		Actual	Target
CIR 1	0.2716	5.6773	0.0181	-0.2587	5.3995	5.677311	11.35456	4.63%	4.63%	3.60	3.60	Overnight	1.25%	1.25%
CIR 2	0.0196	0.2520	0.0423	-0.0002	-0.0188	0.259034	0.511067	7.14%	7.14%	3.69	3.69	1-Year	1.50%	1.50%
CIR 3	0.0010	0.0000	0.0390	0.0003	-0.0595	0.055149	0.055164	2.19%	2.19%	16.80	16.80	20-Year	2.50%	2.50%

Time	Shift Function		
0	-0.1271	Diff	0.0%

Leads to a change in Target States…

Model Parameters										Mean Reversion Spee		Long Term Levels		
CIR Process	Vega	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target	Calculatec	Target		Actual	Target
CIR 1	0.2716	5.6773	0.0181	-0.2587	5.3995	5.677311	11.35456	4.63%	4.63%	3.60	3.60	Overnight	1.25%	1.25%
CIR 2	0.0196	0.2520	0.0423	-0.0002	-0.0188	0.259034	0.511067	7.14%	7.14%	3.69	3.69	1-Year	1.50%	1.50%
CIR 3	0.0010	0.0000	0.0390	0.0003	-0.0595	0.055149	0.055164	2.19%	2.19%	16.80	16.80	20-Year	2.50%	2.50%

Time	Shift Function		
0	-0.1271	Diff	0.0%

Which then leads to new Lambda0 parameters.

Model Parameters

CIR Process	Vega	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target
CIR 1	0.2716	5.6773	0.0181	-0.2587	5.3995	5.677311	11.35456	4.63%	4.63%
CIR 2	0.0196	0.2520	0.0423	-0.0002	-0.0188	0.259034	0.511067	7.14%	7.14%
CIR 3	0.0010	0.0000	0.0390	0.0003	-0.0595	0.055149	0.055164	2.19%	2.19%

Mean Reversion Spee

Calculatec	Target
3.60	3.60
3.69	3.69
16.80	16.80

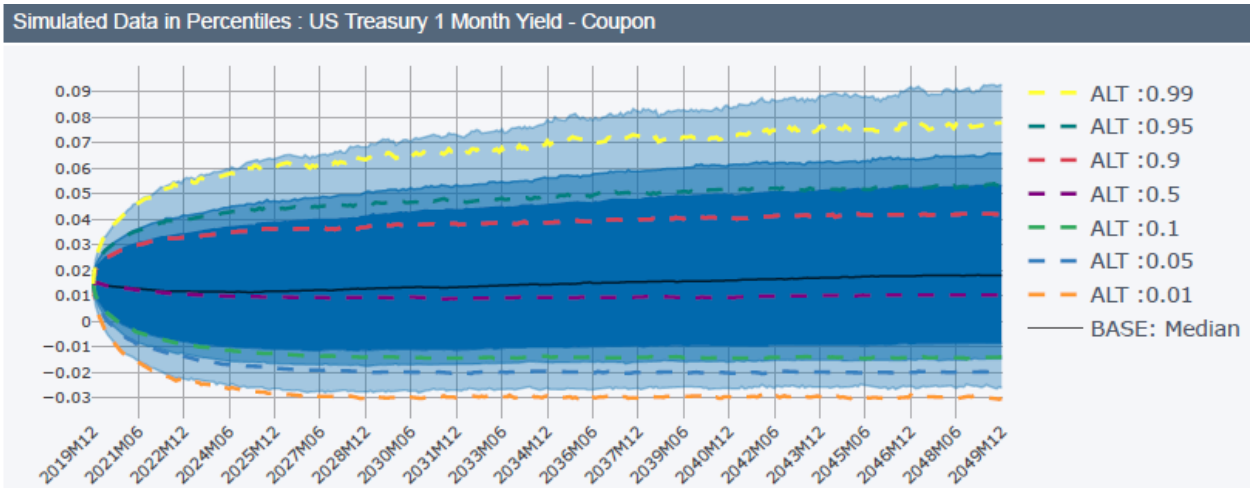
Long Term Levels

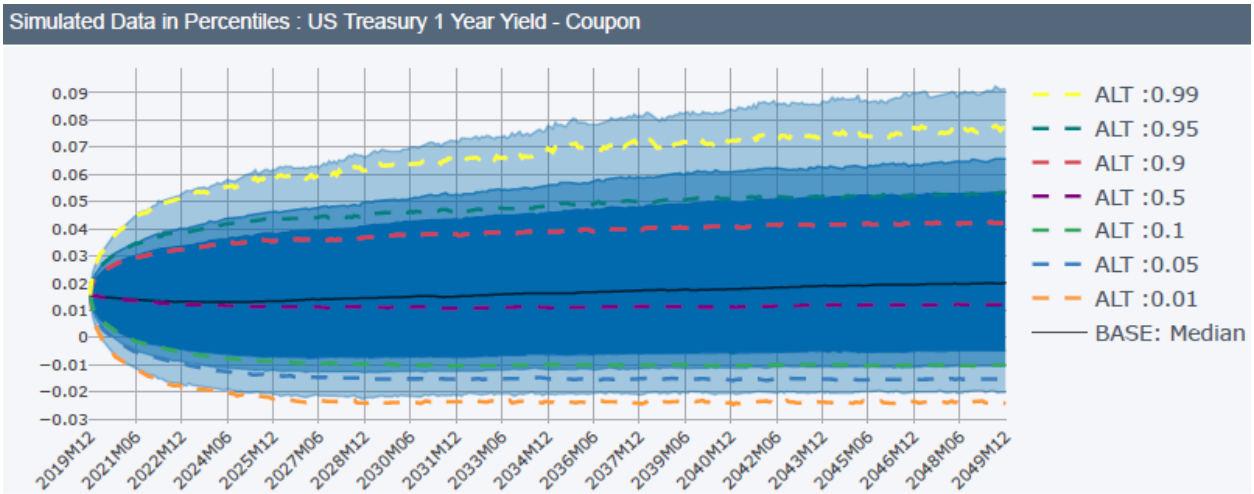
	Actual	Target
Overnight	1.25%	1.25%
1-Year	1.50%	1.50%
20-Year	2.50%	2.50%

