NAIC Economic Scenario Generator (ESG)
Questions and Answers (Q&A)
Last Modified: 4/7/2021

This document provides a summary of questions and answers relating to the development of the new ESG to be used for statutory reporting purposes. This ESG will produce real-world interest and equity scenarios to be prescribed for use in calculations of life and annuity Statutory reserves according to the Valuation Manual (e.g. VM-20, VM-21) and capital under the NAIC RBC requirements (e.g. C3 Phase 1, C3 Phase 2). This is a living document. As additional questions are received, this document will be expanded. Please email Reggie Mazyck, rmazyck@naic.org, with additional questions or any requests for clarification relating to this document.

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Section A: Treasury Model

Q1. Does the GEMS Treasury model require the initial state variables to be non-negative? If so, what happens if the initial Yields produce a negative state variable?

A: Since the states' volatility in the GEMS Treasury model is proportional to its level, the initial state variables must be non-negative. There are several components of the GEMS' fitting procedure which ensure that the initial state variables will meet this condition. First, when performing the search algorithm for the best 3 Pivot Points (see slide 5 of the 12/3/20 Treasury Model Presentation), the process will reject any combination that produces one or more invalid state variables. Second, in the very unlikely case that the algorithm is unable to find a valid combination, the process will:

1. pick a combination of Pivot Points
2. convert the initial yield curve into the implied starting states using the inversion process*.
3. shift the invalid state variables to 0.0001
4. calculate the discrepancy curve of the resulting implied Yield curve

*Please see "Appendix II – Initial State Variable Calculation" of the Technical Interest Rate Documentation for more information.

Q2. Are there any boundary conditions on the projected state variables? If so, how does the GEMS model ensure that those boundaries are not violated?

A: Yes, there is a boundary condition requiring that each of the state variables must be non-negative.

There are several components of the formulation that ensure that this condition is met. First, as with the Cox-Ingersoll-Ross model that is the original basis of the GEMS Treasury Model, the projected volatility of each state variable is proportional to its square root. As a result, as a state gets closer to 0, its volatility will drop to zero, which makes it harder to breach zero. Second, a valid calibration of this model requires both the mean reversion level and the mean reversion speed to be positive. Mathematically, this means **Theta** + **Lambda0** > 0 and **Kappa** – **Lambda1** > 0 for each of the state variables. These conditions ensure that any state variable which gets close to zero will have enough mean reversion so that the simulated values are very unlikely to breach zero. Finally, in the very unlikely scenario that the model does produce a negative state value in the simulation, the procedure will floor the actual value at 0.0001 similar to what the current Academy Interest Rate Generator does for Yields.

Q3. Why aren't the Lambda parameters used in the Auxiliary functions in the Treasury Targets and Parameters.xlsx file?

A: In terms of the Auxiliary function, the lambda parameters are risk premium adjustments. So, they get used in the mean reversion speed and mean reversion level formulas. However, they do NOT get used in any pricing formulas. These auxiliary functions are used to price zero coupon bonds (see section 2.2 of the **Technical Interest Rate Documentation** file).

Treasury Targets and Parameters.xlsx is embedded in the 12/18/20 Exposure document

Q4. What is the purpose of Rows 20-22 of the Auxiliary Functions tab of the Treasury Targets and Parameters.xlsx file?

A: Rows 20-22 are how the Spot Rates are converted into Par Yields. Since the model is arbitrage free, the price of a bond should equal the price of its cash flows. Specifically, for a semi-annual coupon par bond, this means 1 = Price of Par Bond = Sum(PV of Cash Flows) = (Coupon / 2) * Sum(PV of 1 every 6-months) + PV of Principal. The second component is what we're calculating in Row 21. Rearranging this formula, the Coupon = 2 * (1 - PV of Principal) / Row 21 value, which is the formula in Row 22. Since the current Mean-reversion parameter (MRP) values are based on published Treasury Yields, which are expressed as semi-annual Par Yields, this procedure is used to match up the current values.

Q5. What is the foundation of the GEMS' Treasury model? Is this the same as the current Academy generator?

A: Spot rates form the foundation of GEMS' Treasury Yield curve construction. Specifically, if you look in the **Technical Interest Rate Documentation**, there is a formula for the Spot Rate at different tenors based on the current State values on page 5 (under section 2.3 "Initial Yield Curve Fitting"). For context, the 10-Year Spot Rate is based solely on the price of a single cash flow at the end of year 10 (i.e. a 10-Year zero coupon bond). On the other hand, the Academy model starts with Par Yields. In the US, these Yields reflect the semi-annual coupon that a bond would have to pay in order to be priced at Par. These Yields are consistent with the data published on the Federal Reserve's website. These two methods are related, which is why both models can produce both Spot and Par Yields. Specifically, going from Spot Rates to Par Yields involves solving a series of equations of the form: 1 = Par Value of Bond = Sum(PV of Fixed Coupons) + PV of Principal for increasing tenors.

Q6. Which parameters in the GEMS® Treasury model influence the magnitude and frequency of negative interest rates in the projected scenarios?

A: The interaction of several parameters in the GEMS® Treasury model determine the magnitude and frequency of negative interest rates in the projection. First, the shift parameter extends the basic form of the GEMS® Treasury model to allow for the occurrence of negative interest rates. All else equal, the occurrence and magnitude of negative interest rates will increase with more negative values of the shift parameter. Negative interest rates are also influenced by the mean reversion level and the speed of mean reversion. Lower mean reversion targets with slower speeds of mean reversion will produce scenarios with more negative interest rates for longer periods of time in the projection. Additionally, greater volatility will lead to a wider dispersion of scenarios overall, again impacting negative interest rates in the projection.

Finally, although not employed in the 12/18/20 exposure of scenarios, a floor parameter could be added to the model to disallow interest rates below a specified level. Note that the introduction of a floor would cause the GEMS® Treasury model to no longer be arbitrage-free.

Q7. Can you explain the process used to convert the Treasury targets into GEMS parameters?

A: There are several key steps in this process. First, since the Academy model and GEMS are very different, Conning identified either a specific output of the simulations or a characteristic of the model which aligned with the impact that target has on the scenarios. For example, the MRP in the Academy model aligns very closely to the mean long-term 20-Year Par Yield in GEMS. Second, for each of these targets, Conning selected one or more parameters to adjust which best aligns with this target and is likely to have minimal unanticipated impacts on the simulation. For example, as shown in the equation in section 2.1 of the **Technical Interest Rate** document, both Kappa and Lambda1 impact the mean reversion speed of the state variables. However, Kappa also affects the projected shape of the Yield curves because it is used in the Affine functions (section 2.2 of that same document). Therefore, Conning chose to adjust the Lambda1 parameters to meet the desired mean reversion speed targets. Finally, Conning developed either a method or a formula to convert the targets into GEMS model parameters. The final result of this process is this table:

Target	Characteristic	Parameter(s)	Solution Method
Overnight Rate	Mean Ultimate 0-Month Spot Rate	Long-Term Target State Variables	Iterative Solution[1]
1-Year Yield	Mean Ultimate 1-Year Par Yield		
MRP	Mean Ultimate 20-Year Par Yield		
Mean Reversion Strength for the Slope[2]	Mean Reversion Speed of the state variable with the largest Kappa[3]	Lambda1 for the associated state variable	Since the Mean Reversion speed is 1 / (Kappa – Lambda1) (see section 3), Lambda1 = Kappa – 1 / Mean Reversion Speed.
Mean Reversion Strength for the Log of the Long-Term Rate[2]	Mean Reversion Speed of the state variable with the smallest Kappa[3]		
N/A	Mean Reversion Speed of the final state variable[4]		
Long-Term Target State Variables	N/A	Lambda0 for the associated state variable	Since the Mean Reversion level is (Theta + Lambda0) * Mean Reversion Speed (see section 3), Lambda0 = Target / Mean Reversion Speed - Theta.

[1] For the Long-Term Target State Variables, the nature of the problem ensures that there will be a unique solution: we have three equations with three unknowns. However, the math is too complicated to solve analytically since the Affine formulas give us Spot Yields while the longer targets are expressed as Par Yields. Therefore, Conning will simply use a search algorithm to find the unique solution.

[2] The Mean Reversion Strengths in the current Academy model are expressed on a monthly basis. To convert those into the speed targets GEMS needs (i.e. annual), Conning calculated 1 / (1 – (1 – Academy's Mean Reversion Strength) ^ 12)).

[3] Within GEMS, the Kappa value affects the shape of the B(T) function which get multiplied by the state variables to calculate the final Spot Yields (see section 2.2 of the Technical Interest Rate document). When Kappa is close to

zero, this curve becomes essentially flat. In that case, a 1% movement in the corresponding state value will lead to a roughly 1% parallel shift in the Spot curve. This aligns very well with how the Long-Term Rate impacts the current Academy model's simulations. With a higher Kappa, the B(T) curve becomes very steep. So, a 1% move in this associated state variable will move the short end of the curve about 1%, but have very little impact on the long end of the curve. This behavior aligns well with how the slope impacts the current Academy model's simulations.

[4] In the Baseline proposal, this target was set to the (Mean Reversion Speed for the first state variable) * (Mean Reversion Speed for second state variable / same quantity for the first state variable in GEMS standard calibration).

For an example of how this works, please refer to the **Treasury Targets and Parameters** Excel worksheet.

Q8: The document "NAIC Scenario Set Technical Documentation" provides a formula (see A below) for calibrating the generator for t = 0, but there is no formula used to calibrate the generated Yield curve for future times. Is formula B correct for future periods?

A) $$y(0,\tau) = -\frac{1}{\tau}\left(\left(-\int_0^{\tau} l(s)ds\right) + \sum_{i=1}^{3}\left(A_i(\tau) + B_i(\tau)X_i(0)\right)\right)$$

B) $$y(t,\tau) = -\frac{1}{\tau}\left(\left(-\int_t^{t+\tau} l(s)ds\right) + \sum_{i=1}^{3}\left(A_i(\tau) + B_i(\tau)X_i(t)\right)\right)$$

How is $l(s)$ for s > 30 defined? Is it calibrated to longer term bonds? What about interpolation for long terms where there are not enough instruments?

A: First, since the longest maturity Treasury we are using is 30 years, l(s) is assumed to be constant beyond 30. If the Treasury were to issue longer maturity bonds, those could be incorporated into the calibration process, which would require extending the l(s) vector out accordingly. Second, there is no extrapolation in the GEMS Yield Model: the same formula is used for longer maturities. However, there are no plans right now to produce anything longer than the 30-Year Yield. Finally, the second formula is correct for a Decay = 0. For other values, like the 3 that is being used in the exposed scenarios, the shift integral would be multiplied by exp(- γ * t) where γ is set so that 0.95 = 1 – exp(- γ * 3 / Decay). The rest of the weight (i.e. 1 - exp(- γ * t)) gets applied to the initial shift value (i.e. l(0)).

Q9: The formula in Q8 enables the precise calibration of the initial Yield curve to any number of points. Why are only three points mentioned in the description?

A: Three points are mentioned because the GEMS Treasury Model has three state variables. The fitted model (i.e. the one before the application of the varying l(s) vector) is designed to fit at least three points on the initial Treasury curve. This is similar to the current Academy model procedure. In that model, the 1-Year and 20-Year yields are used to initialize the stochastic variables. The remainder of the initial points on the Treasury Yield curve are fit with an adjustment that decays linearly over the first 12 simulation months.

Q10: For real-world calibrations is l(s) set to be a constant?

A: For any one simulation, that vector is constant. However, points other than the Initial Shift value (i.e. l(0)) may change since they are part of the process used to fit the initial Treasury Curve.

Q11: Are there any other restrictions that should be put on the Treasury model's parameters?

