NAIC Economic Scenario Generator (ESG)
Questions and Answers (Q&A)
Last Modified: 3/10/2021

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.

Table of Contents

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.

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.

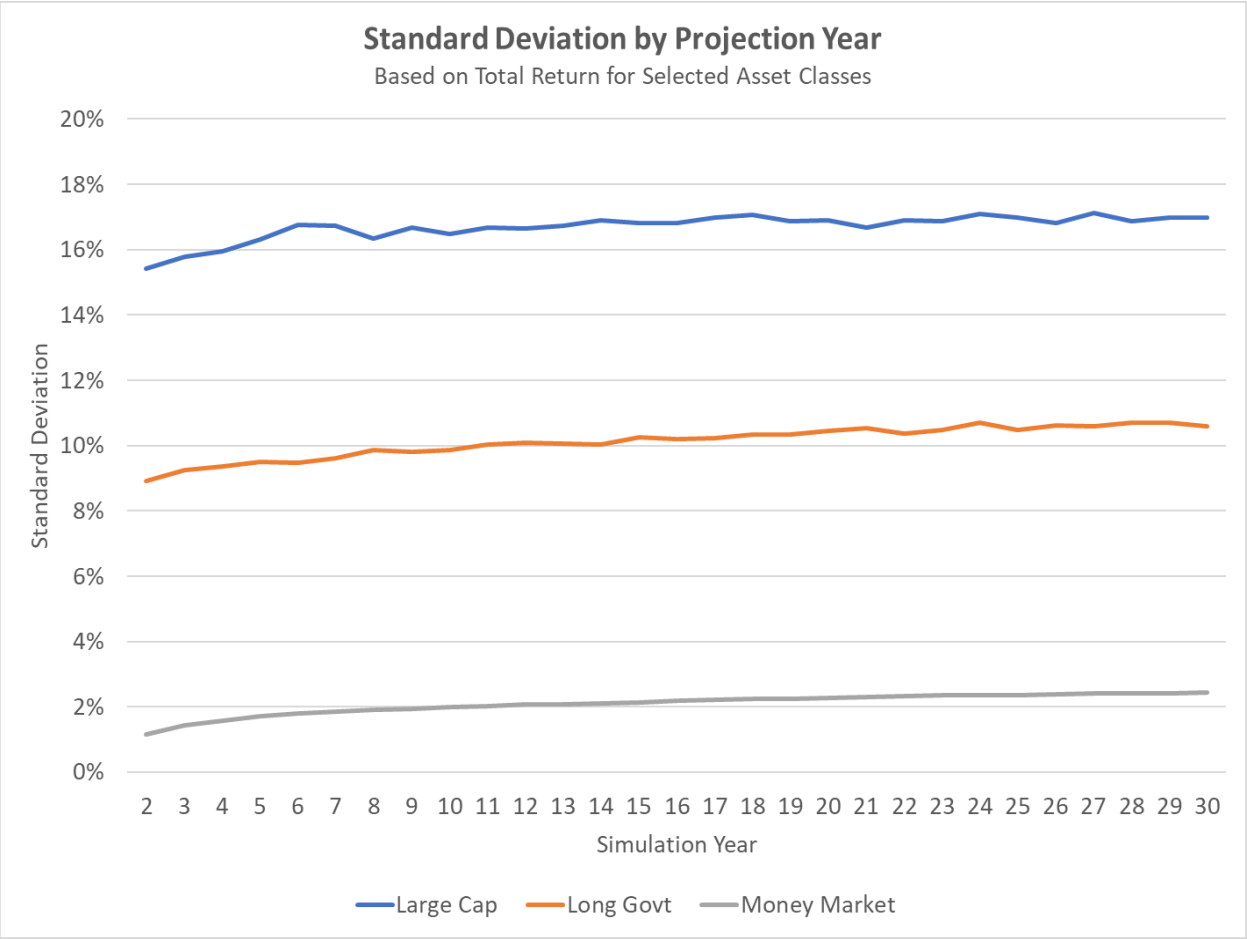

Figure 1: Standard Deviation across time based on the Baseline calibration released on February 24, 2021 for selected Asset Classes

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]