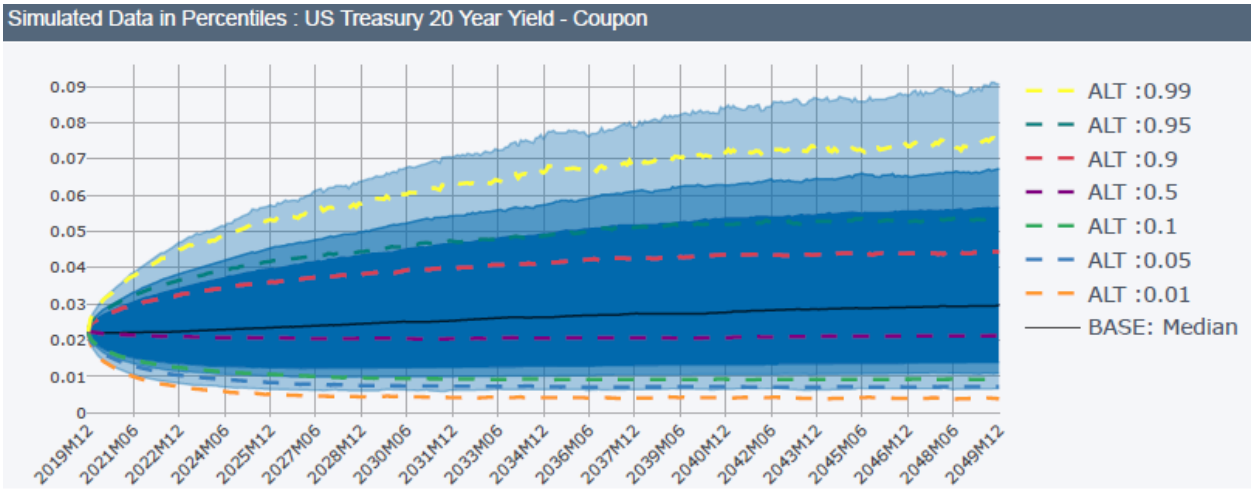
Time	Shift Function
0	-0.1271

Diff 0.0%

Impact on Results







The distributions for all points along the curve decrease by about 100 bps across the 30-year simulation. The results are slightly narrower since volatility increases with level.

Faster Reversion

What is this example testing?

When setting the mean reversion speed, we looked at both the standard GEMS values and the ones used by the current Academy Interest Rate Generator. While the speeds were fairly close on the short-end of the curve (i.e. 3.1 for GEMS vs 3.6 for the Academy), there was a huge difference on the long-end: 4.1 for GEMS vs 16.8 for the Academy. In the original proposal, we used the Academy mean reversion speeds. So, in this example, we test the impact of halving the long-term mean reversion speed.

Impact on Parameters

Baseline parameters

Model Parameters										Mean Reversion Spee		Long Term Levels		
CIR Process	Theta	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target	Calculatec	Target		Actual	Target
CIR 1	0.2716	5.6773	0.0181	-0.2586	5.3995	5.677311	11.35456	4.67%	4.67%	3.60	3.60	Overnight	2.25%	2.25%
CIR 2	0.0196	0.2520	0.0423	-0.0007	-0.0188	0.259034	0.511067	6.96%	6.96%	3.69	3.69	1-Year	2.50%	2.50%
CIR 3	0.0010	0.0000	0.0390	0.0010	-0.0595	0.055149	0.055164	3.33%	3.33%	16.80	16.80	20-Year	3.50%	3.50%

Time	Shift Function		
0	-0.1271	Diff	0.0%

Alternative parameters

When reducing the Mean Reversion Speed target for the long-end of the curve…

Model Parameters										Mean Reversion Spee		Long Term Levels		
CIR Process	Vega	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target	Calculatec	Target		Actual	Target
CIR 1	0.2716	5.6773	0.0181	-0.2586	5.3995	5.677311	11.35456	4.67%	4.67%	3.60	3.60	Overnight	2.25%	2.25%
CIR 2	0.0196	0.2520	0.0423	-0.0007	-0.0188	0.259034	0.511067	6.96%	6.96%	3.69	3.69	1-Year	2.50%	2.50%
CIR 3	0.0010	0.0000	0.0390	0.0030	-0.1190	0.055149	0.055164	3.33%	3.33%	8.40	8.40	20-Year	3.50%	3.50%

Time	Shift Function		
0	-0.1271	Diff	0.0%

That leads to a revised value for that state's Lambda1...

Model Parameters										Mean Reversion Spee		Long Term Levels		
CIR Process	Theta	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target	Calculatec	Target		Actual	Target
CIR 1	0.2716	5.6773	0.0181	-0.2586	5.3995	5.677311	11.35456	4.67%	4.67%	3.60	3.60	Overnight	2.25%	2.25%
CIR 2	0.0196	0.2520	0.0423	-0.0007	-0.0188	0.259034	0.511067	6.96%	6.96%	3.69	3.69	1-Year	2.50%	2.50%
CIR 3	0.0010	0.0000	0.0390	0.0010	-0.0595	0.055149	0.055164	3.33%	3.33%	16.80	16.80	20-Year	3.50%	3.50%

Time	Shift Function		
0	-0.1271	Diff	0.0%

That, means that state's Lambda0 parameters must also be changed to keep the same Long-Term Target.

Model Parameters

CIR Process	Vega	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target
CIR 1	0.2716	5.6773	0.0181	-0.2586	5.3995	5.677311	11.35456	4.67%	4.67%
CIR 2	0.0196	0.2520	0.0423	-0.0007	-0.0188	0.259034	0.511067	6.96%	6.96%
CIR 3	0.0010	0.0000	0.0390	0.0030	-0.1190	0.055149	0.055164	3.33%	3.33%

