AMERICAN ACADEMY *of* ACTUARIES

Report from the American Academy of Actuaries'
Economic Scenario Work Group

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Life and Health Actuarial Task Force

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Economic Scenario Work Group

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Economic Scenario Work Group Report

Summary

The Economic Scenario Work Group (ESWG) was asked to develop scenarios and calibration criteria so companies could utilize either Academy-generated scenarios or their own internal model that calibrates to the Academy model. This report will summarize the recommended scenario generator model and provide a status report on calibration criteria.

The ESWG received its direction from the Standards for Stochastic Methods Work Group that reported to the NAIC in September 2006. The charge to the ESWG is:

- The ESWG will provide a prescribed generator containing updated parameters (a recommendation is being provided electronically with this report, along with a scenario picking tool)
- The ESWG will generate calibration criteria so companies can use their own generator (a recommendation is provided in this report; adjustments are likely once the Academy work groups integrate these results with sample blocks of business)
- Generators will not use pre-selected criteria to approximate specific blocks of business (this methodology differs from C-3 Phase 1, where either 12 or 50 scenarios were chosen to represent the most extreme results from 200 generated scenarios applied to specific annuity blocks of business)

The direction provided by the Standards for Stochastic Methods Work Group was accepted by the NAIC and formed the basis of the ESWG's work.

A scenario generator will never accurately predict the future. Using historical data, the scenario generator model reflects what could happen if the past were recreated consistent with the level and volatility of previous interest rates. The Stochastic Log Volatility (SLV) model is one of many that can be chosen. It has been found to build reasonable interest rate scenarios and is consistent with the model approved previously by the NAIC which is currently used to define capital requirements. Scenario generators for internal models are not limited to the SLV, although their output will need to calibrate against the Academy scenarios. Since model characteristics vary, tolerances have been added to allow consideration of alternative generators.

Definitions are as follows:

- Short rate: 1-year Treasury rate
- Long rate: 20-year Treasury rate
- Spread: Long rate minus short rate

The NAIC [LHATF and LRBC] received a report describing the proposed scenario generator at the Summer 2007 NAIC meeting, and there have been only slight

adjustments since then. Technical aspects of the generator are included in Appendix I. The SLV model utilized is consistent with the previous interest rate model approved by the NAIC during the C-3 Phase I project that was completed in 1999. The revised SLV model contains several updates that have been implemented:

- Refreshed the parameterization using monthly Treasury data from 1953-2006
- Established processes (formulas) to automatically update evolving parameters
  - Mean reversion parameter (MRP) for target long interest rate
  - Starting volatility for the SLV process that governs evolution of the log long rate
- Prepared a Microsoft Excel "generator" for broad distribution to the industry
- Documented the model, data sources, key decisions and parameters

The primary assumption updates utilized are:

- Soft cap of 18% for the long rate limits the maximum rate with minimal impact on overall results ("Soft" means the limit is applied before the random shock)
- Updated mean reversion parameter for the long rate to reflect additional history and to give more weight to recent history relative to the previous model (5.50%, down from previous 6.55%; see Appendix III for the rationale)
- A methodology to automatically update MRP
- Initial volatility parameter of 2.45%
- A methodology to automatically update the initial volatility parameter

Calibration criteria have been established to govern the principles-based approaches. The goals were:

- Subject to the recommended calibration requirements, companies will be able to use their own interest rate generators
- Allow models with similar characteristics to the Academy model with Academy parameterization to "pass"
- Criteria should be dynamic and not require frequent revision by the Academy
- Standards will include qualitative and quantitative requirements, with the qualitative requirements built around documentation.