A: Yes. First, since Theta and Kappa control the shaping of future Treasury Yields, they should be positive for all three state variables. Second, the same should happen for the corresponding Real-World combinations (i.e. Theta + Lambda0 and Kappa – Lambda1). For the currently exposed scenarios, these terms are guaranteed to be positive since they are derived directly from the targeted Mean Reversion Speed and Level. (Note: The risk premium parameters, Lambda0 and Lambda1, do NOT need to be positive themselves. In fact, they are often negative in the final calibration.) This second condition helps ensure that the simulated Treasury Yields do not explode in longer term simulations, say 100 years. Finally, it is desirable for the parameters to pass the Feller condition: 2 * (Theta + Lambda0) > 2 * Sigma ^ 2. This condition, which is met by the proposed "Revised Baseline" parameters, ensures that the state variables cannot reach 0 in the simulation.

Q12: What are the initial values Xi0, i=1,2,3? Will these be published with each monthly update?

A: Those values, which are referred to as the initial State Values, will depend on the initial Yield curve. Specifically, they will be calculated using the inversion process described in Section A, question #1. Conning is planning on publishing enough information to ensure that companies can determine these values.

Q13: With respect to the treasury calibration, is the optimization problem (i.e. solving for theta, kappa, displacement, etc.) a convex problem? If not, how does Conning ensure that the calibration used reflects a global minimum? Is this optimization problem as configured a constrained problem? Does the optimization function contain any regularization terms? Empirically does the optimization routine exhibit sensitivity to initial conditions?

A: The standard optimization procedure Conning uses goes through several steps:

- Select a set of parameters
- Use those parameters to iteratively project the likelihood of the next period's Yield curve
- Distill this series of projections down to a likelihood for the selected parameter set
- Optimize across the parameter space to determine the set with the maximum likelihood

In addition, there are numerous constraints put on the optimization routine, such as the ones outlined in question #11 in this section. As a result, Conning cannot guarantee that the optimization will find the global solution. However, in order to produce more stable calibrations, Conning does NOT redo this optimization with each update. Instead, we simply check that the selected parameters are still reasonable, rather than optimal, given the additional observed data points. Typically, a full refresh of the parameters is only undertaken about once every five years. The exact approach taken for this project will be determined as part of the **Parameter Update** exposure (step #8 of the ESG Implementation Timeline).

Q14: Does the inclusion of the l(s) vector to fit the initial Yield curve still ensure that the Treasury model is arbitrage free?

A: In some situations, this addition does not affect the Treasury model's arbitrage free nature. For example, if the Decay parameter is set to 0, then there is no grading off of this adjustment, just shortening as the simulation progresses (see slide 9 of the 12/3 LATF Treasury Model Overview slides for more information). Since this process generates a direct link between the simulation and the pricing, the resulting scenarios will still be arbitrage free. (Note: This setting is a requirement for Risk Neutral simulations with this particular model.) Additionally, if the l(s) vector is constant (i.e. the initial curve matches the fitted curve), then the scenarios will also still be arbitrage free. However, when the vector is variable and there is a gradual grading off, then there is some ambiguity. On the one hand, Conning has not solved for the mapping which would prove that the resulting scenarios are arbitrage free. On the other hand, we are also not aware of any arbitrage opportunities when the model is run this way. For more information about this item, please reference the paper written by Damiano Brigo and Fabio Mercurio which is referenced in the NAIC Technical Documentation Interest Rates DRAFT.pdf.

Q15: Is there an excessive risk premium that could be taken advantage of to artificially reduce required reserves or capital?

A: No. There is a risk premium built into the current calibration: the average 20-Year Yield will be about 100 bps higher than the average 1-Year Yield. Since this creates a downward sloping expected Yield curve, longer Treasuries will outperform shorter ones by slightly more than the risk premium. Specifically, in the 360th month, Long Government Bonds have an expected return of about 32 bps while the Short Government Bonds only have a 23 bps, which translates into roughly 108 bps on an annual basis. (Note: These figures come from 73-76 of the Fan Charts _ Revised Parameters.pdf.) However, there is also a difference in volatility: the long bonds are about 4 times as volatile as their shorter counterparts. Compounding this risk difference is the fact that these two categories are not perfectly correlated. As a result, differences in returns will also create a risk associated with the mismatch.

Additionally, Principle 5 in VM-21 section 1.B states that "…The use of assumptions, methods, models, risk management strategies (e.g. hedging), derivative instruments, structured investments or any other risk transfer arrangements (such as reinsurance) that serve solely to reduce the calculated stochastic reserve without also reducing risk on scenarios similar to those used in the actual cash-flow modeling are inconsistent with these principles. The use of assumptions and risk management strategies should be appropriate to the business and not merely constructed to exploit "foreknowledge" of the components of the required methodology."

Q16: The equations exposed in the NAIC Technical Documentation Interest Rates DRAFT are expressed in continuous time. Does Conning use a standard discretization process with monthly time steps like the AIRG model does?

A: No, the simple approach of replacing the dt with $\Delta(t - t\text{-}1)$ over monthly steps can negatively impact the expected shape of the scenario output especially over very long runs (i.e. decades). For example, consider the equation $dS / S = k\ dt$. In the simple approach, we would expect the next period's value to be based on $S * (1 + k\ \Delta t)$. However, the actual solution for this formula is $S * \exp(k * \Delta t)$. While the two are close, especially for small k and Δt, the differences will compound over the length of the simulation. Instead, Conning uses a process to approximate the actual integration which is specific to each stochastic equation. To minimize any discrepancies, this integration occurs with a weekly frequency.

Q17: Several documents mention the "Overnight Treasury Rate". What exactly is that?

A: The "Overnight Treasury Rate" is the value you get when entering 0 for the tenor (t) into the Yield Curve calculation (see Question 7 in this section). However, since both the numerator and denominator of the Affine functions approach 0 as the tenor does, we actually need to take the limit as t approaches 0. For the linear component (i.e. $-A(\tau) / t$), the limit is always 0 regardless of the Vega, Kappa and Sigma parameters. For the multiplicative component (i.e. $-B(\tau) / t$), the limit is always 1. That means that this rate will always be $l(s) + \Sigma X_i$ where l(s) reflects the current value of the shift value, adjusted for the decay and how far into the simulation we are, and the X_i are the current state values.

Q18: What is the difference between the Auxiliary and Affine functions?

A: As mentioned on page 4 of the **NAIC Technical Documentation Interest Rates DRAFT.pdf**, the GEMS Treasury Model is in the class of models called affine short rate models. One of the features of these models is that there exist functions of the tenor (τ) such that the price of a zero-coupon bond can be expressed as:

$$P(t,\tau) = e^{\sum_{i=1}^{3}(A_i(\tau) + B_i(\tau)X_i(t))}$$

. The $A(\tau)$ and $B(\tau)$ in this formula are the affine functions. If we wish to turn this price into a Spot Yield, we can use the fact that Price of a zero-coupon bond also equals $\exp(-\tau *$ Spot Yield). Combining these two equations, we get that Spot Yield contains components of the form $-A(\tau) / \tau$ and $-B(\tau) / \tau$. These are the auxiliary functions. You can find examples of the calculations for all of these items on the **Auxiliary Functions** tab of **Treasury Parameters _ Revised Baseline** Excel file on the website.

Q19: Is there any particular meaning to the risk premia (i.e. the Lambda values)? Specifically, how should we interpret the fact that some of them are positive and some negative?

A: There is no specific interpretation of the risk premia. Instead, they allow the model to have yield dynamics which differ from those implied by the initial Yield Curve. So, the Lambda1's affect the mean reversion speed for each of the State variables. Specifically, a positive Lambda1 will result in slower mean reversion. On the other hand, the Lambda0's affect the mean reversion level for these State variables: positive values lead to higher mean reversion levels. Whether this increases or decreases the expected returns for a specific Treasury Asset Class will depend on where the initial Yield curve is relative to these mean reversion levels.

Q20: On page 125 of the new Fan Chart _ Revised Baseline _ Dec 2020 on the website, it shows that the short end of the Treasury Yield curve is negative nearly half the time. What is causing this large probability? Can this be adjusted?

A: At the end of 2020, the 1-Month Treasury Yield stood at 8 bps, or roughly 0%. As mentioned on Page 15 of the **GEMS Treasury Model Discussion_NAIC_Final** presentation, the GEMS Treasury model has the ability to produce negative Treasury Yields. One key to this ability is that the volatility does NOT go to zero as the Yield goes to 0%. In fact, Page 1 of the **Fan Chart** presentation shows that the 1-Month Yield has a roughly 107 bps standard deviation. Given the low levels of the average Yield at that point, it is almost inevitable that roughly half of the scenarios at that point in the simulation will be negative.

There are a few changes that could lower this probability. First, there could be a larger reduction in the volatility at these low levels. Typically, this would be accomplished by increasing the Initial Shift value. The downside of this change is that it would make the potential range of results for the 1-Month Yield very narrow for starting conditions like these. Second, the mean reversion speed could be quickened. Since the Yields the model is reverting toward are well above these initial levels, increasing the mean reversion speed would yield a higher average yield at the same point in the simulation. In turn, that would make less of the distribution below 0. The downside of this change is that it would make the desired "low for long" scenarios substantially less likely.

Q21: On page 56 of the new Fan Chart _ Revised Baseline _ Dec 2020 on the website, it shows that the median 20-Year Coupon Yield is only getting to 2.85%. If the target for this value is 3.5%, why isn't the median getting to that level after 30 years? Does this suggest there is a problem with the mean reversion speed?

A: The Revised Baseline parameters were designed so that the mean, not median, 20-Year Coupon Yields will converge towards 3.5%. As you can see in Figure 1, convergence doesn't happen until closer to Year 70 due to the very low initial Yields. However, since there is positive skew in these simulated results, the median 20-Year Coupon Yield is always about 30 – 40 bps below the mean. So, it barely breaks 3% even after 100 simulation years.

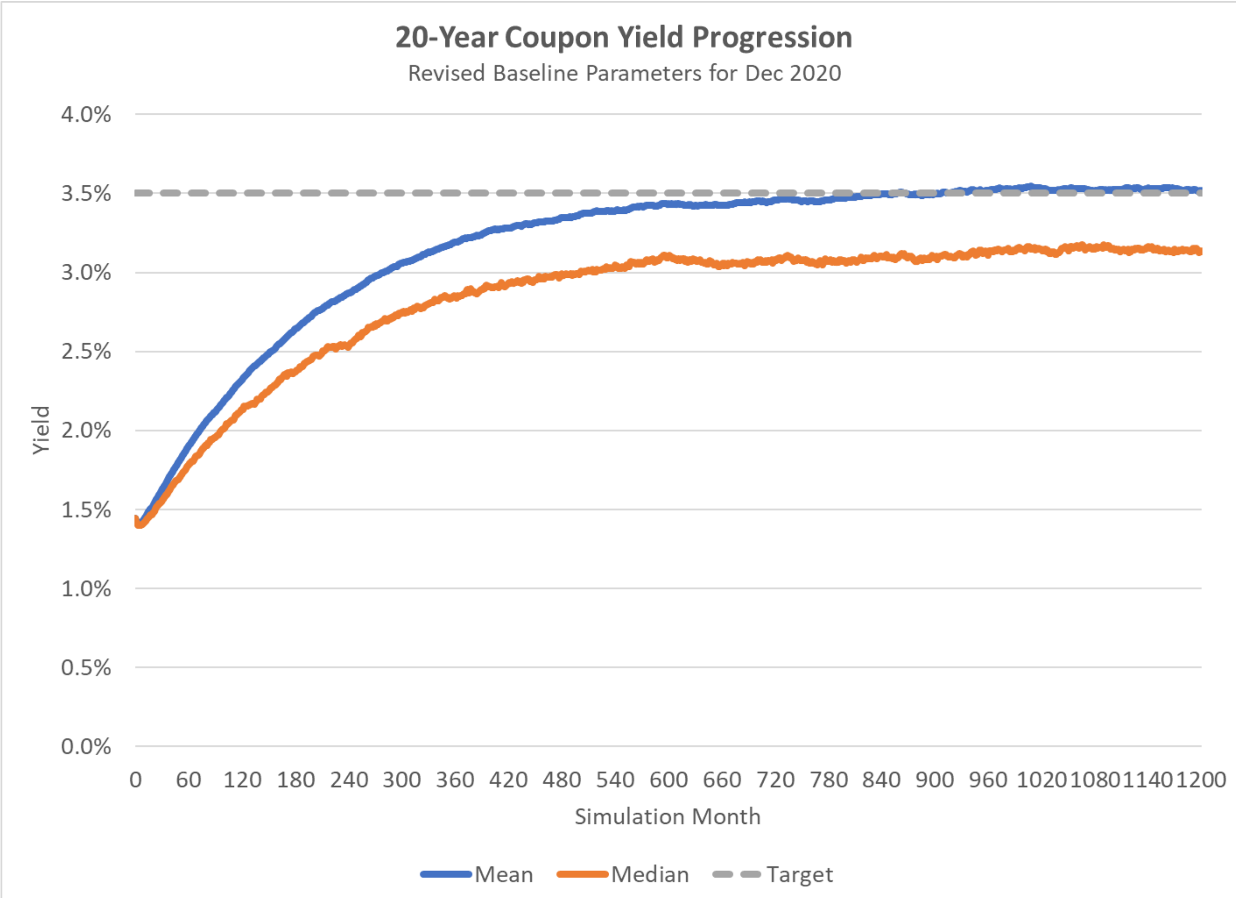

Figure 1: Projected 20-Year Yield statistics by month based on Revised Baseline Parameters and Dec 2020 initial Yield Curve

Q22: In all of the exposed scenarios, there is an odd relationship between the cumulative return distributions between the Treasury classes. Specifically, as the simulation progresses, the shorter maturity segments have less volatility than the longer ones (see Figure 2). Is this because of the specification of the GEMS Treasury Model?