Mean Reversion Spee

Calculatec	Target
3.60	3.60
3.69	3.69
8.40	8.40

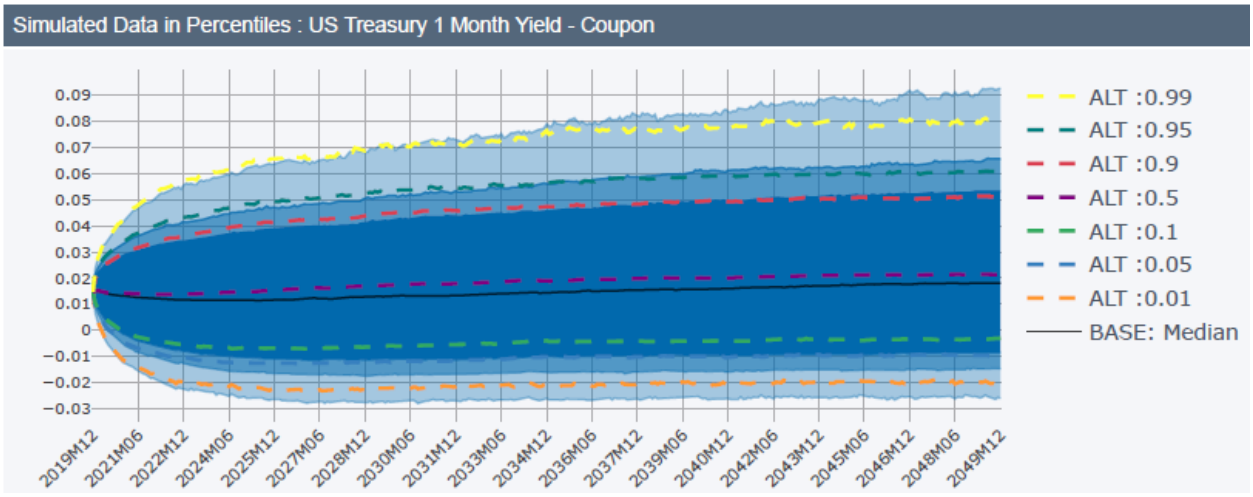
Long Term Levels

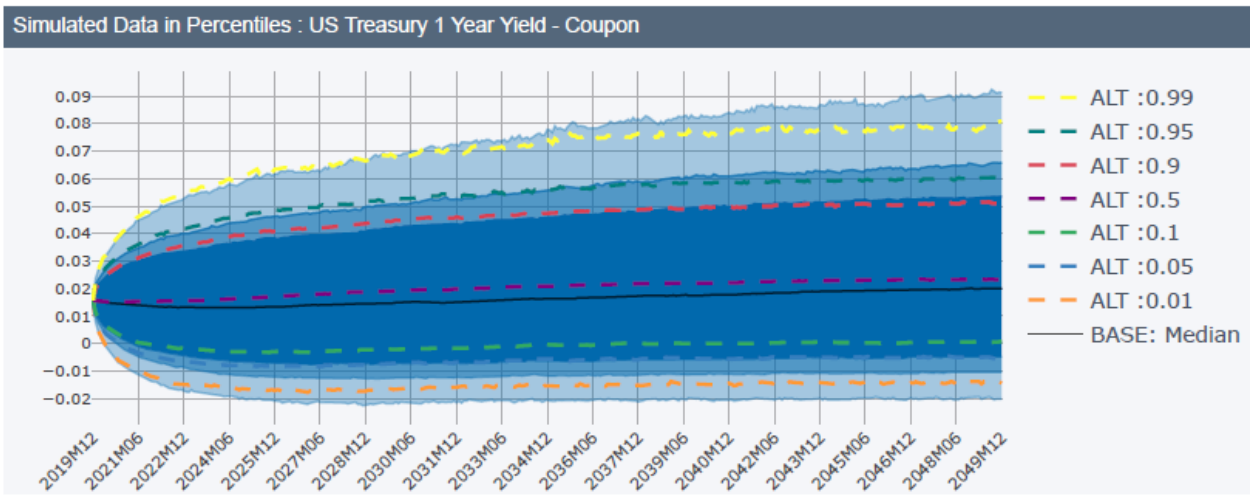
	Actual	Target
Overnight	2.25%	2.25%
1-Year	2.50%	2.50%
20-Year	3.50%	3.50%

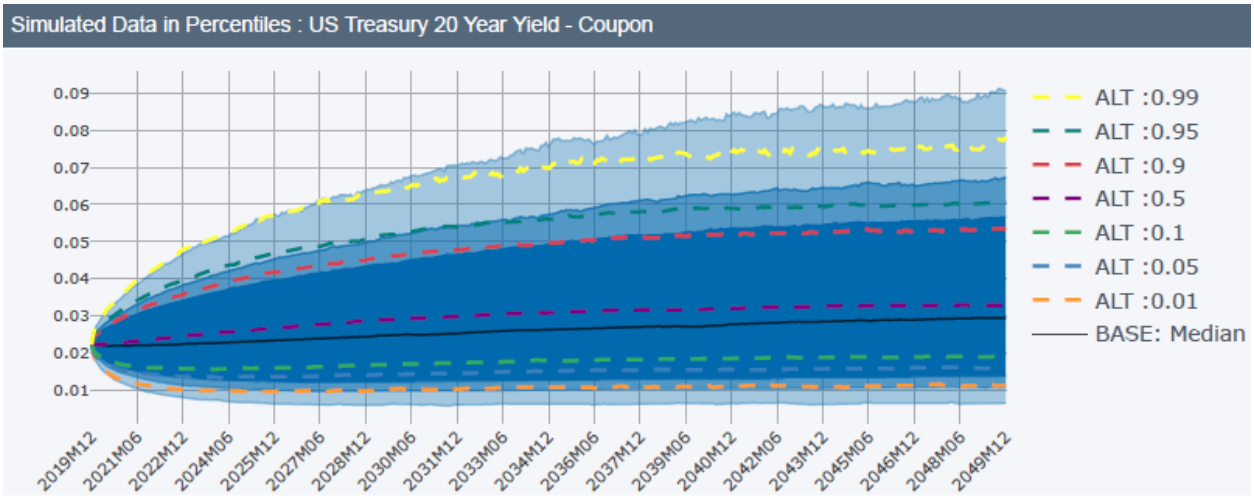
Time	Shift Function
0	-0.1271

Diff 0.0%

Impact on Results







Since the Target Yields are above the initial conditions, using a faster reversion speed shifts the entire distribution up slightly across all tenors. In addition, the faster reversion speed also means that the projected Yields aren't as volatile. The gap in volatility is most pronounced at the long-end of the Yield curve.

Higher Volatility

What is this example testing?

There has been some concern expressed with the lack of double-digit interest rates like we saw in the 1980's. So, in this test, we doubled the volatility parameters to produce more of those scenarios.

Impact on Parameters

Baseline parameters

Model Parameters										Mean Reversion Spee		Long Term Levels		
CIR Process	Theta	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target	Calculated	Target		Actual	Target
CIR 1	0.2716	5.6773	0.0181	-0.2586	5.3995	5.677311	11.35456	4.67%	4.67%	3.60	3.60	Overnight	2.25%	2.25%
CIR 2	0.0196	0.2520	0.0423	-0.0007	-0.0188	0.259034	0.511067	6.96%	6.96%	3.69	3.69	1-Year	2.50%	2.50%
CIR 3	0.0010	0.0000	0.0390	0.0010	-0.0595	0.055149	0.055164	3.33%	3.33%	16.80	16.80	20-Year	3.50%	3.50%

Time	Shift Function		
0	-0.1271	Diff	0.0%

Alternative parameters

Doubled the Sigma parameters to double the expected volatility…

Model Parameters										Mean Reversion Speed		Long Term Levels		
CIR Process	Vega	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target	Calculated	Target		Actual	Target
CIR 1	0.2716	5.6773	0.0363	-0.2579	5.3995	5.677485	11.35474	4.92%	4.92%	3.60	3.60	Overnight	2.25%	2.25%
CIR 2	0.0196	0.2520	0.0846	-0.0057	-0.0188	0.278985	0.531018	5.12%	5.12%	3.69	3.69	1-Year	2.50%	2.50%
CIR 3	0.0010	0.0000	0.0780	0.0020	-0.0595	0.110299	0.110313	4.91%	4.91%	16.80	16.80	20-Year	3.50%	3.50%

Time	Shift Function		
0	-0.1271	Diff	0.0%

Changing the Sigma parameters alters the Auxiliary functions. That requires us to find a new set of the Target State levels to meet the long-term MRPs…

Model Parameters										Mean Reversion Spee		Long Term Levels		
CIR Process	Vega	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target	Calculated	Target		Actual	Target
CIR 1	0.2716	5.6773	0.0363	-0.2579	5.3995	5.677485	11.35474	4.92%	4.92%	3.60	3.60	Overnight	2.25%	2.25%
CIR 2	0.0196	0.2520	0.0846	-0.0057	-0.0188	0.278985	0.531018	5.12%	5.12%	3.69	3.69	1-Year	2.50%	2.50%
CIR 3	0.0010	0.0000	0.0780	0.0020	-0.0595	0.110299	0.110313	4.91%	4.91%	16.80	16.80	20-Year	3.50%	3.50%

Time	Shift Function		
0	-0.1271	Diff	0.0%

Which then leads to new set of Lambda0 parameters.

