AMERICAN ACADEMY *of* ACTUARIES

Usage of Modeling Efficiency Techniques in the US Life Insurance Industry

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Results of a survey analyzed by the American Academy of Actuaries' Modeling Efficiency Work Group

2013 Modeling Efficiency Work Group

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This was a voluntary survey. The companies were asked to not provide any business confidential or proprietary information in response to this survey or any company specific information without the company's expressed permission. The Academy is not responsible for maintaining the confidentiality of any information provided.

AMERICAN ACADEMY *of* ACTUARIES

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1. Background and Scope

The Modeling Efficiency Work Group (MEWG) of the American Academy of Actuaries was created in May 2007 to assist the National Association of Insurance Commissioners (NAIC) on the implementation of a principle-based approach (PBA) to statutory reserves and capital for the life insurance industry.

We recognize that some of the calculations envisioned by a principle-based approach to the determination of reserves and capital can be onerous. The purpose of the MEWG is to examine ways in which these calculations can be made more manageable, by building models and using techniques that enable optimal usage of resources without unacceptable loss of accuracy in calculations – what is well known throughout the life insurance industry as "modeling efficiency."

The Academy undertook a voluntary survey of 51 U.S. life insurance companies in April-May 2012 to assess the current modeling efficiency practices in use. The survey focused on the use of mathematical and actuarial modeling techniques as opposed to looking at hardware/software aspects.

This was a follow-up and an update to a similar voluntary survey that was performed in August 2007, the results of which were published in a report, *Modeling Efficiency Work Group Survey Report – November 2007*. It is instructive to compare the two documents side by side. How far have insurers progressed in the past five years? Are some techniques proving to be more effective than others? Where are insurers looking to go in the future?

Fifty-one distinct life insurance companies participated in this voluntary survey, which was a big improvement on the number of participating companies in the 2007 survey. The MEWG is delighted with this greater participation and we believe it reflects the growing interest in this subject matter.

It should also be noted that the MEWG is not advocating any particular modeling efficiency technique.

2. Executive Summary

The 51 companies participating in the survey responded to questions in three main subject areas. Responses in each area are summarized below.

- **Scenario reduction techniques:** 50 of the 51 participant companies responded to the questions on scenario reduction. In total, 23 (46%) indicated that they use some form of scenario reduction technique. Fourteen (28%) of these companies use the Academy scenario picking tool exclusively as a means of scenario reduction; seven (14%) use a technique or tool different than the Academy scenario picking tool; and two (4%) are using both the Academy scenario picking tool plus a different scenario reduction technique to the Academy scenario picking tool. There is some indication that the variable annuity (VA) writers do have more interest in scenario reduction techniques. Also, based on the survey responses, scenario reduction appears to be just as popular among the smaller companies as it is among the larger companies.

- **Cell compression (excluding traditional actuarial mapping)**: All 51 participating companies responded to the question on cell compression. Twelve (24%) indicated that they did cell compression; 39 (76%) said no. Similar to scenario reduction techniques, the results indicate that the larger VA writers are more interested in cell compression; indeed, they may be using a combination of scenario reduction and cell compression. Cluster modeling is specifically mentioned by three participating companies.

- **Other modeling efficiency techniques:** We received some very interesting feedback on other modeling efficiency techniques. Six respondents indicated using modeling efficiency techniques other than scenario reduction and compression, but similar in nature. A number of companies also mentioned using other types of modeling efficiency techniques. Eighteen companies also indicated that they were considering using some other techniques to supplement or replace what they are currently doing for modeling efficiency.

3. Survey Results and Analysis

3.1 Scenario Reduction

Reducing the number of economic stochastic scenarios that need to be run in order to satisfactorily capture financial market risk exposure is an obvious candidate to decrease overall model runtime.

We posed two questions around this technique:

- Have you used the Academy scenario picking tool to do scenario reduction?

- Have you used alternative approaches to scenario reduction, and if so, what are they?