Actuaries must document their reasoning for the scenarios chosen. The calibration criteria include:

- By definition, the ESWG assumes that the 10,000 scenarios of the SLV model are a calibrated "safe harbor". But, subsets of this scenario set must pass the calibration criteria.
- A definition of "acceptable tolerances" around the SLV statistics - this will ensure that the calibration criteria remain dynamic and relevant in the future.
- Use of the following statistics:

  - Distribution results at the 5% and 95% point-in-time percentiles for long rate, short rate, and spread distributions at 1- , 5- , 10- , and 30-year horizons.
  - Statistic considered will compare the ratio of the tail statistic with the median (i.e., 95th percentile / median and median / 5th percentile)
  - Because volatility parameters are the driver, these tolerances will be 10% (0.90) at shorter horizon points. At the 30-year time horizon the mean reverting parameters will tend to dominate and the factor will tighten to 5% (0.95).
- ESWG expects to develop mean statistics covering partial time horizons as well, but this is not yet completed. For example, the mean long rate over the period between the 5-year and 10-year point in time statistic for an internal model might be compared to the base scenario set. As these calibration criteria receive a trial run, it is likely that these metrics will evolve.

One question still being discussed is how large a subset of the 10,000 provided scenarios should pass the calibration criteria. This will impact how broad the acceptable tolerances will be. The currently proposed tolerances are expected to pass a subset of 1,000 scenarios but might not pass with smaller numbers. The actuary will choose the scenario set, and this might vary by product line and asset mix combination.

The ESWG considered a variety of tolerances around the calibration criteria. A tighter banding will tend to force companies to use the Academy-generated scenarios or the SLV model. While this would encourage consistency, companies which have chosen their own generator may be forced to choose between a set of scenarios that they have worked with in the past and have confidence in, versus a set of scenarios that is new to them. A wider tolerance band will allow greater use of internal generators. While there will be less consistency between companies, there should be more consistency with a company's internal risk management process. Because Principles-Based Approaches encourage companies to take responsibility for their risk management process and develop internal models that best reflect their own blocks of business, the ESWG supports broader calibration tolerances as long as the actuary is required to document and support the choice of scenarios. The actuary should qualitatively document enough information about an internally-generated model that a qualified actuary could understand the approach.

At this point the ESWG does not know how the proposed calibration criteria will impact the amount of RBC that a company is required to hold relative to the SLV model. After the calibration criteria have been tested with actual blocks of business, it is possible that the ESWG might have to tighten or loosen the calibration criteria that is proposed in this report.

Methodologies have been developed to allow both the mean reversion parameter and the volatility parameters to adjust over time to better reflect current conditions. The long rate will revert to a simple average of the long rate over the past 50 years (600-month median, adjusted down by 25 bp) and the past 36 months (mean). It is rounded to the nearest 25 basis points to minimize frequent changes in this parameter but still allow changes to

occur if the underlying trend in the long rate persists. The volatility parameter utilizes the standard deviation from the past 14 months, after dropping the high/low (leaving 12 data points). It is constrained by a floor of 2% and cap of 4%.

The ESWG is considering several options for updating these parameters. One option is to have no automatic adjustments for the reversion parameters. The NAIC would update on an ad hoc basis. This methodology has the upside of having review before action, but could also be forgotten or politicized, which could delay the implementation of an important development. Another option is to recalculate the parameters once each year with data updated through year end. Calculations with projection dates starting with the following March would use these updated parameters. A third option would be to update quarterly, using data through the previous month or quarter.

Once a model is successfully calibrated to the Academy scenarios, it will be deemed calibrated for 3 years, if the only changes to the model are to the initial yield curve and to update the parameters with updated historical data. If the company model is changed in any other way, it will have to be recalibrated to the Academy scenarios.

The scenarios could be defined with a starting yield curve that either reflects the start date point-in-time curve or the average curve during that month.

This work group has not addressed the question of how an economic scenario generator that combines stochastic processes for both equity and interest rate scenarios will calibrate. For now, it is assumed that each will calibrate independently and no calibration is required for correlation factors. This is likely to be revisited in the future.

Calibration Details
The Left (low interest rates) and Right (high interest rates) Tolerance Statistics, as defined below, will be used to define the required calibration criteria for comparison with the Academy-generated scenarios.