Model Parameters

CIR Process	Vega	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target
CIR 1	0.2716	5.6773	0.0363	-0.2579	5.3995	5.677485	11.35474	4.92%	4.92%
CIR 2	0.0196	0.2520	0.0846	-0.0057	-0.0188	0.278985	0.531018	5.12%	5.12%
CIR 3	0.0010	0.0000	0.0780	0.0020	-0.0595	0.110299	0.110313	4.91%	4.91%

Mean Reversion Spee

Calculatec	Target
3.60	3.60
3.69	3.69
16.80	16.80

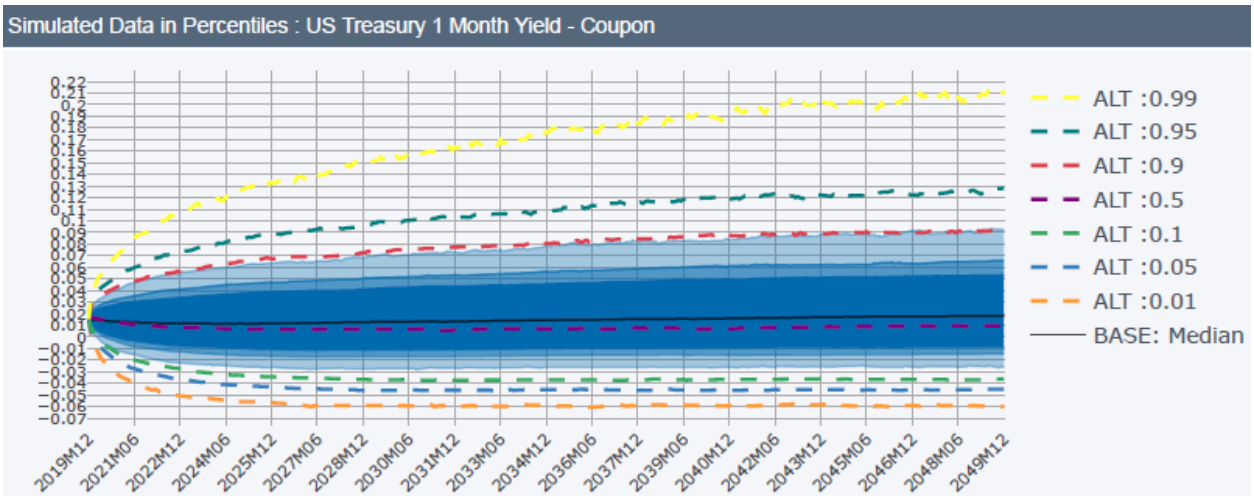
Long Term Levels

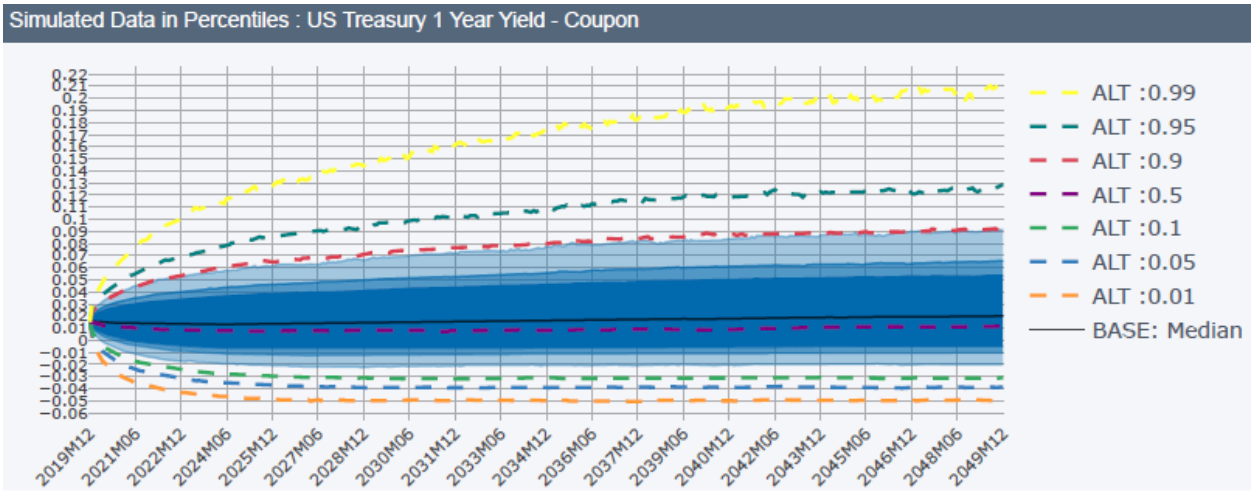
	Actual	Target
Overnight	2.25%	2.25%
1-Year	2.50%	2.50%
20-Year	3.50%	3.50%

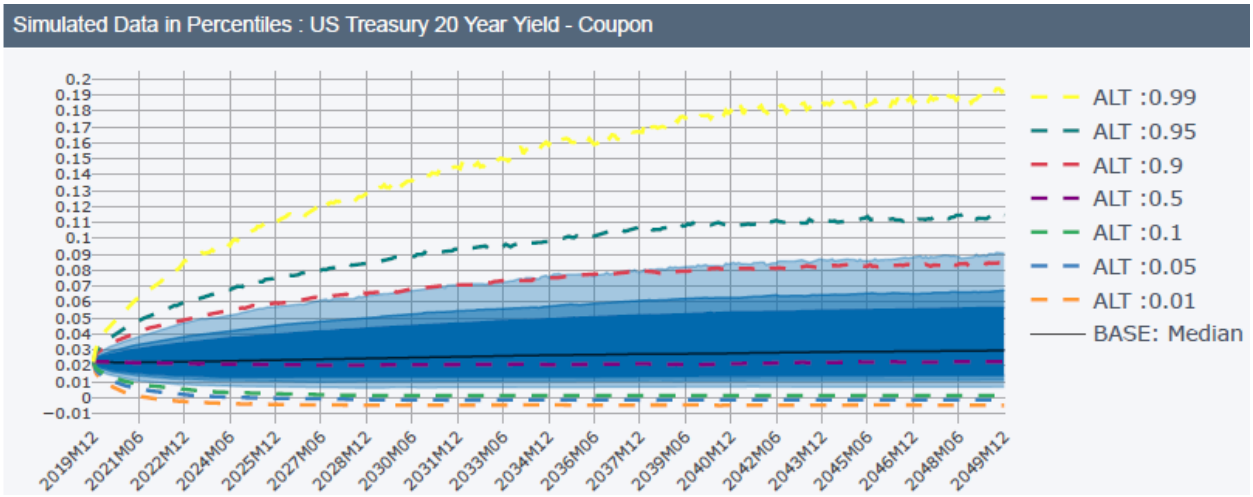
Time	Shift Function
0	-0.1271

Diff 0.0%

Impact on Results







As expected, these higher Sigma parameters lead to roughly double across all tenors. (Note: The increase is not exactly double because of the change in target state levels.) Since there are absolute minimums for all of these tenors, most of the additional volatility is on the upper side. For example, the 1st percentile of the 20-Year Yield at the end of the 30th projection year drops about 100 bps: from 66 bps to -50 bps. However, on the other end, the 99th percentile overs doubles: from a little over 9% to over 19% at that same future date. To keep the mean the same despite this increase is positive skew, there is a slight down tick in the median projections for all the tenors.