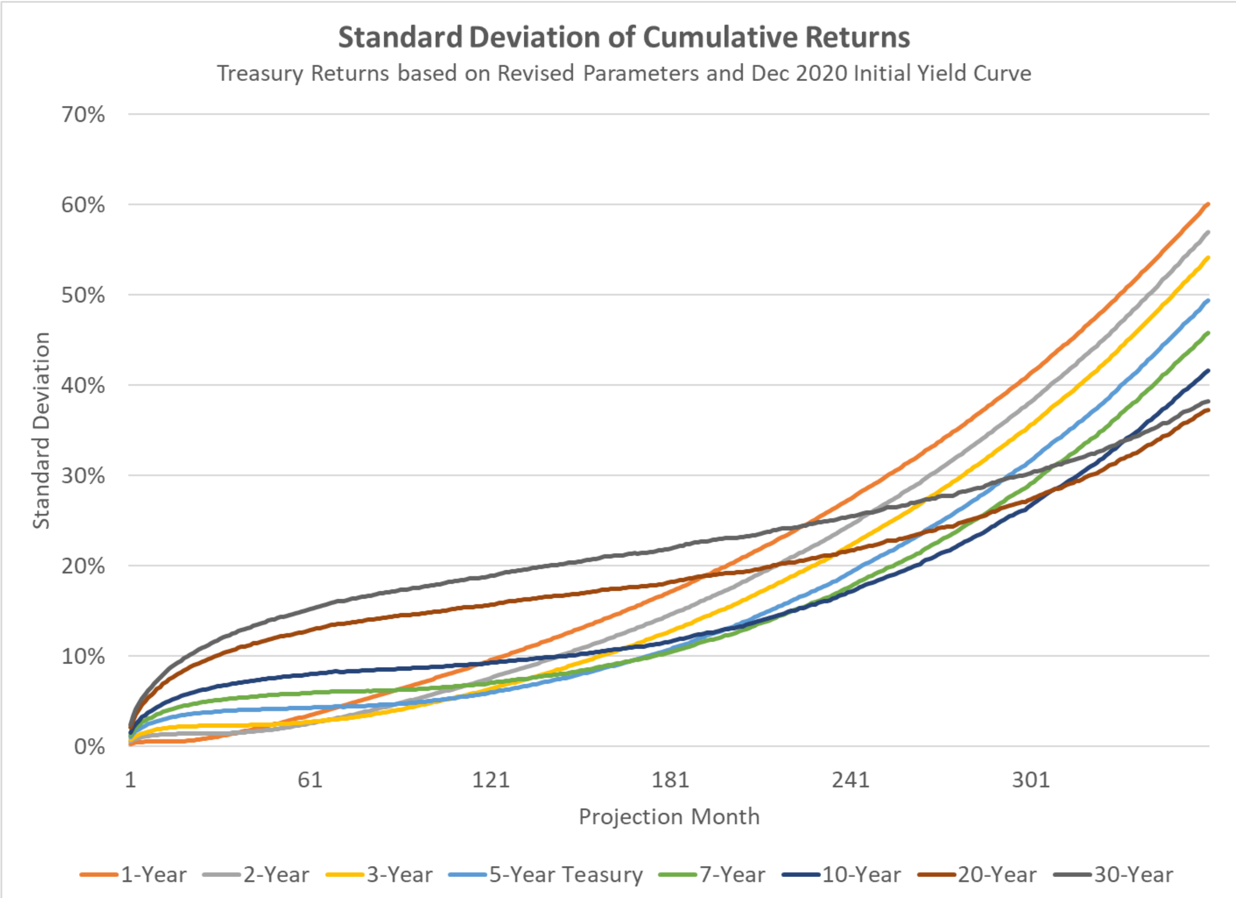

Figure 2: Simulated Standard Deviation of Cumulative Return for Treasuries of different maturity based on Revised Baseline Parameters and Dec 2020 initial Yield curves

A: No, this is largely because of the way Treasury Bond returns work. Specifically, a Treasury Bond will return, roughly, **Purchase Yield** / 12 – **Duration** * **Change in Yield** over a month. Early in the simulation, the **Purchase Yield** will be relatively stable since all scenarios start from the same initial value. So, the return volatility will be driven by the **Change in Yield**. Since longer Treasuries have longer **Durations**, they will tend to have higher volatilities in these early periods. Over the simulation, two changes happen. First, the **Purchase Yields** start becoming more and more volatile. This tends to have more of an impact on shorter bonds because the volatility coming from the **Duration** part of this equation is relatively low. Second, the **Change in Yield** starts feeding into future periods' **Purchase Yields**. As a result, negative returns in early rising Yield scenarios tend to be offset to some extent by higher returns in subsequent periods. This leads to cumulative returns that have very different profiles over the simulation periods depending on the **Duration**. An example may help explain this.

Consider a 20-Year Coupon Treasury investment under a few different scenarios. In all of them, we will start by buying at a 2% Yield. We will then consider 6 scenarios: Yields rise by 0% through 5% in 1% increments during the first simulation period and then stay fixed.[1] As expected, Figure 3 shows that the returns are much worse in the first year the higher the Yields spike up. However, when we move further into the simulation, the picture changes. Specifically, this investment is able to earn higher returns the higher the Yields have spiked up. Over time, these higher returns offset the initial price losses: Figure 4 shows that there is almost no variability in cumulative returns at the end of the 16^{th} year across these scenarios. While the dynamics are different in a fully stochastic model (e.g. there will be multiple shocks to the Yield curve), these dynamics will still shape the dynamics of the cumulative returns.

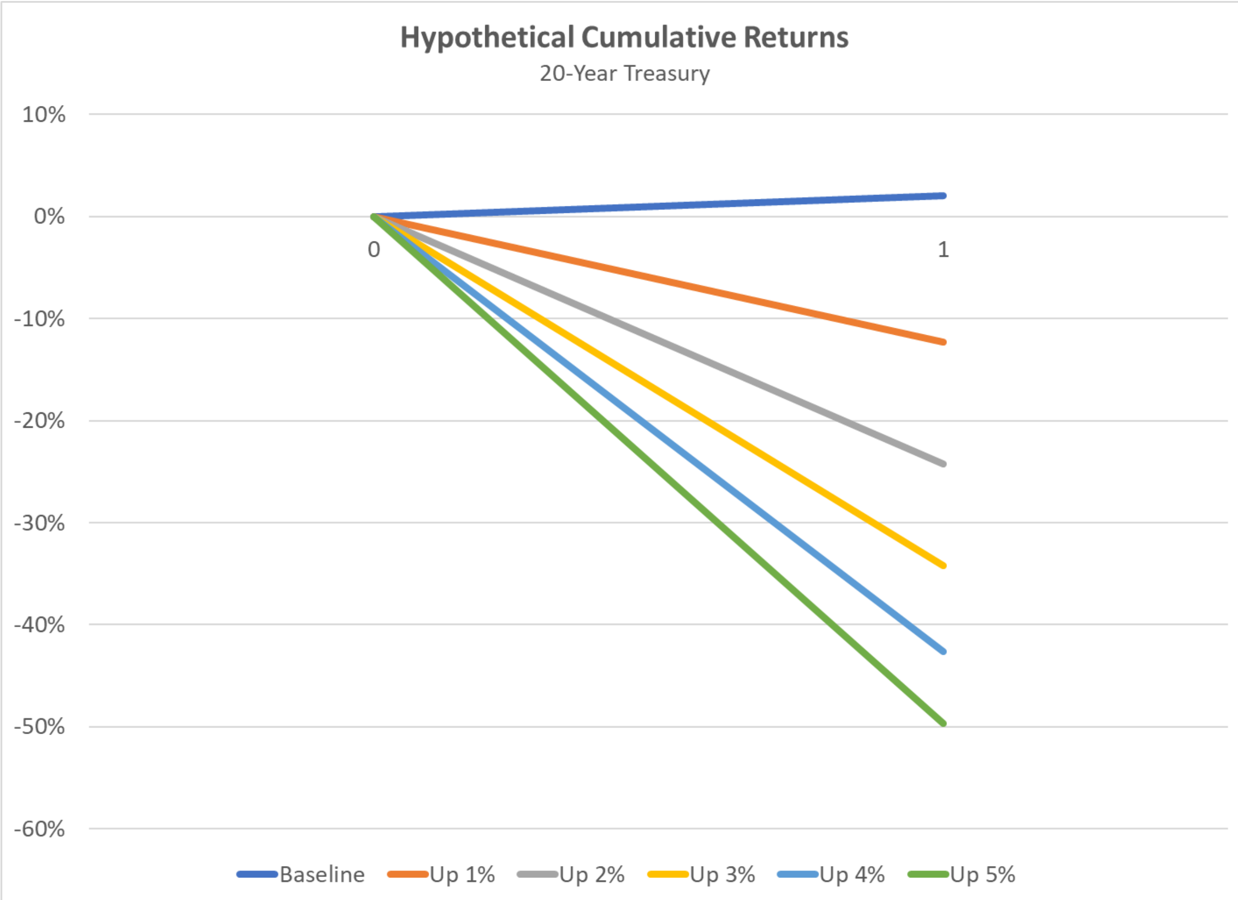

Figure 3: Calculated 1-year total returns for hypothetical 20-Year Treasury under different Yield curve movements