Right Tolerance Statistic: 95^{th}-percentile result divided by the median
Left Tolerance Statistic: Median divided by the 5^{th}-percentile result

In order to meet calibration requirements, the scenarios used must meet the following requirements:

- The Right Tolerance Statistic must be at least 0.90 (or 0.95 depending on the time horizon) times the comparable statistic generated by the full set of the Academy scenarios (10,000 scenarios);
- The Left Tolerance Statistic must be at least 0.90 (or 0.95 depending on the time horizon) times the comparable statistic generated by the full set of the AAA scenarios;
- Adjustments are being considered to better reflect the dispersion of the model when the median in early years differs from the SLV median. This reflects several issues that come about mainly when the initial yield curve is inverted and models

have characteristics that differ from the SLV. By the 30th-year time horizon, a variety of models should have similar medians and no adjustment is made;
- An internally generated model must create results that are at least as far in the tail as these statistics;
- All tests must pass (four time horizons, long and short rate, spread, point-in-time and average).

The model, by definition, calibrates to itself, and the actual scenarios used must be within these tolerances. The American Academy of Actuaries model will provide 10,000 scenarios along with the resulting statistics, in addition to a scenario picking tool, scenario statistics spreadsheet to calculate the statistics from an internal model, and generator which will allow users to run monthly scenarios for the time horizon defined by the actuary's judgment. Calibration requirements extend to 30 years or the end of the projection period if shorter. Actuaries have the flexibility to either run the generator for additional years or stop the generator at 30 years and hold rates level after that. This would depend on the actuary's judgment and knowledge of the balance sheet mix of products and assets. Calibration will be against the resulting scenarios, not the parameters that define the scenario generator.

Calculate the Left and Right Tolerance Statistics for the base scenarios (provided) and internally generated scenarios for

- Long rate (20-year), short rate (1-year) and spread
- Point-in-time statistics at 1, 5, 10 and 30 years

Appendix I

The SLV model has been updated along a number of dimensions

Log Long (20y) Rate:

$$ {}_1i_t = (1-\beta_1)\cdot {}_1i_{t-1} + \beta_1 \cdot \ln\tau_1 + \psi\cdot({}_2\tau_t - \alpha_{t-1}) + {}_1\sigma_t \cdot {}_1Z_t $$

Nominal Long – Short Spread:

$$ \alpha_t = (1-\beta_2)\cdot\alpha_{t-1} + \beta_2 \cdot {}_2\tau_t + \phi\cdot({}_1i_{t-1} - \ln\tau_1) + \sigma_2 \cdot {}_2Z_t \cdot {}_1r_{t-1} $$

Stochastic Log Volatility:

$$ \nu_t = (1-\beta_3)\cdot\nu_{t-1} + \beta_3 \cdot \ln\tau_3 + \sigma_3 \cdot {}_3Z_t $$

where

$$ {}_1r_t = \exp({}_1i_t) $$

Nominal Long Rate:

$$ {}_2r_t = \exp({}_1i_t) - \alpha_t; \text{ If } {}_2r_t < 0.4\%, \text{ then } {}_2r_t = 0.25\times {}_1r_t $$

Nominal Short (1y) Rate:

$$ {}_1\sigma_t = \exp(\nu_t) $$

$$ {}_1Z_t, {}_2Z_t, {}_3Z_t \sim N(0,1); \rho({}_1Z_t, {}_2Z_t) = \rho; \text{ other random variables are independent} $$

- Starting volatility for log long rate process is standard deviation of prior 14 months (excluding highest and lowest values)
- Target τ_1 for long rate is 0.5 × (M – 25 bps) + 0.5 × A, rounded to nearest 25 bps, where
  - M = median 20-year yield over most recent 600 months
  - A = arithmetic average 20-year yield over preceding 36 months
- The rest of the yield curve is based on the relationships from the “best fit” historic curve using data set from 1953:
  - Sample mid-term (7-year) rate based on deterministic formula (derived from history)
  - Curve that produces lowest weighted sum of squared deviations is “best fit” (weights = 40, 20, 40)
  - Simulated 7-year rate is estimated from historic best fit curve, not “sample rate”