Alternative Shift

What is this example testing?

Regulators expressed some concern about the frequency and the severity of negative Yields. The easiest way to make those adjustments is to move the linear shift up.

Impact on Parameters

Baseline parameters

Model Parameters										Mean Reversion Spee		Long Term Levels		
CIR Process	Theta	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target	Calculatec	Target		Actual	Target
CIR 1	0.2716	5.6773	0.0181	-0.2586	5.3995	5.677311	11.35456	4.67%	4.67%	3.60	3.60	Overnight	2.25%	2.25%
CIR 2	0.0196	0.2520	0.0423	-0.0007	-0.0188	0.259034	0.511067	6.96%	6.96%	3.69	3.69	1-Year	2.50%	2.50%
CIR 3	0.0010	0.0000	0.0390	0.0010	-0.0595	0.055149	0.055164	3.33%	3.33%	16.80	16.80	20-Year	3.50%	3.50%

Time	Shift Function		
0	-0.1271	Diff	0.0%

Alternative parameters

An increase of the Shift parameter by 100 basis points…

Model Parameters										Mean Reversion Speec		Long Term Levels		
CIR Process	Theta	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target	Calculated	Target		Actual	Target
CIR 1	0.2716	5.6773	0.0089	-0.2585	5.3995	5.677267	11.35452	4.70%	4.70%	3.60	3.60	Overnight	2.25%	2.25%
CIR 2	0.0196	0.2520	0.0230	-0.0012	-0.0188	0.254124	0.506157	6.77%	6.77%	3.69	3.69	1-Year	2.50%	2.50%
CIR 3	0.0010	0.0000	0.0585	0.0005	-0.0595	0.082731	0.082746	2.49%	2.49%	16.80	16.80	20-Year	3.50%	3.50%

Time	Shift Function		
0	-0.1171	Diff	0.0%

Changing the Shift parameters requires us to find a new set of the Target State levels to meet the long-term MRPs. For example, the Target Overnight Yield = Shift + Sum of Target State variables. So, if the Shift increases by 100 bps, then the States must decrease by that same amount…

Model Parameters										Mean Reversion Speec		Long Term Levels		
CIR Process	Theta	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target	Calculated	Target		Actual	Target
CIR 1	0.2716	5.6773	0.0089	-0.2585	5.3995	5.677267	11.35452	4.70%	4.70%	3.60	3.60	Overnight	2.25%	2.25%
CIR 2	0.0196	0.2520	0.0230	-0.0012	-0.0188	0.254124	0.506157	6.77%	6.77%	3.69	3.69	1-Year	2.50%	2.50%
CIR 3	0.0010	0.0000	0.0585	0.0005	-0.0595	0.082731	0.082746	2.49%	2.49%	16.80	16.80	20-Year	3.50%	3.50%

Time	Shift Function		
0	-0.1171	Diff	0.0%

Which then leads to new set of Lambda0 parameters…

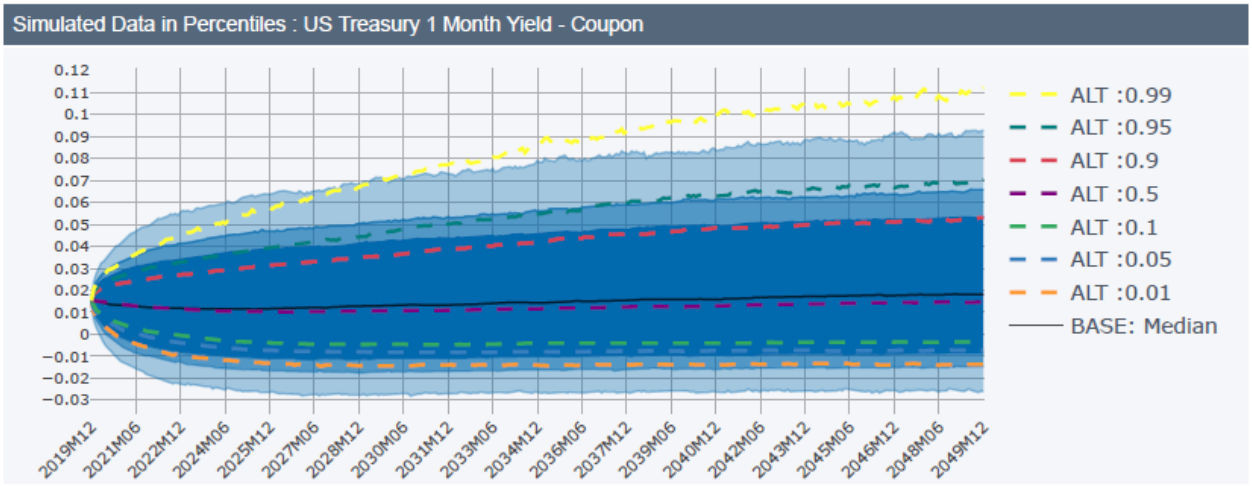
Model Parameters											Mean Reversion Speed		Long Term Levels		
CIR Process	Theta	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target		Calculated	Target		Actual	Target
CIR 1	0.2716	5.6773	0.0089	-0.2585	5.3995	5.677267	11.35452	4.70%	4.70%		3.60	3.60	Overnight	2.25%	2.25%
CIR 2	0.0196	0.2520	0.0230	-0.0012	-0.0188	0.254124	0.506157	6.77%	6.77%		3.69	3.69	1-Year	2.50%	2.50%
CIR 3	0.0010	0.0000	0.0585	0.0005	-0.0595	0.082731	0.082746	2.49%	2.49%		16.80	16.80	20-Year	3.50%	3.50%
Time	Shift Function													Diff	0.0%
0	-0.1171														