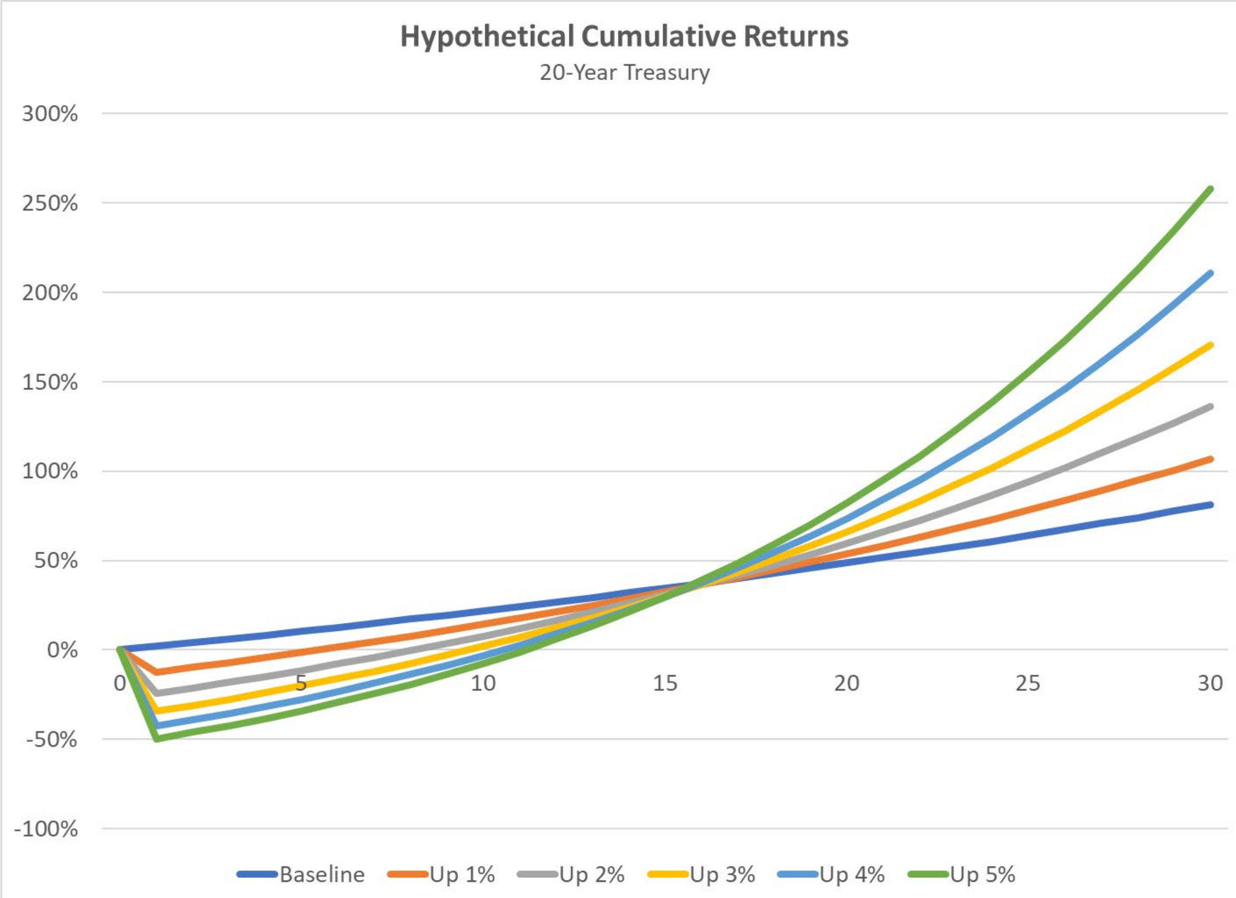

Figure 4: Calculated cumulative total returns for hypothetical 20-Year Treasury under different Yield curve movements

[1] For the purposes of this example, we are assuming: 1. a flat Yield curve and 2. annual rebalancing (for example, at the end of Year 1, the model is selling the now 19-year Treasury and buying a new par 20-year Treasury). The actual dynamics in the GEMS' model (i.e. variable Yields curves, monthly rebalancing) would not have a material impact on these results.

Section B: Equity Model

Q1. How are the international fund returns expressed: hedged or unhedged?

A: The international funds are in USD and are presented on an unhedged basis. The AAA ESG also expresses international fund returns on an unhedged basis.

Q2: On the February 25th LATF call, it was mentioned that over longer projection periods the wealth factors for equity indices will be roughly lognormal despite the jump parameters (slide 13). Can you please explain the reason for this?

A: This is a consequence of the Central Limit Theorem (CLT). Based on that Theorem, if X_i are independent samples from the identical distribution, then ΣX_i converges to a normal distribution regardless of the distribution of the X_is. A corollary of that theorem is that if Y_i are independent samples from the identical strictly positive distribution, then ΠY_i converges to a lognormal distribution. To see that, we use the transformation $Y_i = \exp(X_i)$. Then, $\Pi Y_i = \Pi \exp(X_i) = \exp(\Sigma X_i)$ since the X_i are independent if the Y_is are independent. Finally, if ΣX_i converges to a normal distribution, then $\exp(\Sigma X_i)$ converges to a lognormal one.

Now the key question: how does that apply to the wealth factor for equity indices? First, the wealth factor at the end of a simulation is $\Pi(1 + \text{Return}_i)$ across the simulation. As long as the Return_i can't be less than -100%, which is the case for the equity returns in GEMS, we can let $Y_i = 1 + \text{Return}_i$ in the above discussion. Then, the only question is whether or not these Y_i meet the other conditions of this Theorem. In Figure 1, we can see that the standard deviation for the Large Cap index is fairly stable over the 30-year projection period. Plus, the volatility reverts to long-term levels very quickly. As a result, these equity returns are close enough to being identically distributed that they will meet one of the weak forms of the CLT.[1] By comparison, the Money Market returns have dramatic shifts in their cross-sectional volatility (see the Revised Baseline Fan Charts for an example): the returns in year 30 are almost 5 times as volatile as the returns in year 1. Therefore, the Money Market returns will take longer to converge.

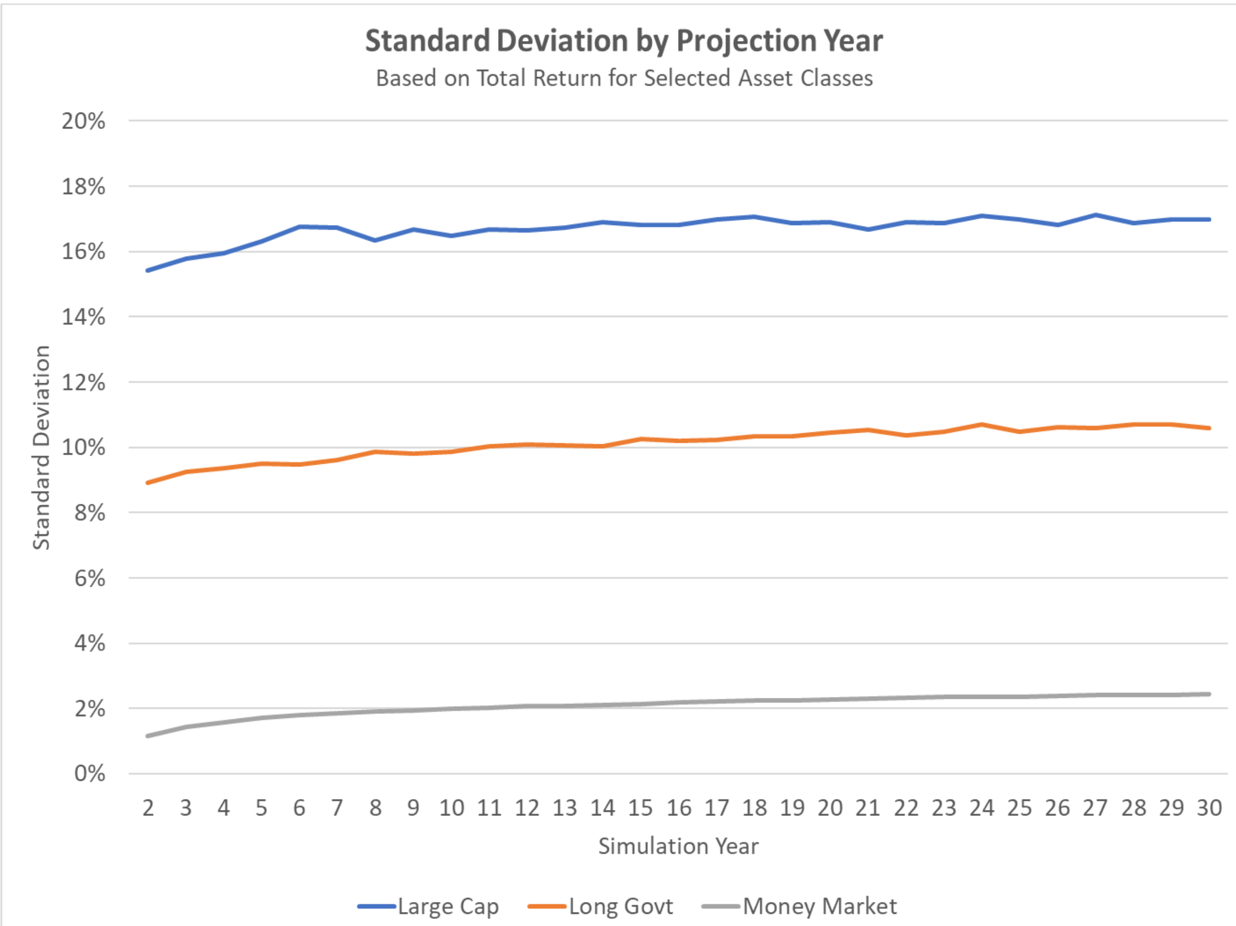

Figure 5: Standard Deviation across time based on the Baseline calibration released on February 24, 2021 for selected Asset Classes

Second, we need to consider independence. Under the CLT under weak dependence extension[2], we really just need the returns to have very little serial correlation. From Figure 2, we can see that this is the case for the Large Cap returns coming out of the GEMS model across the entire simulation period: the year over year serial correlation is never beyond +/-5%. As a result, we can expect fairly rapid conversion of the Large Cap asset class' wealth factor to a lognormal distribution. Money Market returns, on the other hand, have a serial correlation that approaches 1 in the later projection years. This is because the Money Market returns in later years are largely driven by the simulated short-term Treasury Yields. Since the 3-Month Treasury Yield at the end of the 28th simulation period is highly correlated to the one at the beginning of the 29th, we see very high serial correlation in this asset class. Once again, this means the Money Market asset class' wealth factor may never converge to a lognormal distribution.[3]

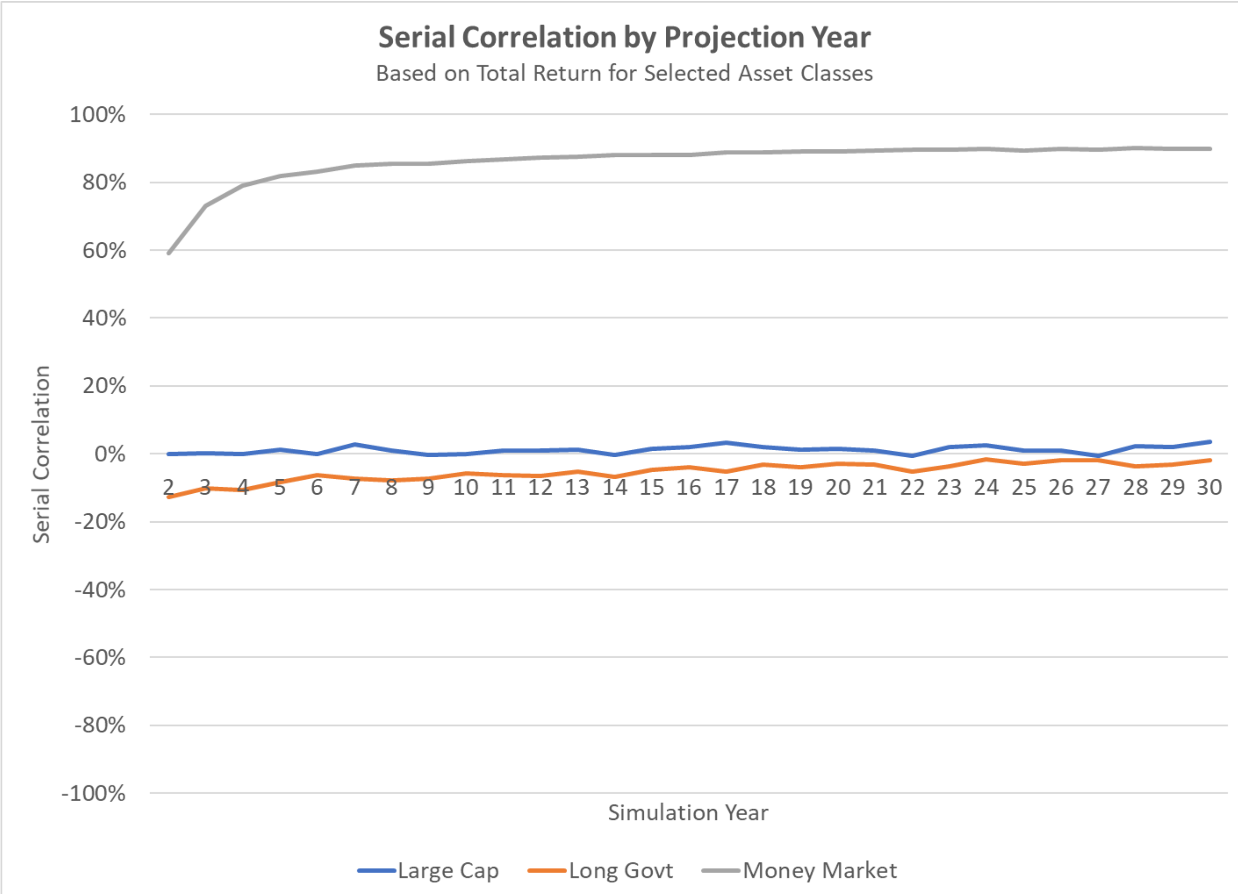

Figure 6: Serial correlation across time based on the Baseline calibration released on February 24, 2021 for selected Asset Classes

[1] Since the GEMS model links equity returns to short-term Treasury Yields, the expected returns will change over the projection period as Treasury Yields revert to their long-term targets. However, differences in means have no impact on the conversion process.