SLV(1) with Linear Spread Volatility

Academy ESG Workgroup Parameterization

Maturities (years): LRate = 20, SRate = 1					
MODEL	History	L SLV-1	L SLV-1	L SLV-1	L SLV-1
Starting Short Rate	1953.04	4.94%	4.94%	4.94%	4.94%
Starting Long Rate	2006.06	4.78%	4.78%	4.78%	4.78%
# of Scenarios		10,000	10,000	10,000	10,000
Selection Routine		FULL SET			
Model Type		1	1	1	1
Parameter Set #		25	25	25	25
Horizon (years)		1	5	10	30
		27	27	27	27
$\tau 1$		5.50%			
$\beta 1$		0.00509			
θ		1			
$\tau 2$		0.01			
$\beta 2$		0.02685			
$\sigma 2$		0.04148			
$\tau 3$		0.0287			
$\beta 3$		0.04001			
$\sigma 3$		0.11489			
$\rho(1,2)$		-0.19197			
$\rho(1,3)$		0			
$\rho(2,3)$		0			
ψ		0.25164			
ϕ		0.0002			
$\tau 2\#$		0			
Horizon (years)		1	5	10	30
Starting LR Volatility		2.45%	2.45%	2.45%	2.45%
		L	L	L	L
Sheet Name		'SLV(1) L-1'!	'SLV(1) L-5'!	'SLV(1) L-10'!	'SLV(1) L-30'!
Curve Inversions (15 bps)					
Frequency (Median)	**16.2%**	33.3 %	16.7 %	14.2 %	12.5 %

Frequency (Average)	**16.2%**	37.6 %	24.7 %	19.4 %	15.0 %
Stdev Diff Log Rates					
Short (y), Median	**6.9%**	5.2%	6.2%	6.8%	7.6%
Long (y), Median	**3.1%**	2.5%	2.9%	3.1%	3.3%
Short/Long Correlations					
Diff Rates	**0.73**	0.65	0.67	0.68	0.69
Diff Log Rates	**0.64**	0.65	0.66	0.67	0.67
Change Spread/Long	**-0.23**	-0.19	-0.18	-0.17	-0.17
Short (-year) Rate		**POINT IN TIME STATISTICS**			
Min	**0.82%**	1.73%	0.50%	0.41%	0.40%
0.01	**1.07%**	3.00%	1.43%	1.03%	0.99%
0.05	**1.45%**	3.52%	2.17%	1.85%	1.66%
0.1	**2.35%**	3.78%	2.60%	2.29%	2.14%
Median	**5.43%**	4.82%	4.52%	4.37%	4.30%
0.9	**9.39%**	5.97%	7.07%	7.71%	8.33%
0.95	**11.66 %**	6.30%	8.07%	9.14%	10.19%
0.99	**14.87 %**	6.97%	10.33%	12.51%	14.90%
Max	**16.72 %**	9.58%	17.54%	20.62%	21.32%
Avg	**5.70%**	4.86%	4.73%	4.79%	4.90%
Stdev	**2.99%**	0.86%	1.84%	2.34%	2.78%
Skew	**1.01**	0.27	0.94	1.37	1.70
Kurt	**1.29**	0.30	1.96	3.49	4.54
Dispersion 95th		0.58	1.30	1.67	1.99
Long (-year) Rate		**POINT IN TIME STATISTICS**			
Min	**2.57%**	3.24%	1.97%	1.71%	1.06%
0.01	**2.64%**	3.96%	3.12%	2.70%	2.45%
0.05	**3.07%**	4.26%	3.69%	3.36%	3.14%
0.1	**3.75%**	4.41%	4.02%	3.75%	3.53%
Median	**6.28%**	4.97%	5.33%	5.42%	5.41%
0.9	**10.62 %**	5.58%	7.15%	8.05%	8.82%
0.95	**12.06 %**	5.78%	7.80%	9.24%	10.50%
0.99	**13.88 %**	6.28%	9.53%	12.21%	14.53%
Max	**15.13 %**	7.83%	15.81%	20.27%	19.08%
Avg	**6.66%**	4.99%	5.50%	5.74%	5.90%
Stdev	**2.65%**	0.47%	1.32%	1.88%	2.37%
Skew	**0.83**	0.40	1.10	1.40	1.60
Kurt	**0.41**	0.99	3.08	3.69	3.94
Dispersion 95th		0.31	0.77	1.09	1.36
Spread (Long - Short)		**POINT IN TIME STATISTICS**			
Min	**-3.33%**	-2.18%	-3.69%	-5.52%	-5.75%
0.01	**-1.85%**	-1.32%	-1.71%	-1.78%	-2.02%
0.05	**-1.01%**	-0.88%	-0.82%	-0.76%	-0.79%