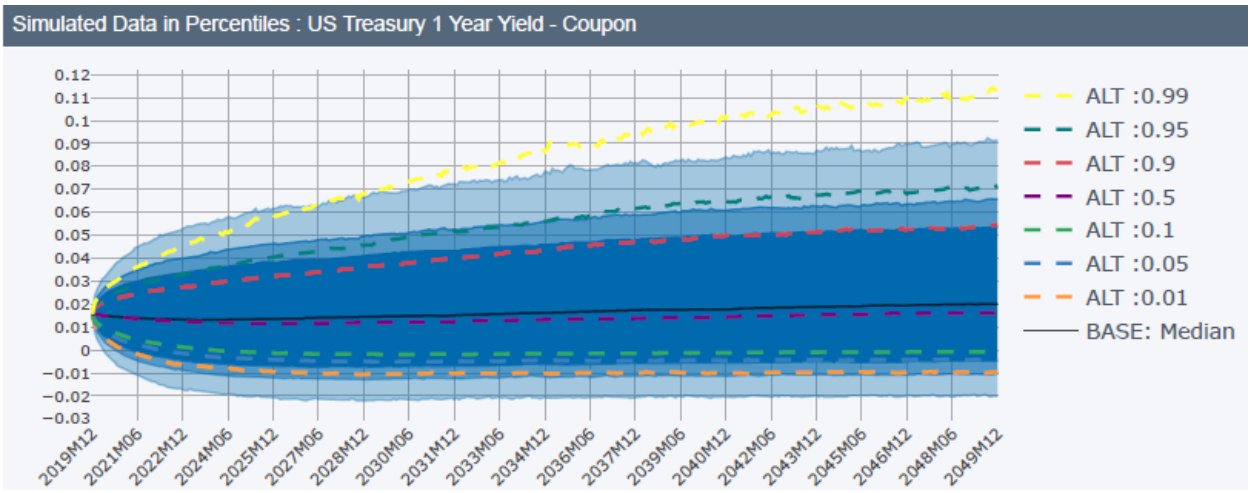
Since the volatility is linked to the level of the State variables, we need to increase the Sigma values to get back to the target volatility.

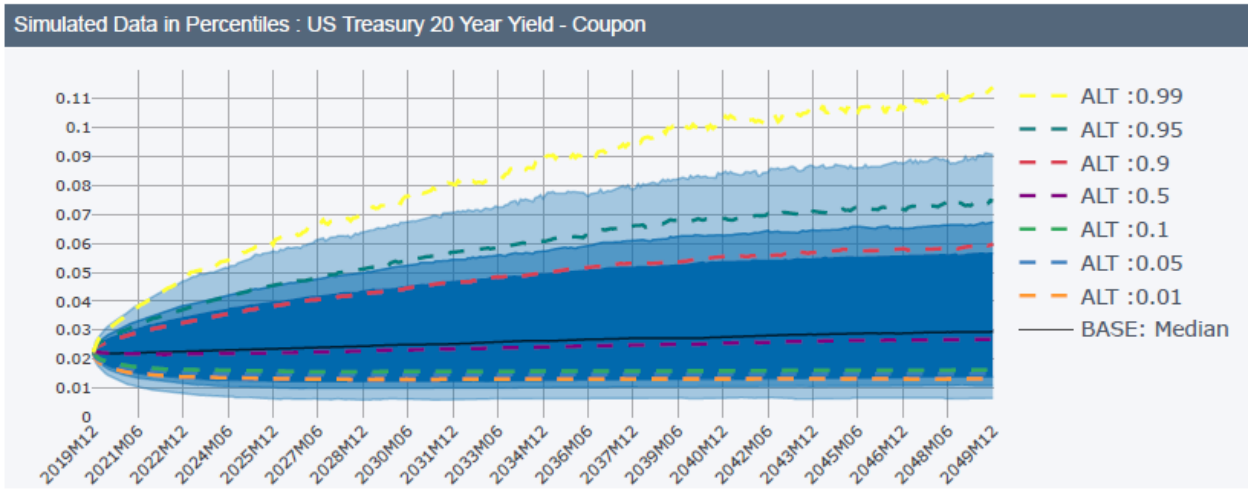
Model Parameters											Mean Reversion Speed		Long Term Levels		
CIR Process	Theta	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target		Calculated	Target		Actual	Target
CIR 1	0.2716	5.6773	0.0089	-0.2585	5.3995	5.677267	11.35452	4.70%	4.70%		3.60	3.60	Overnight	2.25%	2.25%
CIR 2	0.0196	0.2520	0.0230	-0.0012	-0.0188	0.254124	0.506157	6.77%	6.77%		3.69	3.69	1-Year	2.50%	2.50%
CIR 3	0.0010	0.0000	0.0585	0.0005	-0.0595	0.082731	0.082746	2.49%	2.49%		16.80	16.80	20-Year	3.50%	3.50%
Time	Shift Function													Diff	0.0%
0	-0.1171														

Since the change in Sigma will impact the Auxiliary functions (see the **Higher Volatility** example), this change will also change the Target State variables. So, unlike the other items, this process involves either several iterations or the use of Conning's optimization methodology.

Impact on Results







In the early projection years, there is a fairly large drop in the volatility especially for the shorter tenors. (Note: This is a function of the lower Sigma values for the first two state variables.) In the later projection years, the volatility ends up at about the same level as the Baseline parameters for all the tenors. However, the reduction of the downside possibilities, due to the higher shift value, means that there has to be more upside to the distributions.

Alternative Start Date

What is this example testing?

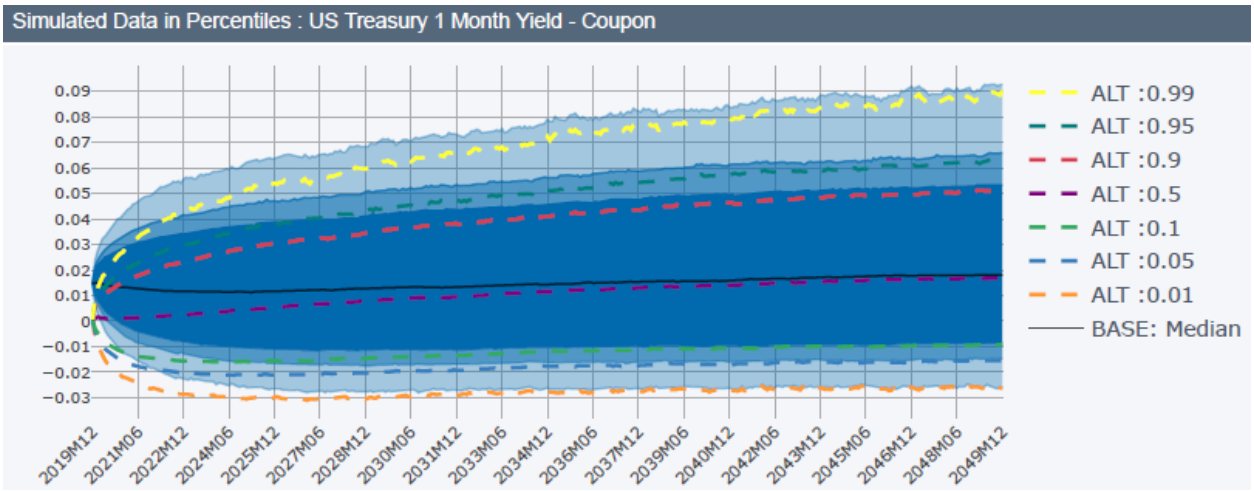
Several regulators expressed interest in understanding how the initial conditions will impact the projections. So, in this example, we move the initial conditions from 12/31/2019 to 12/31/2020.