[2] https://en.wikipedia.org/wiki/Central_limit_theorem#CLT_under_weak_dependence

[3] Despite the many differences between GEMS and the current Academy models, all of these same results would apply to the current Academy model for both Large Cap and Money Market returns.

Q3: In the Revised Baseline scenarios posted on February 24, 2021, the wealth factors for some of the equity returns are quite extreme. For example, the maximum return at the end of the 30-year projection period for the Large Cap asset is over 14,600% while the minimum is -97.6%. Is this something that could be controlled through the model parameterization?

A: These values are almost entirely driven by the expected mean and standard deviation of the annual returns for this index. For comparison purposes, the corresponding values from the current Academy model for this index are about 19,400% and -53% based on the December, 2019 model. However, the Academy model has an average cumulative return that is roughly 47% higher, or roughly 1.3% per year[1]. If we adjust the Academy returns by this difference, then the corresponding values would be roughly 13,200% and -68%. The majority of the remainder of the difference is due to the fact that the GEMS returns are about 1.5% more volatile (i.e. 17.5% vs 16% annual standard deviation). As described in Q2 above, these returns end up being fairly close to lognormal, as can be seen in Figure 3.

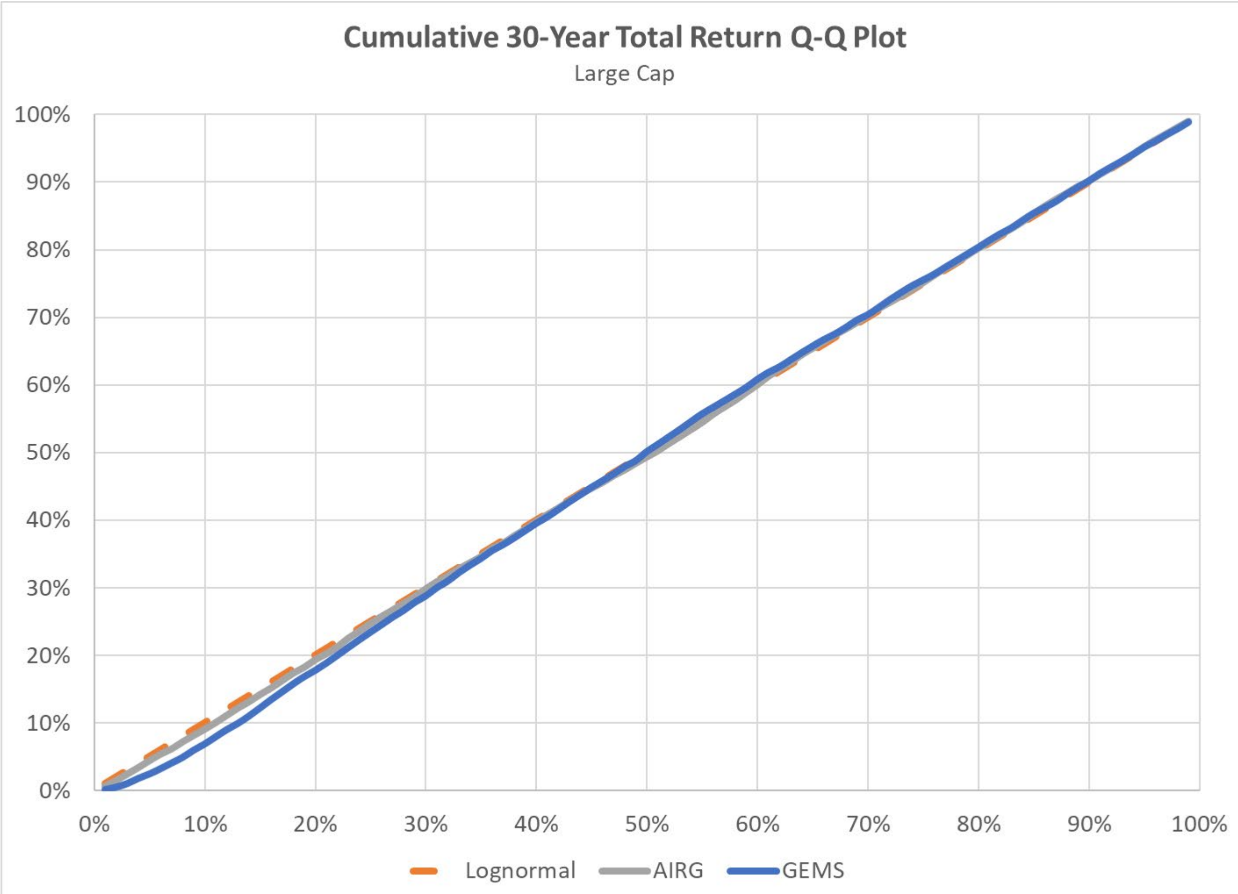

Figure 7: Comparison of simulated percentile distribution for the GEMS and Academy models' Large Cap wealth factor and the corresponding values from a lognormal distribution (i.e. the dotted line).

So, what would have to change in the model structure to alter these extremes? As mentioned above, the returns at the extreme tails are largely influenced by the targets for the expected mean and standard deviation. About the only other items that could be tweaked would be to add negative serial correlation for these projections, at least of the magnitude of those seen for the Long Govt index in Figure 2. With that adjustment, the cumulative returns would grow slower than those in the Revised Baseline model.[2] However, the historical data on which this index is built does not indicate that such an adjustment is in line with the data (see Figure 4).

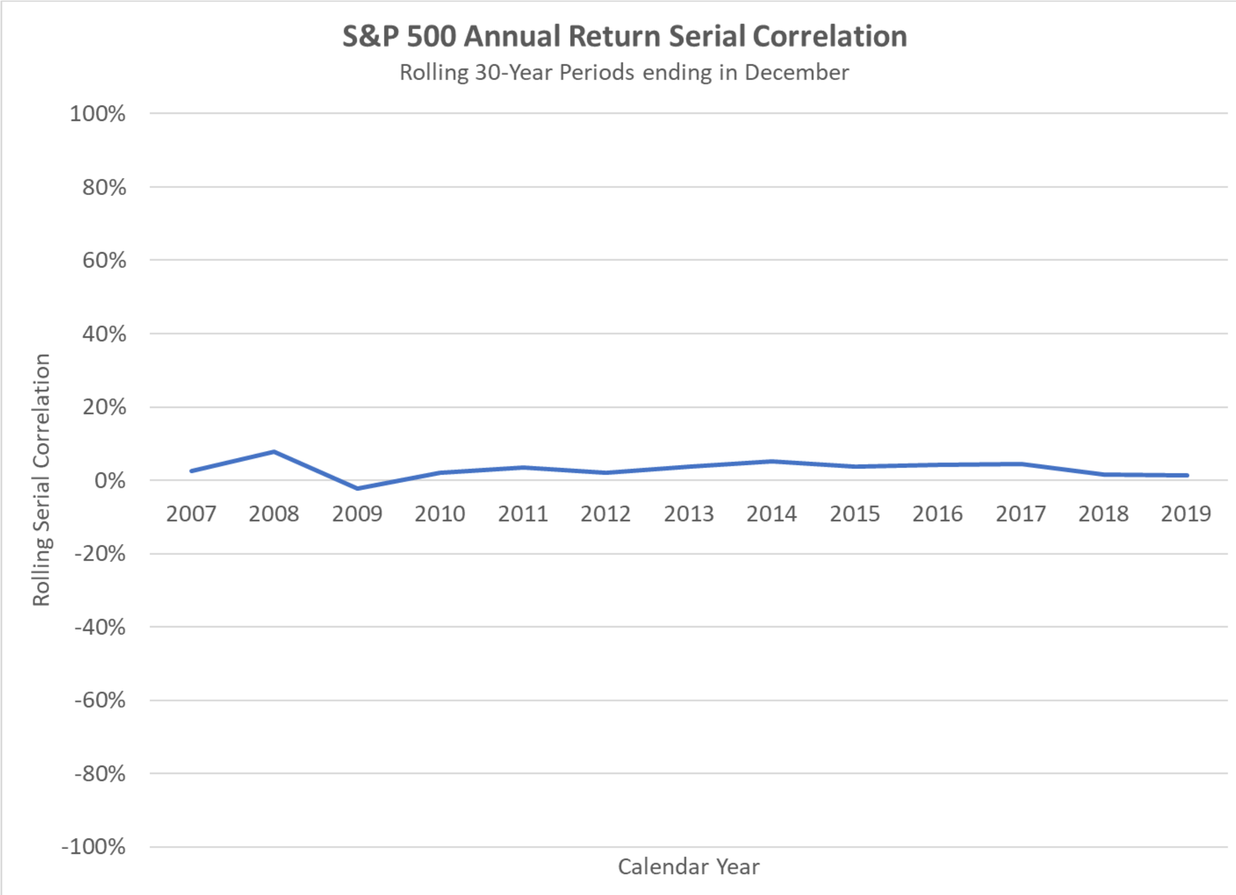

Figure 8: Serial correlation of annual returns of different rolling 30-year calendar years. For example, the 2015 figure is based on the 30 annual S&P 500 total returns from December 1985 through December 2015.

[1] The average annual Large Cap return from the AIRG is 8.3%. The corresponding value for the Revised Baseline GEMS Scenarios is 7.2%.

[2] With no serial correlation, the cumulative return's volatility grows with, roughly, the square root of time. With positive serial correlation, like those for Money Markets, they grow faster than that. With negative serial correlation, they will grow slower.

Q4: In the graph on page 12 of the Equity Model Discussion from the February 25th, 2021 meeting, the projected cumulative wealth factors from AIRG and GEMS at the end of the 30th year can be approximated by the line AIRG cumulative wealth factor = 1.3082 x (GEMS cumulative wealth factor) + 1.4558. What are the drivers of this difference?

A: As discussed in Q3 above, both the GEMS and the Academy's wealth factors are roughly lognormally distributed. So, the main driver of this ratio is the difference in expected returns between these two models: the AIRG model has an average of about 8.5%, the GEMS model has an average of about 7.2%. There is also a difference in the standard deviations, which brings the regression coefficient down from the 1.47 that would be indicated by the returns and the 1.3 for the actual data.

Q5: On page 3 of the Equity Model Discussion from the February 25th, 2021 meeting, the differential equation is listed as follows:

$$\frac{dS(t)}{S(t)} = [(r(t) - D(t)) + \mu_0 + \mu_1 V(t) - \lambda m V(t)]dt + \sqrt{V(t)}dW_1(t) + \gamma dN(t)$$

As the jump parameters λ and V(t) are positive and m is negative in page 10, the drifting factor due to the jump parameters is negative. Does it mean that the jump parameters would reduce the drifting factor for the equity return?