0.1	**-0.36%**	-0.65%	-0.44%	-0.29%	-0.33%
Median	**0.91%**	0.14%	0.79%	0.97%	1.01%
0.9	**2.70%**	0.91%	1.92%	2.20%	2.35%
0.95	**3.40%**	1.12%	2.23%	2.59%	2.80%
0.99	**3.80%**	1.50%	2.92%	3.38%	3.77%
Max	**4.08%**	2.39%	5.52%	5.56%	6.21%
Avg	**0.96%**	0.13%	0.76%	0.95%	1.01%
Stdev	**1.24%**	0.61%	0.95%	1.03%	1.12%
Skew	**0.17**	-0.11	-0.23	-0.23	-0.11
Kurt	**0.22**	0.00	0.59	1.06	1.58
Dispersion 95th	**4.85**	13.83	3.84	3.46	3.56

Appendix III

Updating the Mean Reversion Point for the Long Rate Stochastic Process

Background

When the Academy's C3WG established the Mean Reversion Point (MRP) during the late 1990s, using Maximum Likelihood Estimation (MLE) to fit the stochastic variance model, the MRP was set at 6.55%. This compares to an average (median) of 6.94% (6.99%) for the GS20 for the period 1953 to 1995. The current average (median) for the period 1953 to 2005 is 6.71% (6.38%). Other factors in the model along with the MLE optimization, primarily the steepness adjustment, biased the MRP to be slightly lower than the long-term average or median.

Recommendation of the ESWG

The Economic Scenario Working Group ("ESWG") is recommending a modification of the model's Mean Reversion Point (MRP) for the Long Rate (LR) from 6.55% to a value near 5.4%. The basis for this change is a shift in perspective, from a completely historical viewpoint, to a prospective view driven by an analysis of Federal Reserve Bank behaviors and objectives. While the MRP recommendation for today's environment is 5.4%, the ESWG believes that, if long-term economic and market expectations were to change in the future, then the MRP recommendation would have to be reconsidered. These expectations include inflation, real growth, market liquidity and other risk preferences.

Furthermore, the ESWG recommends that the long rate revert to a simple average of the long rate over the past 50 years (600-month median adjusted down by 25 bp) and the past 36 months (mean). It is rounded to the nearest 25 basis points to minimize frequent changes to this parameter, while still allowing changes to occur if the underlying trend in the long rate persists.

This view is a compromise of the competing views presented below.

Historical Perspective: The MRP should be set consistent with a historical perspective.

Support for this view is based on practical considerations, as it contends that models based on expectations are very complicated, and difficult to calibrate and obtain a consensus on. These challenges are inconsistent with the resources available to the Academy that are needed to maintain such models on a regular basis. On the other hand, a model based totally on history is objective and easy to calibrate to.

However, most who support the use of history to measure the MRP accept that we can't simply use the average of known history, as this would produce an MRP that is higher

than 6%. Thus, some degree of subjectivity is still likely to be required, and those who hold this view would peg the MRP lower, at a level in the 5.7- 5.8% range.

