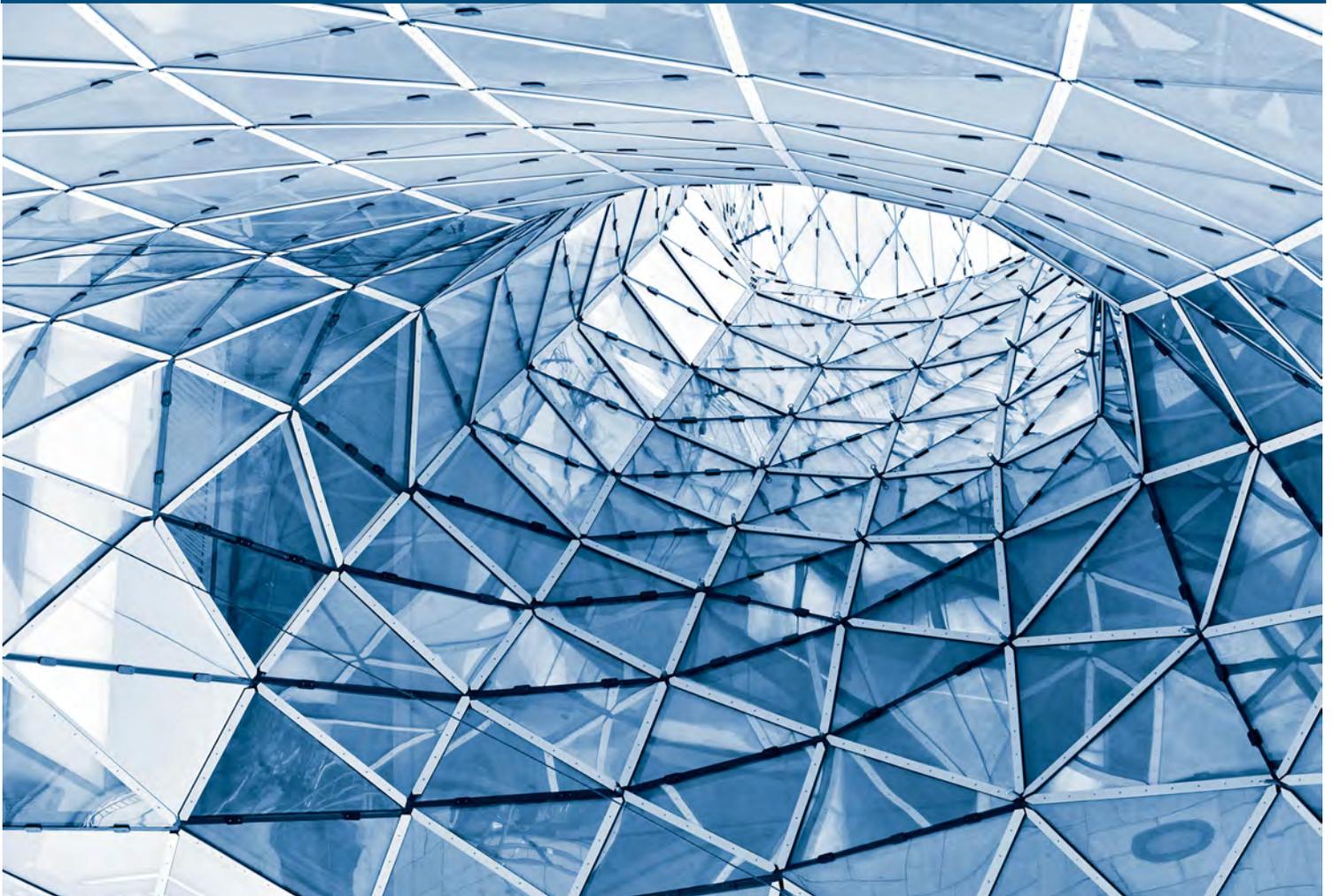


2015 Society of Actuaries Survey on Nested Stochastic Modeling



November 2016



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Financial Reporting
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Section 1: Introduction

1.1 Background

Over the past decade, the insurance practices and regulatory requirements in insurance markets around the world started to move toward growing dependence on stochastic approaches. Insurance company managements have stronger desires for improved technology for nested stochastic modeling. Financial reporting is in particular an area of actuarial practice that sees the need for better understanding and integration of new modeling techniques.