The following table summarizes the extent to which scenario reduction techniques are used and whether it is the Academy scenario picking tool that is used or some other technique:

	Total
Academy scenario picking tool plus other scenario reduction technique(s)	2 (4%)
Academy scenario picking tool only	14 (28%)
Other scenario reduction technique(s) only	7 (14%)
No scenario reduction technique used	27 (54%)
Total respondents	50

The following table gives a further breakdown of results for those companies using the Academy scenario picking tool. Again, we were interested in whether they might be a difference between VA writers and non-VA, so we have attempted to split the results accordingly using other data in the public domain.

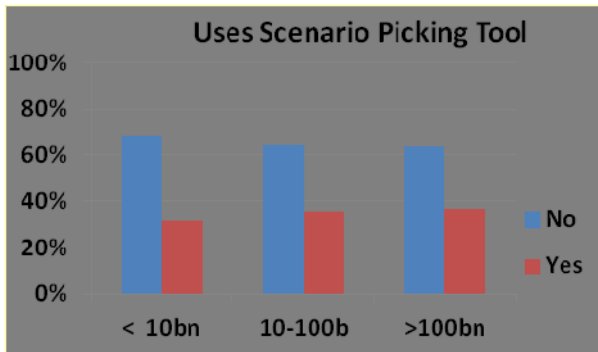**Do you use the Academy scenario picking tool for scenario reduction (for any purposes, not just statutory)?**

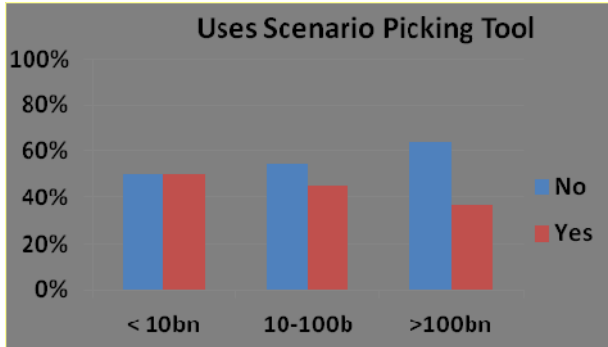|	Total	Yes	No
VA writers	26	11 (42%)	15 (58%)
Non-VA writers	21	5 (24%)	16 (76%)
Not indicated	3	0	3
All	50	16 (32%)	34 (68%)

Analysis and interpretation

Similar to cell compression, there is some indication that the VA writers do have more interest in scenario reduction techniques; indeed, they may be using a combination of cell compression plus scenario reduction. Again, some further analysis of the data has been performed to look at the correlation between company size and the usage of scenario reduction according to the survey responses:

Do you use the Academy scenario picking tool for scenario reduction? – split by company size (assets under management)

Assets under management	Total	Yes	No
< $10bn	22	7 (32%)	15 (68%)
$ 10 bn - $100bn	14	5 (36%)	9 (64%)
>$100 bn	11	4 (36%)	7 (64%)
Unidentified	3	0	3
Grand Total	50	16 (32%)	34 (68%)

Do you use the Academy scenario picking tool for scenario reduction? – VA writers only, split by company size (assets under management)

Assets under management	Total	Yes	No
< $10bn	4	2 (50%)	2 (50%)
$ 10 bn - $100bn	11	5 (45%)	6 (55%)
>$100 bn	11	4 (36%)	7 (64%)
Grand Total	26	11 (42%)	15 (58%)

Similar to cluster modeling, there is considerable interest in scenario reduction techniques among the larger VA writers, but a big difference is that the smaller companies (VA and non-VA) have been using scenario reduction techniques quite widely too.

Specific comments from respondents:

- For companies using the Academy scenario picking tool, we received a number of responses indicating how the tool is being used:
    o A number of companies indicated usage for variable annuity statutory reserves (AG43) and capital (C3 Phase II).
    o General cash-flow testing and ALM were frequently referenced – a number saying that the technique was used across a number or all lines of business.
    o One company said the tool is used to help limit the amount of projections we run for equity-indexed models.
    o One company uses the tool for stochastic asset adequacy testing for variable and fixed annuities, variable universal life, universal life and LTC.
    o Three companies specifically mentioned selecting 1,000 scenarios out of the Academy's base 10,000; another company said 100 scenarios were chosen.
    o One company mentioned using a modification of the Academy tool that stratifies on both interest rate levels and equity returns simultaneously.