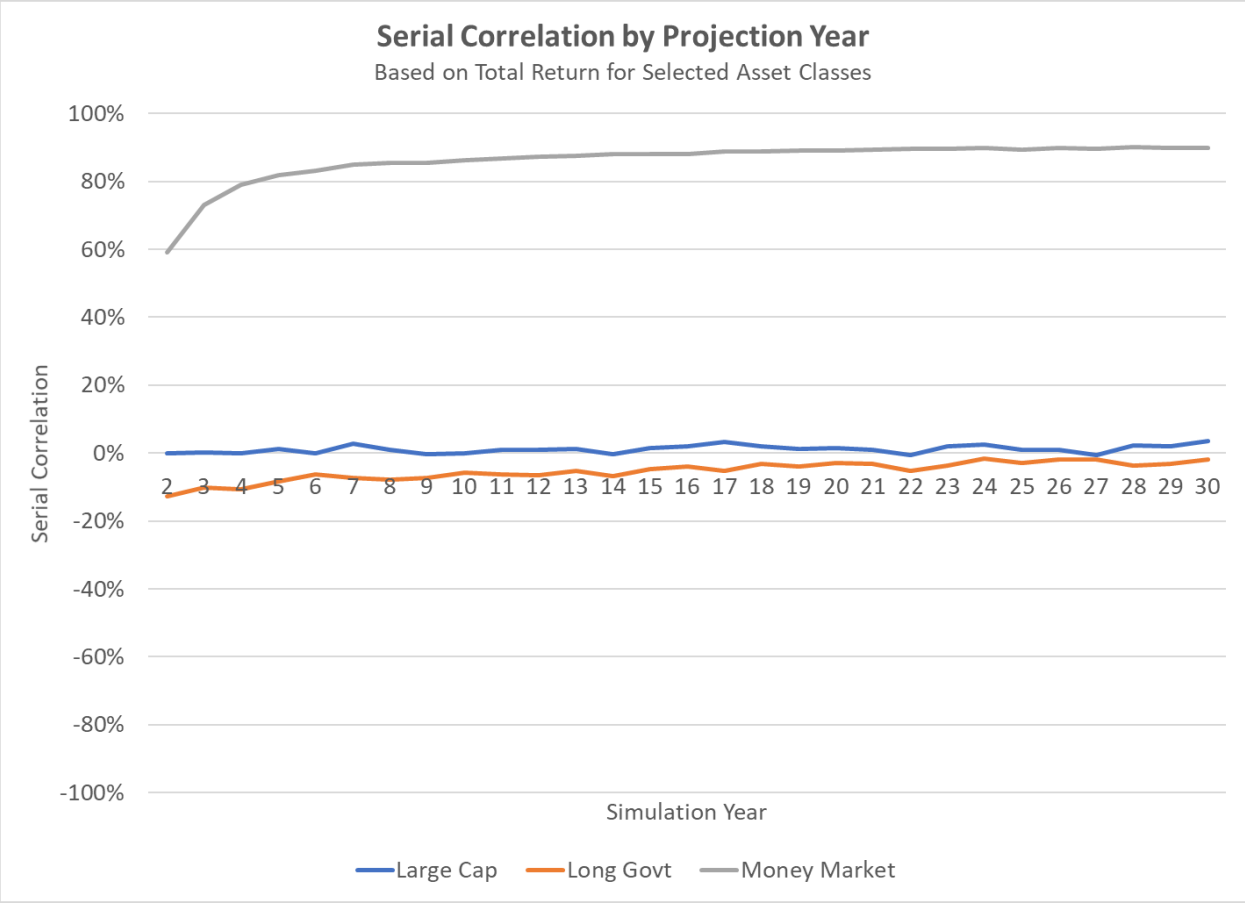

Figure 2: Serial correlation across time based on the Baseline calibration released on February 24, 2021 for selected Asset Classes

[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.