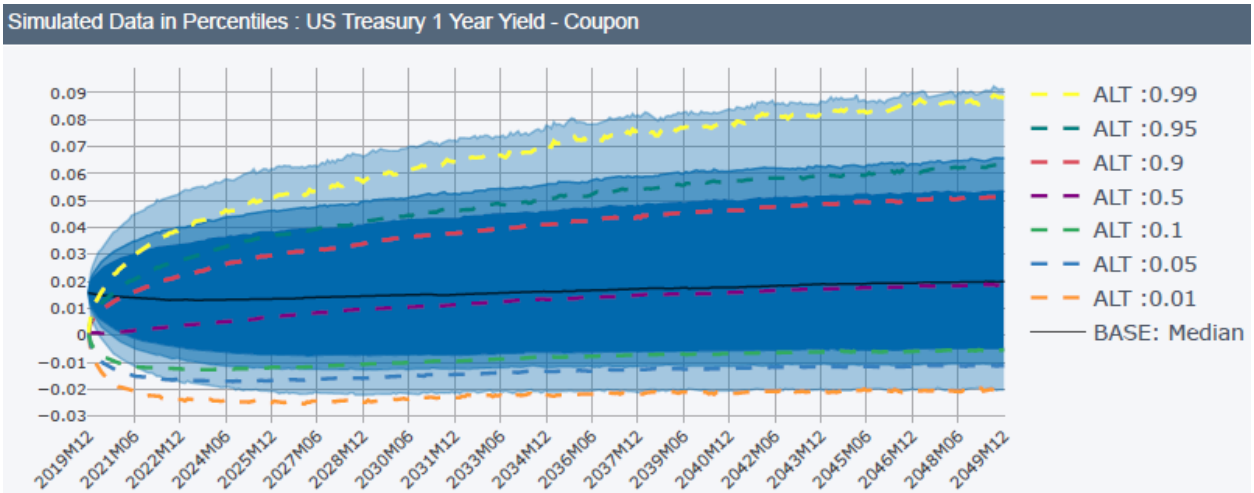
(Note: Solely for the purpose of this example, we did NOT make any adjustments to the MRPs even though the current procedure would have had an update in January 2020.)

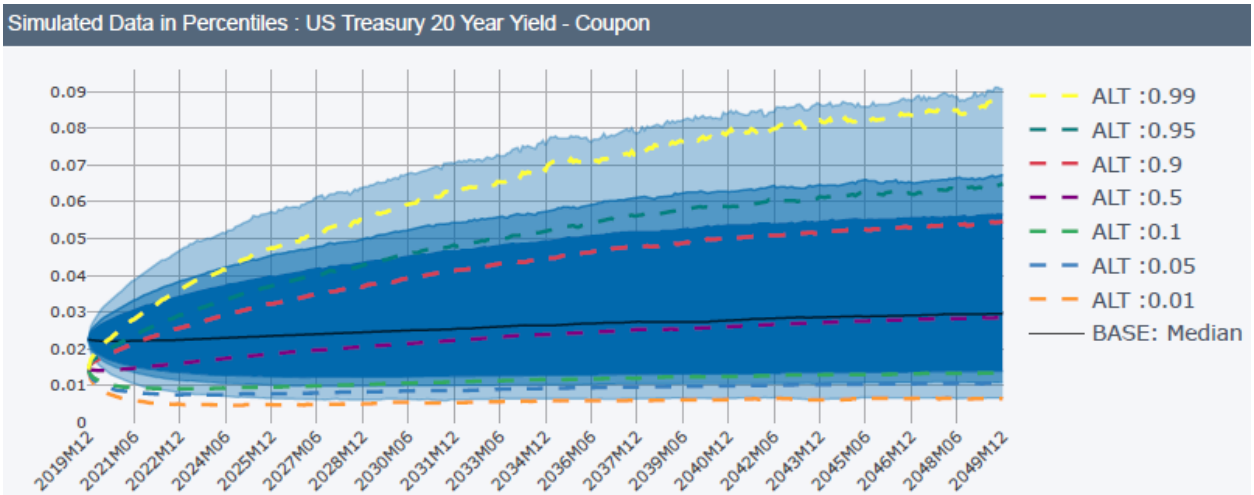
Impact on Parameters

Since there are no change in the long-term targets, there are no changes in the model parameters.

Impact on Results







Since the initial Yields are about 100 bps lower, the entire distribution is lower across all tenors. Because of the difference in reversion speeds, the short tenors are pretty close to the baseline projections by about the end of the 10th projection year. On the other hand, the distribution for the longer tenors takes most of the 30 year projection periods to revert to the baseline projections.

Alternative Shift + Volatility

What is this example testing?

This alternative combines the increase in the Shift function, to lower frequency of negative Yields, and increases the volatility, to increase the likelihood of 1980's Yields.

Impact on Parameters

Baseline parameters

Model Parameters										Mean Reversion Spee		Long Term Levels		
CIR Process	Theta	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target	Calculatec	Target		Actual	Target
CIR 1	0.2716	5.6773	0.0181	-0.2586	5.3995	5.677311	11.35456	4.67%	4.67%	3.60	3.60	Overnight	2.25%	2.25%
CIR 2	0.0196	0.2520	0.0423	-0.0007	-0.0188	0.259034	0.511067	6.96%	6.96%	3.69	3.69	1-Year	2.50%	2.50%
CIR 3	0.0010	0.0000	0.0390	0.0010	-0.0595	0.055149	0.055164	3.33%	3.33%	16.80	16.80	20-Year	3.50%	3.50%

Time	Shift Function		
0	-0.1271	Diff	0.0%

Alternative parameters

An increase of the Shift parameter by 100 basis points…

Model Parameters										Mean Reversion Speec		Long Term Levels		
CIR Process	Theta	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target	Calculated Target			Actual	Target
CIR 1	0.2716	5.6773	0.0134	-0.2582	5.3995	5.677285	11.35454	4.83%	4.83%	3.60	3.60	Overnight	2.25%	2.25%
CIR 2	0.0196	0.2520	0.0345	-0.0039	-0.0188	0.256713	0.508746	5.78%	5.78%	3.69	3.69	1-Year	2.50%	2.50%
CIR 3	0.0010	0.0000	0.0878	0.0010	-0.0595	0.124097	0.124112	3.35%	3.35%	16.80	16.80	20-Year	3.50%	3.50%

Time	Shift Function		
0	-0.1171	Diff	0.0%

Changing these parameters requires us to find a new set of the Target State levels to meet the long-term MRPs. For example, the Target Overnight Yield = Shift + Sum of Target State variables. So, if the Shift increases by 100 bps, then the States must decrease by that same amount…