- For companies using a technique other than the Academy scenario picking tool, the following techniques were specifically referenced:

  o Distance technique calibrated to a rate sensitive measure.

  o Two companies specifically mentioned using a significance method.

  o Two companies mentioned using stratified sampling based on a key metric. However, one of these companies mentioned that this technique was now being replaced with in force cell compression using traditional actuarial mapping and then employing a "brute force" approach to run through many scenarios.

  o Two companies mentioned using the Yvonne Chueh efficiency technique.

  o One company referred to choosing 250 scenarios out of the original 1000 that most closely reproduce the time value of guarantees for purposes of doing its market consistent embedded value (MCEV) calculation. This is used for all the stochastic analysis of change runs.

  o Another company referenced using a Barrie & Hibbert method involving variance reduction techniques ensuring the Martingale property is maintained for market consistent scenarios. The technique is used for valuation of guaranteed minimum death benefits, deferred annuities, immediate annuities, and universal life.

  o One company also made the point that they used the "sometimes overlooked technique" of testing the smallest number of scenarios that gives answers within an acceptable tolerance of those obtained from larger scenario sets.

3.2 Cell Compression

We posed the question to participants: Do you currently use cell compression (i.e., techniques intended to reduce liability and/or asset model sizes, aside from "traditional" actuarial mapping) for any purpose?

Traditional actuarial mapping refers to the building of asset and liability models that summarize the business into groups of similar contracts, as opposed to running projections of the business on a seriatim basis. Obvious summarizations that have been used for many years include grouping by similar product, age, sex, premium mode, and issue date.

More recently, actuaries have investigated more complex approaches to compression, most notably the technique of clustering[1] which has been gaining increasing attention. We were interested in capturing feedback from survey participants on these more complex approaches.

The following table summarizes the number of companies doing cell compression. We were interested in whether there might be a difference between VA and non-VA writers, so we have attempted to split the results accordingly using other data in the public domain.

Do you do cell compression?

	Total	Yes	No
VA writers	26	8 (31%)	18 (69%)
Non-VA writers	22	3 (14%)	19 (86%)
Not indicated	3	1	2
All	51	12 (24%)	39 (76%)

Analysis and interpretation

Three possibilities are suggested by these responses:

- VA writers generally are larger companies that may have larger models and more to gain from using compression,

- VA business lends itself particularly well to non-traditional cell compression techniques, or

- Because of the statutory requirements for valuing VA business (AG43 and C3 Phase II), more extensive stochastic analysis is required for VA business

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[1] See Freedman, A., Reynolds, C., 2008. "Cluster analysis: A spatial approach to actuarial modeling." Available at: http://publications.milliman.com/research/life-rr/pdfs/cluster-analysis-a-spatial-rr08-01-08.pdf.

compared to other product lines, which makes modeling efficiency a higher priority.

Further analysis of the data illustrates the correlation between company size and the usage of cell compression according to the survey responses:

Do you do cell compression? – split by company size (assets under management)
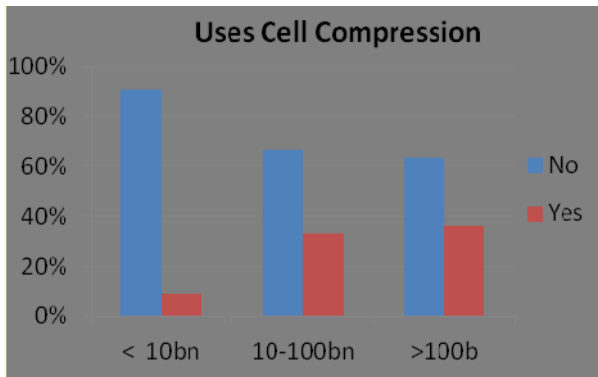
Assets under management	Total	Yes	No
< $10bn	22	2 (9%)	20 (91%)
$ 10 bn - $100bn	15	5 (33%)	10 (67%)
>$100 bn	11	4 (36%)	7 (64%)
Data not available to enable categorization	3	1	2
Grand Total	51	12 (24%)	39 (76%)