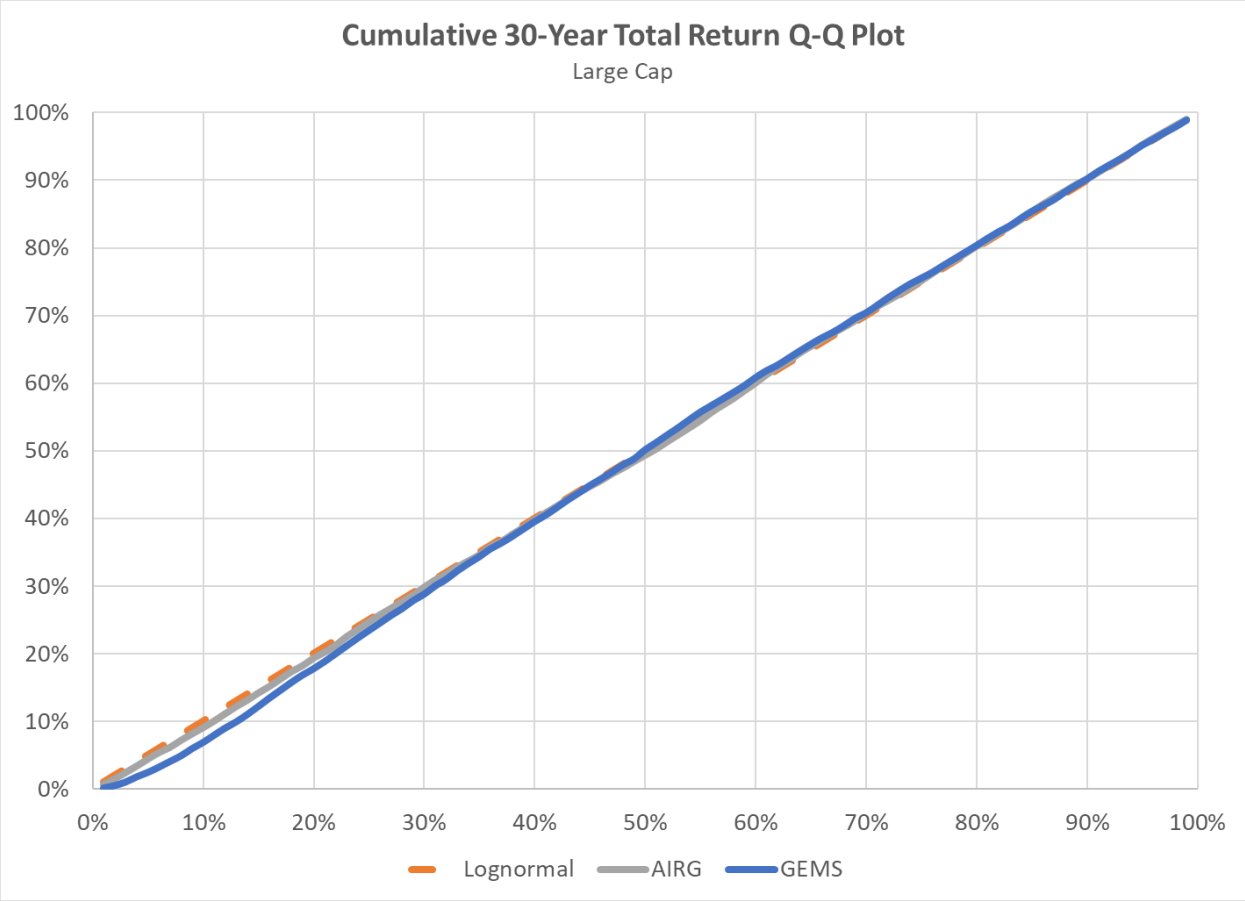

Figure 3: Comparison of simulated percentile distribution for the GEMS and Academy models' Large Cap wealth factor and the corresponding values from a lognormal distribution (i.e. the dotted line).

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).