Model Parameters										Mean Reversion Speec		Long Term Levels		
CIR Process	Theta	Kappa	Sigma	Lambda0	Lambda1	Gamma	Gamma + Kappa	LT State	Target	Calculated Target			Actual	Target
CIR 1	0.2716	5.6773	0.0134	-0.2582	5.3995	5.677285	11.35454	4.83%	4.83%	3.60	3.60	Overnight	2.25%	2.25%
CIR 2	0.0196	0.2520	0.0345	-0.0039	-0.0188	0.256713	0.508746	5.78%	5.78%	3.69	3.69	1-Year	2.50%	2.50%
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Time	Shift Function		
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Which then leads to new set of Lambda0 parameters…

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Time	Shift Function												Diff	0.0%
0	-0.1171													

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CIR 3	0.0010	0.0000	0.0878	0.0010	-0.0595	0.124097	0.124112	3.35%	3.35%	16.80	16.80	20-Year	3.50%	3.50%
Time	Shift Function												Diff	0.0%
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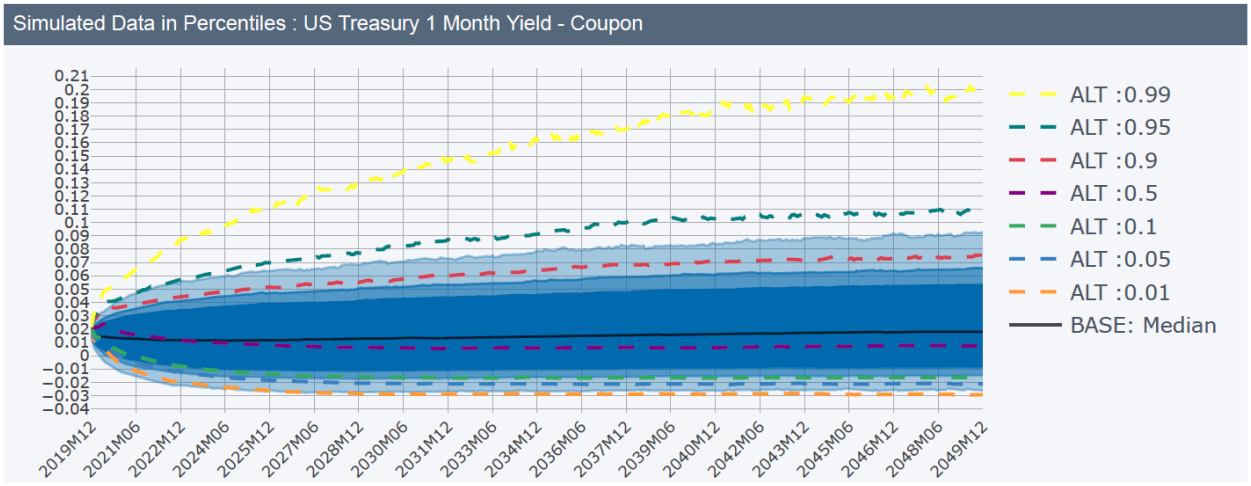
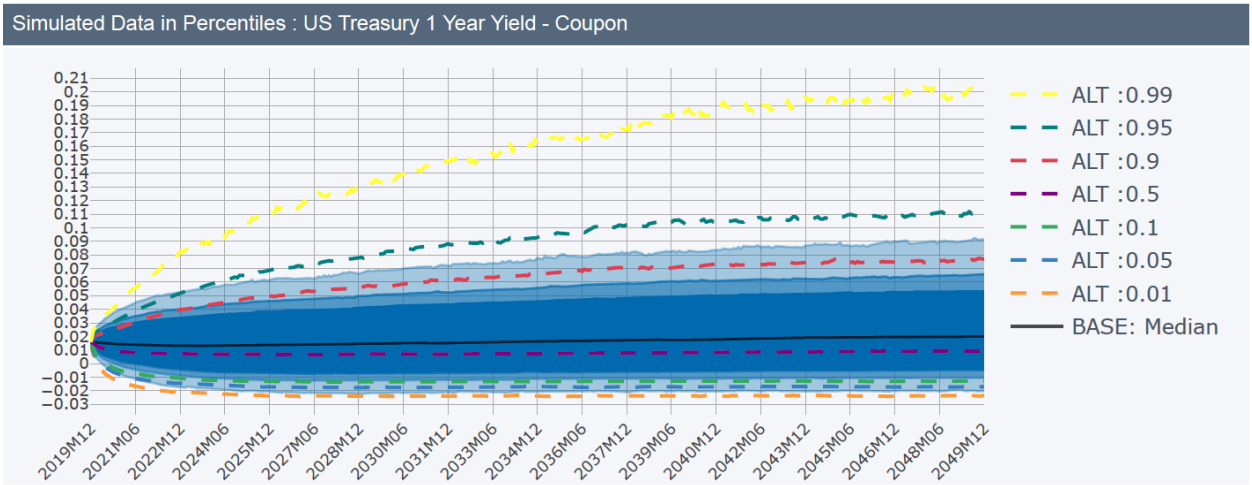
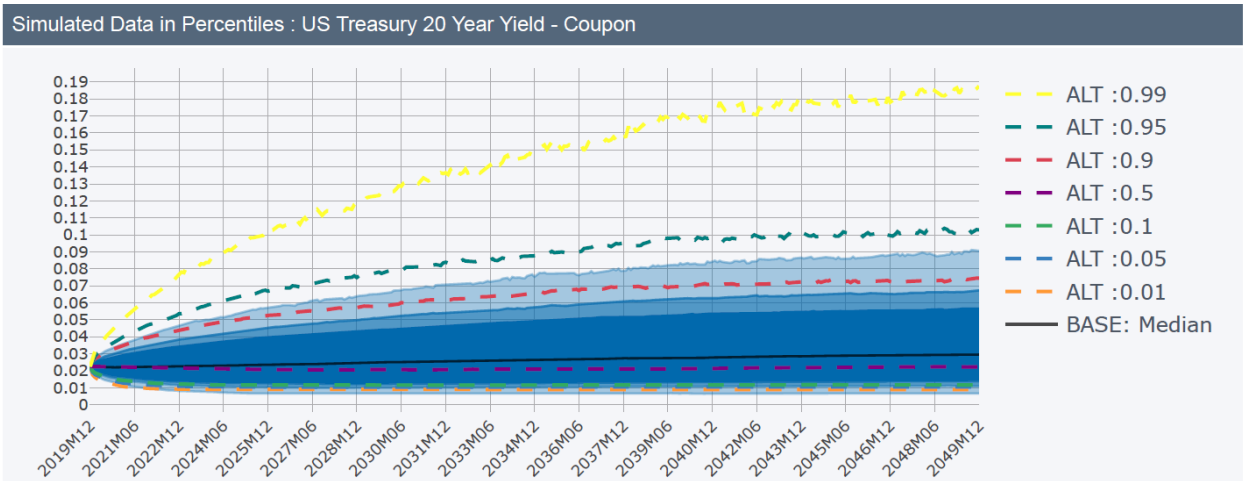
Impact on Results







As targeted, the volatility roughly doubles with this calibration relative to the baseline. However, since there is a lower bound, which has been shifted even higher, that extra volatility leads to markedly higher levels at the upper percentiles. In particular, this calibration has a material chance of returning to the double-digit levels of the 1980s.