Do you do cell compression? – VA writers only, split by company size (assets under management)
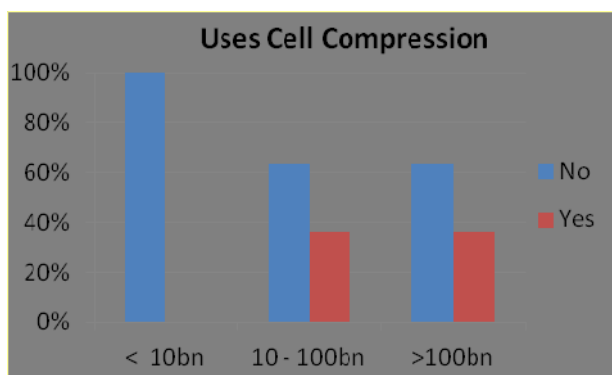
Assets under management	Total	Yes	No
< $10bn	4	0 (0%)	4 (100%)
$ 10 bn - $100bn	11	4 (36%)	7 (64%)
>$100 bn	11	4 (36%)	7 (64%)
Grand Total	26	8 (31%)	18 (69%)

The results indicate that there is more of an interest in cell compression among the larger VA writers.

Specific comments from respondents:

- Cluster modeling is specifically mentioned by three participating companies.

- One company mentioned that liability cell compression was used for some valuation work where adequate for result accuracy, but not for seriatim statutory reserve calculations; linear and non-linear banding and multi-stage compression methods are used; funds are mapped to general asset classes.

- Another company mentioned doing compression for deferred annuities with short term interest rate guarantees, grouping together buckets of money that share the same guarantee, even across different plan codes.

Four companies indicated they did cell compression but their comments, recapped below, suggested that what they are doing is actually not significantly different from traditional actuarial mapping:

- Business is bucketed by issue age and plan groupings for traditional life and interest sensitive life, and by issue age, plan and minimum guaranteed interest rate for deferred annuity.

- Deferred annuity and universal life put into groupings that adequately reproduce seriatim projections.

- MBS modeling: by asset issue date, underlying collateral coupon and aging. Liability grouping for some purposes by age/size band, etc.

- Group ages for VUL - very small block

Notwithstanding the above, one company answering "no" to this question said that it had studied "sampling" techniques, but is not currently using them for any ALM purposes.

3.3 Other Modeling Efficiency Techniques

Six respondents indicated using modeling efficiency techniques other than scenario reduction and compression, but similar in nature:

- For fixed cash flow lines of business (e.g., payout annuities and traditional life) when not testing stochastic mortality or stochastic lapses, use the valuation system to project a single scenario of liability cash flows and balance sheet items and use that one same liability scenario in the projection system when running all scenarios for assets.

- For life business, map smaller blocks of business to representative blocks of business instead of modeling them explicitly.

- Determine a confidence interval on the key result (for example the CTE 90 result of stochastic testing) using bootstrapping techniques. Increase the number of stochastic scenarios as needed to reduce the range of the confidence interval to an acceptable level.

- Increase the length of calculation time step and reduce output frequency (monthly/quarterly/annually) to reduce data and runtime, and then define separate reports for each valuation purpose that only include necessary outputs.

- For sensitivity testing of variable annuity business select 60 scenarios from the "picked" 1000 to represent the CTE 70 set. Rank the 300 scenarios used to calculate CTE 70. Within the 300, create 60 groups of five, where the first group is the worst five scenarios. Within each of the 60 groups, select the middle scenario of the five. Testing shows error is immaterial.

- Traditional actuarial grouping as facilitated by the actuarial projection software, where policies with the same, or suitably similar, assumptions are grouped together.