A: Not exactly. While that component (in red above) of the drift equation is positive, it is really designed to offset the expected drift from the jumps. Specifically, if we look at the last term (i.e. γdN(t)), it would have an expected value of E[γ] $*$ E[dN(t)] since the jumps are independent of their frequency. Based on the parameters on that page, E[γ] = m and E[dN(t)] = λV(t)dt. Combining that, we see that the expected value of that term is λmV(t)dt (i.e. the opposite of the final term in the drift equation). (Note: In the literature, this term (in red above) is referred to as the compensator for this reason.)

Q6: Conning stated that the interest rate generator is arbitrage-free, but the equity return has a positive risk premium. Does that mean that the GEMS equity model is not arbitrage-free?

A: The inclusion of the risk premiums in the Treasury and Equity model does not change the fact that both of them are arbitrage-free. Arbitrage-free means that there is no way to make a riskless profit on an investment. In general, the way to prove that a model is arbitrage-free is to show that there is a one-to-one mapping from the Real-World simulation space to a Risk Neutral measure. If we look at the equation on page 3 of the Equity Model Discussion from the February 25th, 2021 meeting, the differential equation is listed as follows:

$$\frac{dS(t)}{S(t)} = [(r(t) - D(t)) + \mu_0 + \mu_1 V(t) - \lambda m V(t)]dt + \sqrt{V(t)}dW_1(t) + \gamma dN(t)$$

This model will be Risk Neutral if the risk premium (i.e. μ_0 and μ_1) are both 0.[1] If we rearrange some of the terms, we can see that we need to find a mapping from (μ_0 + μ_1 * V(t))dt + $\sqrt{V(t)}dW_1(t)$ to just $\sqrt{V(t)}dW_1(t)$. Since we can do this by simply subtracting the drift term (i.e. the dt component), we can show that the GEMS equity model is arbitrage free regardless of the risk premia.

[1] While setting these risk premia to 0 will make the model Risk Neutral, the resulting model may not be consistent with tradeable options in the market. So, the Risk Neutral scenarios that Conning will be offering as part of its relationship with the NAIC will take the further step of recalibrating the other parameters of this model (e.g. λ, m and V(t)) to align with those prices each month.

Q7: Can you provide some more detail about the calibration process for the equity model? For example, how do you treat the movements we saw in the market in early 2020? Was that one jump or multiple jumps? If there is a jump, how do you determine the magnitude?

A: Like the Treasury model, most of the stochastic parameters of the equity model (e.g. V(t) and the jumps) are unobservable. In addition, for most price movements, there are multiple possible causes. For example, a large, rapid drop like we saw in March 2020 could be caused either by getting a really unlikely random selection for the $dW_1(t)$ or by having one or more jumps. As a result, the Conning calibration process involves a multi-step process where are the parameters are simultaneously estimated.

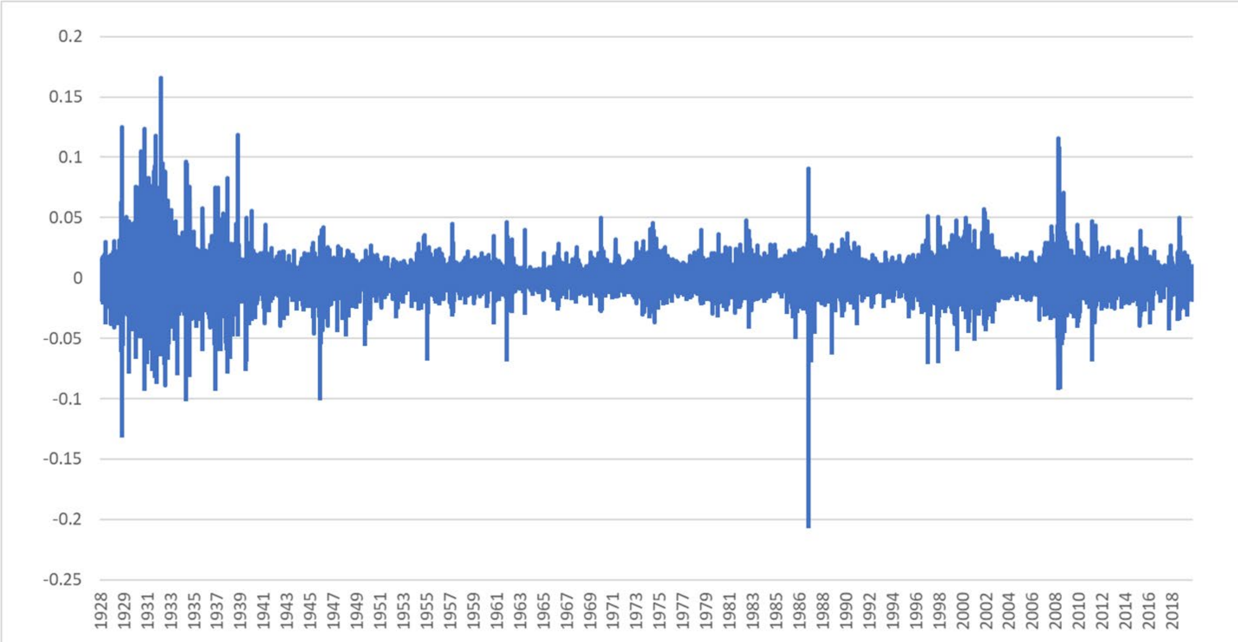

Figure 9: Daily returns for the S&P 500 from 1928 through 2019

The first step in the process is to apply a Kalman filter to the observed market data. At a given point in the historical series, the Kalman filter process combines the market data up to that point with a potential set of parameters to derive a best estimate of the unobservable model parameters. Next, those values are used to estimate the likelihood of the next observed value. By iterating this process across all the historical data, we can calculate a cumulative likelihood of the observed results given a set of model parameters. The final step in the process is to run an optimization procedure to find a set of parameters which maximizes this likelihood calculation.

So, what are some of the ramifications of this calibration approach? First, it means that all of the characteristics of the simulated results are interrelated in the calibration process. For example, both the stochastic volatility and the jump process impact the equity market's total return volatility. But they do so in separate ways: the jumps tend to drive more of the tail behavior, both left and right, while the stochastic volatility drives more of the center of the distribution. This is one reason why the GEMS model, which has jumps, has much fatter tails over short projection periods than the Academy model, which does not have jumps (see Figure 6). Second, when the market experiences bigger daily swings, either positive or negative, the calibration process will adjust the V(t) parameter. However, because these periods of large volatility tend to be relatively fleeting, the calibration of this parameter is driven largely by recent returns. Table 1 shows the results of this process for several different starting dates over the past year.

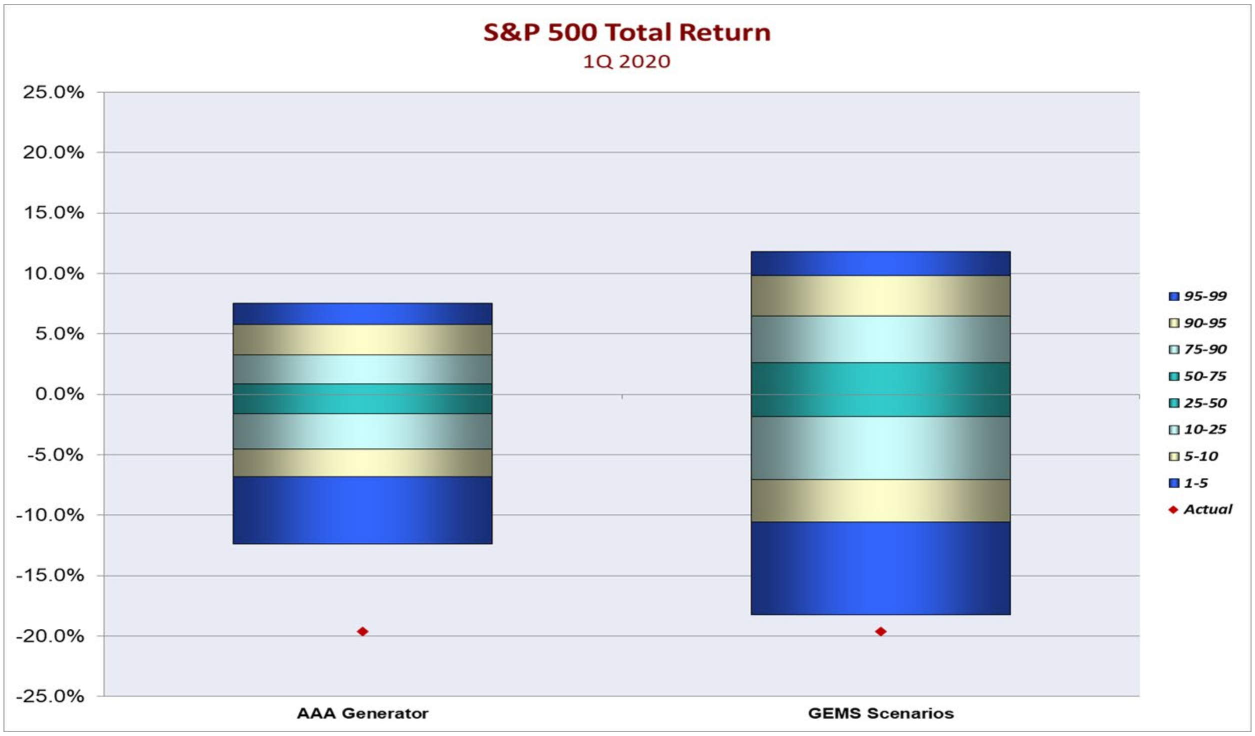

Figure 10: Comparison of the projections of 1Q 2020 S&P 500 total returns between Conning's standard GEMS calibration and the December 31, 2019 Academy generator.

Start Date	Large Cap	Mid Cap	Small Cap	Aggressive Equity
12/31/2019	0.0104	0.0148	0.0158	0.0189
3/31/2020	0.0128	0.0191	0.0198	0.0199
6/30/2020	0.0124	0.0201	0.0218	0.0172
9/30/2020	0.0091	0.0178	0.0181	0.0113

Table 1: Initial value of the variance parameter for the four equity indices included in the standard GEMS calibration at multiple starting dates

Q8: Does the fact that the GEMS Equity Model includes a link to the Treasury Model mean that equity returns will drop/rise with changes in the MRP?

A: Not necessarily. It will depend on how the equity return targets are expressed. In the alternatives exposed on February 24th, 2021, the assumption was that only the Treasury parameters were changing. In that case, changes to the MRP would directly lead to changes in the expected equity returns. However, if the target equity returns were expressed as absolute values (e.g. 8.5%), then changes in the MRP would be offset by changes in the equity risk premium parameters. In that case, the expected long-term equity returns would be unchanged. Consider the following example: the NAIC selects a target for the Large Cap's expected return of 8.0%. Based on the current Overnight Rate target of 2.25%, that would yield an equity risk premium of 5.75% (i.e. 8.0% - 2.25%). A year later, the target for the Overnight Rate gets lowered to 2%. Now, the Large Cap's equity risk premium would be 6% (i.e. same 8.0% target – new 2% Overnight Rate target). The result of these two changes will be that there is very little change in the expected long-term Large Cap equity returns.

Q9: With respect to the equity model, do the parameters vary over the simulation? If not, does that mean that the equity distribution for the first timestep will accurately reflect the history but will not at later timesteps?

A: The equity parameters are fixed throughout a simulation. So, once set, they will only change as a result of changes in the agreed upon targets. As a result, the only parts of the equity model that will vary are: 1. the stochastic volatility, 2. the dividend yield and 3. the price level, which combines the "regular" price movement and any jumps. In terms of calibration, the typical approach is to set calibration targets based on historical data for the long-term dynamics of this model (i.e. once all the items have stabilized including Treasury Yields). As a result, it is the first timestep's distribution, not the later timesteps, than will often differ from the targets based on historical data. For example, in the first timestep, the expected equity return will be higher (or lower) than the target when short Treasury Yields are higher (or lower) than their long-term targets.