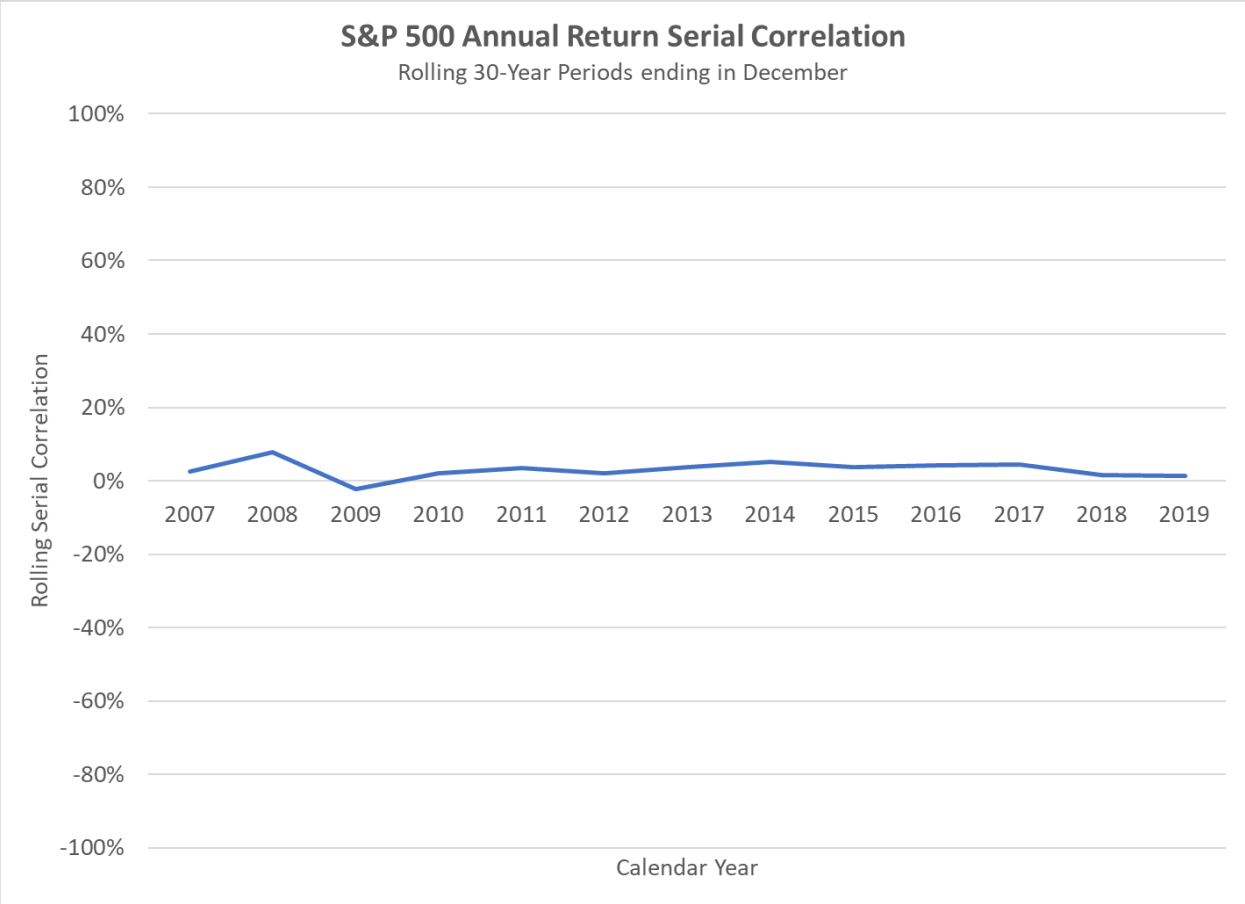

Figure 4: Serial correlation of annual returns of different rolling 30-year calendar years. For example, the 2015 figure is based on the 30 annual S&P 500 total returns from December 1985 through December 2015.

[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 $E[\gamma] * E[dN(t)]$ since the jumps are independent of their frequency. Based on the parameters on that page, $E[\gamma] = m$ and $E[dN(t)] = \lambda V(t)dt$. Combining that, we see that the expected value of that term is $\lambda m V(t)dt$ (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 ($\mu_0 + \mu_1 * V(t)$)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.