Another major difficulty with this approach is that it is highly dependent on the selected historical period. This period could be out of synch with how the economy is being managed going forward and with market expectations about future interest rates.

In selecting the historical period, if one selects the period of known data since 1953 but we exclude the 1970s and 1980s because it reflects the period of "easy money," we get the following results:

	GS20[1]	CPI
1953-2005	6.71%	3.81%
1953-1970 & 1990-2005	5.23%	2.44%

As we discuss below, a 2.44% inflation assumption is consistent with current economist expectations that are measured in a survey by the Philadelphia Federal Reserve Bank. Thus, a 3.81% inflation rate would probably not be tolerated by the Federal Reserve.

Federal Reserve Expectations: The MRP should be based on current Federal Reserve expectations.

The Federal Reserve is charged with maintaining full employment and stable prices. There have been periods of time when Fed policy was compromised by emphasizing one objective over the other. An example of this is the "easy money" policy of the 1970s, which was initiated to maintain high employment. However, this did not lead to full employment and "stagflation" was the result. The economy and market settled into a phase of expecting inflation and this self-fulfilling expectation countered any employment benefits from an "easy money" policy. The belief at the Federal Reserve has now evolved, to one which holds that low inflation, in the range of 1.5-2.0%, is the best policy to preserve a healthy growing economy and high employment. This view was held in the Volcker/Greenspan era and is expected to continue under Bernanke's new leadership.

As an illustration, this view would set the MRP at approximately 4.90%, based on historical quarterly information over the last three years, using a building block approach to rationalize a 4.90% MRP.

Inflation Expectations	2.30%
TIPS Yield (20-yr)	2.20%
Risk Premium	0.40%
GS20 Expectation	4.90%

1 U.S. government securities/Treasury constant maturities/Nominal

In the table above, the source for inflation expectations is the Philadelphia Fed survey of economic forecasters, which measures the ability of the Federal Reserve to control inflation. Note the unofficial Fed target for inflation is 1.50% to 2.00%. The TIPS and GS20 yields are from the Federal Reserve website. The risk premium, reflecting the uncertainty in inflation expectations, is set to the residual to arrive at the total GS20 Expectation.

The TIPS yield is a real interest rate and can also be viewed as a component of expected GDP real growth. If a combination of factors were to materialize, such as the Fed attaining its inflation target, while at the same time conveying an expectation of a more stable inflationary environment, along with a fall of GDP into a slow growth longer term trend, then the GS20 yield could drop considerably. For example, under this scenario, economic forecasters may expect inflation to be 1.80%, and the risk premium and TIPS yield may drop to 0.20% and 1.00%, respectively. Adding these three components, we obtain a 3.00% GS20 yield. However, under a scenario of low inflation, GDP is likely to grow faster and the TIPS yield would move higher. Of course, the opposite can happen and the GS20 could rise to 6.00% or more.

Although more accurate, the challenge with relying on Federal Reserve policy is that it is subjective and maintenance of the Academy model parameters is higher.

Market Expectations: The MRP should be set consistent with current market expectations.

This approach is based on the simple proposition that market interest rates reflect a blend of pessimism and optimism concerning the market. For example, if market participants are pessimistic and see interest rates rising, they are inclined to sell bonds. And if they see rates falling they will typically buy bonds. That is, pricing in the market will settle into equilibrium between pessimists and optimists. Furthermore, this approach is based on the assumption that Federal Reserve policy is inherently reflected in current market prices and interest rates.

This method involves selecting a recent historical period to measure market interest rates. The longer the period selected, the more likely idiosyncrasies in the market will tend to cancel each other out. However, a shorter period will tend to favor outdated temporary inflationary expectations and other market expectations about the future. The appropriate period is probably in the three-to-five-year range. If a three-year period ending in 2005 is selected, the average GS20 yield is 4.88%. If a five-year period is selected, the average is 5.14%. Therefore a number in the 4.9%-5.1% range would be consistent with market expectations.