Q10: The exposed scenario set appears to have roughly 0% +/-25% correlation for individual scenarios. Does this mean that the Conning ESG links equities to rates solely via an equity risk premium assumption and does not assume any explicit rate/equity correlation? How is Conning determining or considering the observed range of correlations in their scenarios?

A: As discussed on the March 11, 2011 LATF call, the equity model has two direct links to the Treasury model. First, the expected drift term is linked to Overnight Treasury Rate: this is the r(t) in the first equation on page 3 of the February 25, 2011 LATF Equity Equations presentation. Second, the Dividend Yield is linked to a longer Treasury Rate: this is the z(t) in the third equation on that page. (Note: In the exposed calibrations, the simulations used the 10-Year Yield.) There are no other direct or indirect links between these two models. Since there are no other links between these two models, Conning is not specifically targeting this correlation.

Q11: Please describe the process through which current (@ valuation date) equity volatilities revert towards long-term equity volatility targets, with a focus on the speed and strength of the reversion process.

A: The formula for the stochastic volatility's evolution can be found in the February 25, 2011 LATF Equity Equations presentation: it's the second equation on page 3. The parameters for the 4 native US equity indices: Large Cap, Mid Cap, Small Cap and Aggressive US can be found on page 7 of that same presentation. For example, the Large Cap's Beta value of 0.396 is consistent with a mean reversion speed of roughly 2.5 years (i.e. 1 / 0.396).

Q12: Describe the out of the box capabilities in GEMS to allow different relationships (vs. just substituting different parameter values)?

A: In general, Conning only supports one model for each main driver (e.g. the 3-factor affine for Treasuries, the stochastic volatility with jumps for equities). Even when a model is a subset of the Conning model (e.g. the Cox-Ingersoll-Ross model is a subset of the GEMS' affine model), Conning would need to build a new calibration tool since the current system is designed specifically for the selected model structure.

Q13: Are there any additional changes that Conning would be willing to consider / implement?

A: The GEMS model is very flexible, so it can be customized to support a wide range of extensions or replacements for the existing framework. Conning is happy to consider tapping into any of these features if/when the NAIC thinks that they may be beneficial.

Q14: The jump process in the equity model seems mostly designed to capture daily movements like the ones from Black Monday. However, these scenarios are mostly focused on projections in terms of years and decades. Given that the results from this model converge towards a lognormal distribution over those periods (see Q2 of this section), has any consideration been given to using a simpler equity model?

A: The jump process does have its largest impact over shorter horizons, typically up to a year. For example, slides 16 and 17 of the Overview of GEMS Equity and Corporate Model 12.17.2020 LATF shows that the GEMS Equity model has substantially larger tails over a one quarter projection period than the current AIRG model, although still smaller than the observed movements in the first two quarters of 2020. However, there are also other advantages of this model. For example, slide 22 of that same presentation points out that adding the jump process also allows a better alignment of the simulated results with the historical data across the entire range of results for equity indices than is possible with the simpler AIRG model. In addition, while the projection period will be long, that does not mean that reserves will only be impacted by returns over the entire projection period. Instead, there are a number of features of the products and companies' risk management procedures, like dynamic hedging, which will be heavily influenced by the entire path of results. Given these facts and since Conning has already developed a calibration method for this model, there does not seem to be any benefit in using a simpler model.

Q15: There are several results (e.g. monthly drops of 25% or more) that have only happened once or twice, yet they occur in a large number of these posted scenarios. Does that suggest that there is a problem with the equity model calibration?

A: No. For the variables we are projecting in these scenarios, we have no more than 100 years of reliable data. For some (e.g. NASDAQ returns), we have substantially less. So, if something has happened only once, we can assign it a rough probability of 1 / 1200. However, in the posted scenarios for a 30 year projection, we are looking at 3,600,000 simulated months (i.e. 10,000 scenarios * 360 months). So, even for a 1 / 1200 event, we would expect it to come up roughly 3000 times in this size simulation.

Section C: Corporate Model

Q1. Why are bond funds assumed to only invest in industrials (not financials)?

A: One of the goals of the bond funds was to make them consistent with the data being included in the Robust Data set. Since that data set is only going to include one set of Corporate Yields, which will be for industrials, we are suggesting only using these bonds for the bond fund returns.

Q2. Do BBB bonds in the U.S. Investment Grade Corporate bond fund returns reflect a selected BBB bond, a universe of BBB+ / BBB / BBB- bonds, or some other blend of bonds?

A: For any of the Corporate ratings, the bonds will be issued exactly at that rating (i.e. only BBB bonds in this case). The returns will reflect a broadly diversified set of bonds of the selected rating and maturity.

Q3: Are the credit spread model and related bond fund returns arbitrage free?

A: Yes, like the Treasury and Equity models, the Corporate Yield Model in GEMS is arbitrage free.

Q4: Would the NAIC and Conning consider releasing credit spreads and migration/default losses underlying the exposed Basic Data Set bond fund returns for the iterative scenario calibration discussion? That would facilitate understanding and allow evaluation of their reasonability and historical context even if they will not ultimately be included in the Basic Data Set.

A: Yes, the NAIC and Conning would be happy to expose this data for the calibration discussions.

Q5: What are the coupon, maturity and rating characteristics of the bonds used in the fund modelling?

A: The proposed characteristics of the different Bond Categories can be found on Page 9 of the GEMS Equity and Corporate Model 12.17.2020 LATF presentation. For example, the US Long Term Corporate Bonds category would consist of equal parts of each of the following:

- 10-Year A Corporate
- 30-Year A Corporate
- 10-Year BBB Corporate
- 30-Year BBB Corporate

All of these will be issued as Par Yields.

Q6: What are the rebalancing assumptions for these funds through each timestep in the projection?

A: At start of each month of the simulation, the model will rebalance each of these Bond Classes back to their target allocation. There will be no rebalancing within the month. For the quarterly and annual files, the returns will just be accumulations of these monthly values (i.e. they will also reflect monthly rebalancing).

Q7: How do the coupon, maturity and ratings of the fund change over the timesteps in the projection?

A: At the beginning of each month, the maturity and rating distribution will be reset to the then current Par Yield. Over the next month, the maturity will shorten by one month and the rating will adjust based on the scenario's transition matrix. (Note: The transition will be probabilistic, like for a bond index, not selected, like it would for an individual bond.)

Q8: How are bond fund returns calculated?

A: First, GEMS calculates the price and total return for the individual components. Specifically, at the beginning of each month, the model is issuing new Par Bond indices. So, their coupon is based on current market Yields and are issued at a price of 1. (Note: To better align with indices, these indices will be using monthly paying bonds. This also avoids any confusion with the Income calculation due to accrued interest.) At the end of the simulation month, each index is priced based on the shorter bond and new market conditions. For a Treasury index, this just means the cash flows are all one month shorter. For a Corporate index, it means that there is a weighting based on the price of these flows under the different Corporate Ratings and the scenario's simulated transition matrix. Next, these values are weighted together based on the Asset Class' selected weightings. (Note: As mentioned in Question Q7 in this section, these weights are fixed across the entire simulation.) For quarterly and annual files, these monthly calculations get accumulated. Finally, the income return is calculated as the total minus the price return. For the monthly files, this calculation will ensure that the income return aligns with the coupon. However, for the other summaries, the income return will include some reinvestment components. But, in all summaries, the price and income returns will add to the total.

Section D: ESG Ancillary Tools

Q1. What is the purpose of the Scenario Reduction Tool referenced in item #9 of the ESG Implementation Timeline?

A: Conning will deliver a full set of 10,000 economic scenarios on a monthly basis along with scenario subsets produced using the Scenario Reduction Tool that is eventually adopted. The purpose of the Scenario Reduction Tool is to select subsets from the full set of 10,000 that are representative of the full set. A proposal to follow the American Academy of Actuaries' scenario picking methodology has been exposed for public comment through March 7th, 2021. See the link below for more details.

ESG Scenario Picker Tool

Q2. What is the GEMS® API?

A: The GEMS® API (Application Programming Interface) will offer companies an alternative way to generate data in either the Basic or Robust Data Sets. The API code can be incorporated directly into third-party software to allow for faster processing of the data and a more tailored workflow. This will allow users more flexibility in the number of scenarios and projection length in their simulation process. The GEMS® API is available for a fee from Conning.

Q3. Does the API accept a starting Yield Curve or is it fed the initial state variables?

A: Right now, the API starts with the initial state variables. An enhancement to the API to accept the starting yield curve as input is planned.

Q4. Does the GEMS API support dynamic generation of forward-starting inner loop scenarios, based on a user-specified outer loop scenario Yield curve at that future projection period?

A: Yes, the GEMS API can be configured to produce inner loop scenarios based on a user-supplied outer loop scenario Yield curve.

Q5: Will the GEMS API be capable of dynamically generating the 16 Stochastic Exclusion Test scenarios for VM-20 and Company Specific Market Path scenarios for VM-21 (also at future dates)?

A: Right now, the GEMS API is not capable of producing either of those items. No decision has been made about whether or when that functionality will be added to that program.

Q6: Can the NAIC or Conning share information about the GEMS API processing speed, i.e. how long would it take to generate 10,000 scenarios on a single processor?

A: Given the wide range of processor speeds and the need for integration with other systems, Conning won't be providing a specific example of processing speed. In particular, the way in which the GEMS API is called (i.e. with initial state variables versus with initial Treasury Yields) can have a marked impact on the total time. In addition, Conning expects that many companies may only want to produce a subset of the Basic Data fields (e.g. just Spot Yields, not Par Yields) within their applications. As a result, those that are interested in testing out the GEMS API should contact Conning directly about setting up a trial. While there is an annual fee associated with licensing the GEMS API, Conning has agreed to offer free trials of this software to insurance companies during this phase of the process.

Q7: Are the 50, 200, 500, or 1000 selected scenarios only available as pre-generated files, or will the functionality also be in Conning's API?

A: The functionality will not be built directly into the GEMS API. Instead, each month, Conning will apply the selection procedure to the 10,000 scenarios to come up with scenarios for each of these subsets and publish them to the website. With this list of scenarios, companies will be able to instruct the GEMS API to only generate those scenarios that are needed for their selected subset. Since the GEMS API program will produce the same results by scenario any way it is run (see Section F, Question #7), this will allow companies that use the GEMS API to produce only the scenarios that they want.

Q8: How will the percentiles be applied to the equity return distribution to get the equity SERT scenarios?

Will the equity percentiles be applied:

1. **To the total equity return distribution directly,**
2. **separately to the price and income return distributions,**
3. **To the equity return distribution given / conditional on Conning's selected SERT rates, or**
4. **To the distribution of accumulation factors derived from one of the aforementioned options?**

A: #1 - The equity percentiles will be applied directly to the cumulative total returns. To be consistent with the current methodology, these calculations will be done across the entire 10,000 scenarios, not conditional on the Treasury Yields. For example, Scenario 1 (Pop up, high equity) and Scenario 2 (Pop down, high equity) will have the same projected equity returns despite very different Treasury paths. In terms of the Dividend Yields, those will assume to be fixed at the initial level for all 16 scenarios.

Q9: How will the Corporate Bond Fund returns be calculated in the SERT scenarios?

A: Since the Corporate Bond returns are dependent on both the Treasury and Equity movements, they will vary with these underlying movements. For example, in Scenario 1 (Pop up, high equity), Corporate Yields will increase for all ratings and tenors. However, all of the other random drivers (e.g. the Corporate Jump process, transition variability) will be turned off.

Q10: For the SERT scenarios, could there potentially be unintended volatility (within a scenario) or instability (between valuation dates) given equity jump processes or potentially other discontinuous elements in the Corporate model?