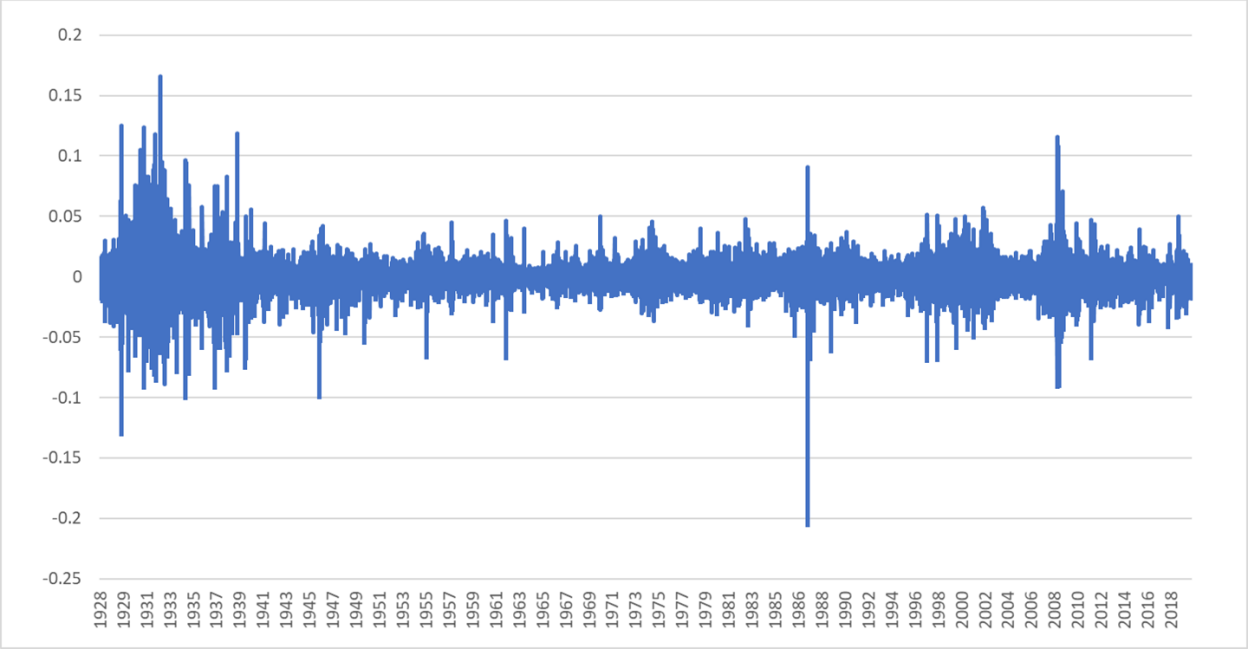

Figure 5: Daily returns for the S&P 500 from 1928 through 2019

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.

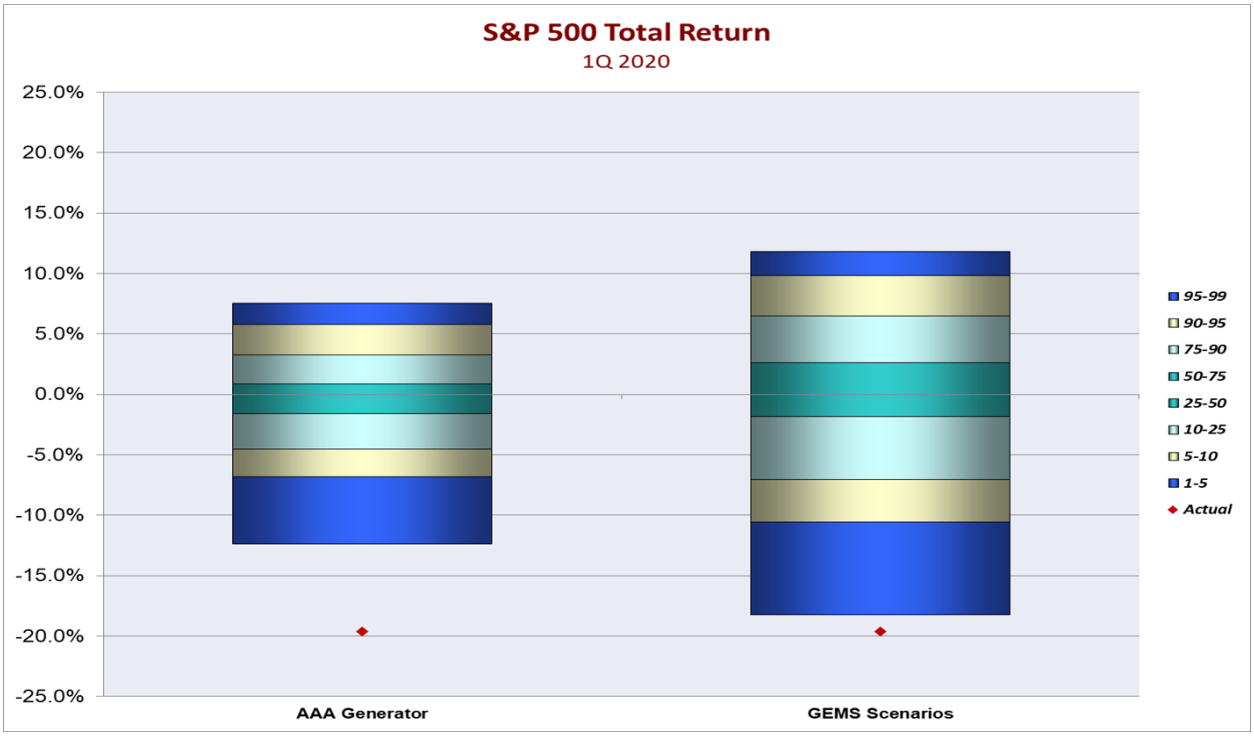

Figure 6: Comparison of the projections of 1Q 2020 S&P 500 total returns between Conning's standard GEMS calibration and the December 31, 2019 Academy generator.

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

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.

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.

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.

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.

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.