A number of survey participants also mentioned using other types of modeling efficiency techniques:

- Depending on how asset sales are defined, combine asset cash flows from BondEdge projections. The most detail needed is usually portfolio, asset type (e.g., corporate) and quality. Sales can then be simulated as *pro rata* portions of a portfolio aggregate rather than using an algorithm to select which assets to sell.

- Vary the size of time steps over model period, e.g. use monthly time steps for first 3 years, quarterly time steps for next 3 years, annual time steps thereafter.

- Use of a regression formula for projection of AG 43 reserves.

- Pre-process assets rather than processing them with liabilities in the same system at the same time.

- Use multi-thread processing to improve run time. Output from cells can be written to database while other cells are being calculated.

- Use high-performance computing to reduce the need for modeling efficiency techniques.

- Use a curve fitting approach for estimating asset and liability values across a range of scenarios for Solvency II modeling.

- Indirectly related: Use processing farms with prioritization and allocation of resources.

- Improve modeling efficiency through efficient software design techniques other than multi-threading and utilization of processor grids.

Eighteen companies also indicated that they were considering supplementing or replacing what they are currently doing for modeling efficiency.   The following techniques, some of which are listed above as already in use by other companies, were mentioned as being under consideration:

- Cluster modeling (5 companies)

- Towers stratified sampling technique

- Proxy reserves

- Two companies mentioned wanting to use a scenario picking technique

- Scenario mapping

- Liability cell compression. Possibly scenario reduction for VA sensitivity analysis.

- Sampling techniques to select in force cells for stochastic modeling of domestic Life business

- Scenario reduction, cell reduction, software design

- A stratification process that maintains risk-neutrality (such a process is yet to be developed)

Four companies mentioned they are considering adopting additional techniques but are still gathering information as to what techniques are good candidates for consideration, but gave no further information.

3.4 Other Comments

A number of participants provided additional qualitative feedback:

- Some companies have only done deterministic modeling.

- One company is in a period of transition from a third party system to new parent company's legacy system that currently processes seriatim only.

- Modeling efficiency will be looked at as needed.

- Modeling efficiency is not a concern due to lack of stochastic modeling needs or small block size.

- 90%+ of liabilities are non-interest sensitive, so higher granularity is reflected on the liability side, and then the non-interest-sensitive liability cash flows are compressed into a limited number of projected liability streams to be incorporated into the projection software along with the assets.

- One company is planning to move to cluster modeling instead of traditional actuarial mapping later this year to produce a model small enough to allow dynamic liability interaction that would not be possible in a larger model.

- One company plans to return from cell compression to seriatim analysis for some blocks where it now has sufficient IT infrastructure and the outcome of results is worth a refined modeling (e.g., policy dependent features and refined modeling of policyholder behavior).

Appendix 1: Survey Questions

1. Do you currently use cell compression (i.e., techniques intended to reduce liability and/or asset model sizes, aside from "traditional" actuarial mapping) for any purpose?

2. Do you currently use scenario reduction via the Academy scenario picking tool for any purpose?

3. Do you currently use scenario reduction via any other technique (i.e., techniques intended to reduce scenario set sizes without suffering the sort of decrease in accuracy that would result from making the reduction on a purely random basis) for any purpose?

4. Do you currently use other techniques that do not fit neatly into the above categories, but that you consider similar in nature to the above techniques, for any purpose?

5. Please list any other techniques you use that may be modeling efficiency techniques.

6. Are you actively considering adopting any additional model efficiency techniques (pick the first choice that applies)?
- Yes, we are in (or expect to begin within the next few months) the process of testing. If you select this answer, please list the techniques you are testing or plan to test.
- Yes, but we are still gathering information as to what techniques are good candidates for consideration.
- No.

7. Have you made a decision not to use any techniques that you once adopted or seriously considered (pick the first choice that applies)?
- Yes, we seriously considered one or more techniques, but decided they were not suitable.
- Yes, we adopted one or more techniques, and then discarded them.
- No, we have never given serious consideration to adopting such techniques.
- No, we have adopted such techniques and we continue to use them.
- Other (explain)

8. Other comments?