A: All of the models involved are continuous, so there won't be any discontinuities. It is possible that there could be "wiggles" in the process since it is being applied to a limited sample, but that is very unlikely given the percentiles involved and that there are 10,000 scenarios. This graph below shows the results of the proposed methodology applied to the Large Cap index for the LATF Exposed scenarios exposed on December 18, 2020.

Figure 11: Projected Large Cap Cumulative Price Returns based on proposed methodology for Baseline Calibration scenarios released on December 28, 2020.

Section E: ESG Field Test

Q1. Our company would like to volunteer to participate in the field test. How can we sign up?

A: Companies wishing to participate in the field test should contact Reggie Mazyck by March 1st, 2021 at rmazyck@naic.org and provide the following information:

- Company name
- NAIC company code
- Names and email addresses of company contacts
- A list of the product types the company intends to include in the field test

More information is provided in this document:
ESG Field Test Request

Q2. What is the scope of the ESG field test?

For both Variable Annuity (VM-21 and C3P2) and Life (VM-20) business, it seems that the new ESG directly replaces the existing prescribed AIRG parameterization. However, for fixed annuities (C3P1) there will be additional methodology considerations as the new ESG will not necessarily act as a direct substitute for the one that is currently prescribed. For example:

- **C3P1 currently uses a special 12 or 50 scenario subset designed to approximate 95%-tile interest rate risk. Would new subsets be developed, or would Conning's 200 scenario set be used directly?**
- **C3P1 currently prescribes only the interest rate scenarios. Would prescribing GEMS mean that equity scenarios also become prescribed? This would expand the scope of C3P1 to both interest rate and market risk.**
    - **Some companies currently use a deterministic equity scenario with the prescribed C3P1 interest rates scenarios.**
    - **If C3P1 were expanded to cover market and interest rate risk, it seems like we'd need to split the total, similarly to how C3P2 needs to be split.**
    - **In addition, if stochastic equity returns were applied to inforce general account assets (e.g., alternative assets like hedge funds and private equity), would there be a double count with asset risks covered by C-1?**

A: The scope is expected to include VA (VM-21 and C3P2), and Life (VM-20), with the new ESG directly replacing the existing prescribed AIRG parameterization. For C3P1, the methodology needs to be considered, along with field test timing, given the developments on VM-22. For now, please assume C3P1 is in scope for field testing. This will give regulators an indication of the level of participation for companies with products subject to C3P1.

Q3: Is the NAIC expecting to produce alternative calibrations with changes to the starting rate levels to help insurers understand the impact of the initial curve on the projected distribution?

A: While the exact design of the ESG Field Test has not been finalized, there is an expectation that it will include Basic Data Sets for multiple start dates. Feedback on which dates would be appropriate, both from the industry's ability to run them through their models and from the perspective of understanding the sensitivity, would be helpful to this process.

Section F: Scenario File Form and Format

Q1. Once the new ESG is in production, how will scenario files be accessed?

A: Conning will produce scenarios from the Basic Data Set as of each month-end and post them to the ESG landing page on Conning's website by 4:00 PM Central Time on the first business day of the following month. The ESG landing page on Conning's website can be accessed by clicking the link in the "Economic Scenarios" section of the NAIC's PBR webpage. This will be different than the prior process employed by the American Academy of Actuaries, where an excel tool was made available for users to generate scenarios on demand.

Q2. The scenario file is very large and doesn't have the same format as the Academy scenarios. Can this be changed?

A: Yes. Please provide feedback with specifics on how you would like the output to be provided.

Q3. The 12/18/20 exposure only includes 30 projected years of economic scenario data. Is it possible to produce economic scenario files with a longer projection period?

A: Yes. Please provide feedback on the projection period desired for the scenario data. Please note that the GEMS software can generate an unlimited number of periods.

Q4. The International Diversified Equity (MSCI EAFE) and Aggressive Foreign Equity (MSCI Emerging Market) do not have Income Returns in the sample data set. Will this be split between price and income in the future?

A: The model only projected total returns for these indices. Conning is developing an alternative calibration for these two indices which will split their total returns into Price and Income.

Q5. Is the scenario file labeled "Initial Exposure thru Jan 2021 GEMS Output for Dec 2019" considered to be the "Basic Data Set"?

A: Yes. The contents of the Basic Data Set are summarized in the "Basic Data Columns" file. The comment period for the exposure has been extended to March 7, 2021. The initial set of scenarios represent a first cut at the types of changes that may be desired for the ESG. Additional modifications are expected based on comments received.

Q6. There are 10,000 scenarios included in the 12/18/20 exposure. Is there a simple way to extract a smaller set of scenarios from this file?

A: If you would like to look at a smaller sample, you can just use a portion of the file (e.g. the first 1000 scenarios). The time periods for each scenario are in order, so 1,000 scenarios would be the first 36,000 rows of data. This is different from the scenario selection process exposed on 1/21/21, but it will allow you to look at a representative subset. If you are interested in just the characteristics of the scenarios, you may also be interested in the Initial Exposure Full GEMS Fan Charts on the site. That is a PDF summary for each of the columns across the full 10,000 scenarios and 360 months.

Q7: Will scenarios be consistent from month to month? In other words, will new scenario number 1 be comparable to old scenario number 1 or will the scenarios be an entirely new random set?

A: The GEMS model is designed to produce the same random number sequences regardless of start date. So, scenario 1 in the December 2019 scenarios will be closely linked to scenario 1 for the December 2020 files. Like the current AAA ESG, there will be differences in these results, but they will be due to either changes in initial conditions or calibration targets. Currently, the GEMS software and the GEMS API have different random processes built into them. Conning is updating the code to ensure that these two simulation methods are consistent. Those coding changes will be in place before the end of 2021.

Q8: What time steps will be available (daily, weekly, monthly, quarterly, annual) within the scenarios?

A: Conning will produce data for three different time steps: monthly, quarterly and annual. The scenario-by-scenario results will be the same, just rolled up for the longer time steps. The GEMS model uses continuous time equations, so it can be integrated over shorter time periods. (Note: For improved accuracy, the current standard is to use weekly time steps even though the shortest timestep is monthly.) However, companies that are interested in accessing this functionality will need to talk to Conning about using the GEMS API.

Section G: Calibration and Parameter Updates

Q1. How often will the parameters of the model be updated?

A: This is to be determined and is included as item #8 on the ESG timeline.

Q2. What will the governance process be for monthly scenario releases, routine changes to the ESG calibration, and more structural changes to the ESG model?

A: This is to be determined and will be addressed as part of items #8 and #25 on the ESG timeline.

Q3. Will calibrated parameters of the GEMs model be published?

A: The expectation is that the parameters will be published. There will also be formulas published which link the target parameters, such as the MRPs, to the GEMS' model parameters.

Q4. Will the data used for each calibration be publicly available?

A: Every attempt will be made to use public information. However, when that is not possible, Conning will release the Bloomberg ticker, or other appropriate indicators, for the source of the data.

Q5. Will a spreadsheet tool be made public that replicates the new algorithms used to develop the scenarios?

A: No. While some components of the model will be documented via spreadsheets, such as the Treasury Targets and Parameters.xlsx file that was included in the Exposure Draft, those interested in generating the scenarios directly should contact Conning about either the GEMS API or software.

Section H: Documentation

Q1. What is the plan for releasing additional documentation on the Treasury, Equity, and Corporate models?

A: Conning has produced initial documentation for the Treasury, Equity, and Corporate models. This documentation can be accessed by clicking the link under the "Economic Scenarios" section of the NAIC's PBR Webpage. More information will be added to the documentation throughout the project as it evolves. Specific requests for additional items to cover in the documentation can be made to Reggie Mazyck at the NAIC.

Q2: What does GEMS stand for?

A: Originally, it stood for Global Economic Market Simulator. Although, now Conning simply refers to their ESG offering as GEMS.

Q3: What random number generator and process is used?

A: For the current scenarios, Conning used a standard linear congruential pseudo random generation process. However, that may change once we harmonize the method used by the software and the API (see section F, question #7).

Section I: 12/17/20 LATF Equity and Corporate Model Presentation

Link to 12/17/20 Equity and Corporate Model Presentation

Q1. On page 13, are the 2 year and 30 year "columns" annualized returns?

A: No, those are summaries of the total return over the associated year. For example, the values in the second column reflect a summary of the 10,000 total returns from Sept 2021 through Sept 2022 from the current AIRG model.

Q2. On page 18, are the 34 negative thirty year returns for GEMS, and 3 for the AIRG, out of 10,000 scenarios? One would expect about 50 negative returns for the AIRG, if it is for 10,000 scenarios.

There have been no negative 30-year periods for the S&P 500, even if you include the Great Depression. There are some good reasons to exclude the Great Depression from consideration for S&P 500 returns. The S&P did not become 500 stocks until 1957, being only 90 stocks from 1929 until 1957. SEC rules and other governance and advances in understanding of economics provide greater information and protection for investors than existed in the 1920's and 1930's. Comparisons to those periods might be more appropriate for some of the smaller and less well diversified indices in the scenarios.

A: Yes, both of those counts are out of 10,000 scenarios. These were scenarios selected where the cumulative return was below 0 for all 30 years of the simulation. So, it is a subset of the ones that end the simulation below zero.

Q3. How are the correlations on page 22 being computed?

A: For those correlations, we first sorted the relevant scenarios (i.e. rolling 12-month periods for the historical data, the 10,000 scenarios for the first year for the simulations) based on the US Large Cap (i.e. S&P 500) total return. Next, we broke that data down into 5 equal quintiles. So, for the GEMS scenarios, the ones in the 1st quintile reflect the 2000 scenarios with the smallest US Large Cap total returns. Finally, the bars reflect the correlation between the US Large Cap and US Small Cap (i.e. Russell 2000) within these quintiles.

Section J: 12/18/20 LATF Exposure

Link to 12/18/20 Exposure

Q1. Scenarios were provided as of 12/31/19. Can they be provided as of 9/30/20 or 12/31/20?

This would be useful given lower starting rates than 12/31/19, and the scenarios could use the 3.25% 20-year mean reversion target for UST.

A: Yes. However, we expect to improve the model calibration and provide a new set of scenarios based on comments received on the 12/18/20 exposure. We propose to wait until then to provide scenarios as of different dates.

Q2. In the target formulas shown in the Targeting Example.xlsx file included in the 12/18/20 exposure, it looks like Theta and Lambda0 get added together in the targets. Why are there two separate parameters?

A: For the Long-Term State value targets (i.e. Column J of the **Model Parameters** tab of **Targeting Example.xlsx** file), the formula does add together **Theta and Lambda0**. A similar manipulation happens with the **Kappa** and **Lambda1** parameters: those same formulas use the difference between these two parameters. Both **Lambda0** and **Lambda1** are risk premium parameters. Specifically, they are the ones which allow the long-term reversion levels for Yields to differ from those implied by the initial Yield curve. Whenever the model needs to price a set of cash flows (e.g. determining a particular Spot Rate), it does NOT use these risk premiums. That is why all of the formulas on the **Auxiliary Functions** tab of that spreadsheet, which are used to determine spot rates at different tenors, only reference parameters from the **Theta**, **Kappa,** and **Sigma** columns. This is also why there are two separate parameters: one that gets used for pricing (i.e. Theta and Kappa) and one that gets used as a risk premium (i.e. Lambda0 and Lambda1).

For more information, see the [Treasury Model documentation.]

Q3. Do the mean reversion level and speed in the Risk-Neutral model impact the scenarios in the Real-World model?

A: No, the Real-World model only relies on the mean reversion characteristics of the Real-World model, just like the current Academy generator.

Section K: Governance

Q1. What is the LATF ESG exposure, testing, and approval process?

Please explain the process for:

- **Regularly scheduled / routine updates beyond initial condition or formulaic updates (E.g., bringing an additional year of historical data into the calibration), and**
- **More fundamental model changes (e.g., structural changes, changes in calibration methodology / philosophy).**

A: The governance process is to be determined and will be addressed as part of items #8 and #25 on the ESG timeline.