The Financial Reporting Section in collaboration with the Modeling Section sponsored research on the practical use of nested stochastic modeling for financial reporting actuaries. A University of Illinois research team has been engaged to perform the study.

The current survey is the first such survey sponsored by the Society of Actuaries and the Financial Reporting Section, which aims to better understand industry practices on nested stochastic modeling. The survey is also the first of a two-part research study conducted by the same research team. The overall goal of the research study is to provide actuaries with answers to the following questions:

- In what situations is nested stochastic modeling currently used or planned to be used in the insurance industry?
- What other approaches are currently used instead of nested stochastic modeling?
- What techniques can be used to accelerate the run time for nested stochastic modeling?

The findings of this survey mostly address the first two questions, while the answer to the third question is addressed in the second part of the research study.

1.2 Scope

This survey on nested stochastics is a joint effort by research staff of the Society of Actuaries, the project oversight group and the research team. The survey was conducted in November and December 2015 and sent to practicing actuaries who are members of the Financial Reporting Section and/or members of the Modeling Section. The survey requests one response from each company. As the intent of the survey is to understand the prevalence and practices of nested stochastic modeling among insurance companies, the survey explicitly stated that consulting firms and software vendors are excluded.

The survey covers five categories of questions as well as a comment section.

- Part I: Context of Survey Participants

This section collects respondents' background information and asset mix in relation to product lines that may require stochastic modeling.

- Part II: Infrastructure and practice on general stochastic modeling

This section collects information on computational resources and common practice on stochastic modeling in non-nested setting.

- Part III: Circumstances for nested stochastic modeling

This section seeks to find out circumstances under which nested stochastic modeling is needed or utilized in practice and general opinions on the need and benefits of nested stochastic modeling.

- Part IV: Implementation of nested stochastic modeling

This section addresses how nested stochastic modeling has been implemented and what challenges respondents face.

- Part V: Methodologies for nested stochastic modeling

This section collects the most common methodologies that are developed specifically for nested stochastic models

- Part VI: Parting comments

The last section is intended to assess respondents' priorities and perceptions of competing factors when considering adopting new technology. Comments and suggestions are also collected.

1.3 Acknowledgement

We would like to acknowledge and thank a number of individuals who contributed the success of this survey.

- Project Coordination: Ronora Stryker and Jan Schuh from the Society of Actuaries provided coordination of the survey and the subsequent research study. The online questionnaire was created and managed by Jan Schuh
- The Project Oversight Committee not only provided guidance on overall objectives of the survey, but also contributed significantly to the design and the distribution of the questionnaire:

Bill Beatty, FSA, FCIA

Fontaine Chan, FSA, MAAA

Frank Clapper, FSA, MAAA

Mark Evans, FSA, MAAA Mike

Leung, FSA, MAAA (Chair)

Bruce Rosner, FSA, MAAA

Ronora Stryker, ASA, MAAA

- Zhenyu Cui, PhD, Stevens Institute of Technology, participated in the conceptual design of the survey and the subsequent research study. Two consultants provided invaluable assistance in the development of the questionnaire and model examples in the research study:

Feng Sun, FSA, MAAA

Yang Ho, PhD, FSA, MAAA

- A group of undergraduate students from the University of Illinois assisted the lead investigator in cleaning, merging data and performing analysis:

Qianyu Chen

Tianyi Xing

Yitong Huang

- Some of survey questions are based on technical issues raised in the following professional articles.
 - Patricia Matson and Don Wilson, RBC C3 Phase II: Easier Said than Done. *The Financial Reporter*, March 2006, No. 64, 10–13.
 - Craig Reynolds and Sai Man, Nested Stochastic Pricing: The Time Has Come. *Product Matters!* June 2008, No. 71, 16–20.
 - Craig Reynolds and Sai Man, Nested Stochastic Pricing: A Case Study. *Product Matters!* October 2008, No. 72, 12–15.
 - Patricia Matson, William Hines and Rony Sleiman, Solvency II—What Does It Mean to U.S. Companies? *The Financial Reporter*, June 2010, No. 81, 1 and 2–9.
 - Avi Freedman and Craig Reynolds, Cluster Modeling: A New Technique to Improve Model Efficiency. *CompAct*, July 2009, No. 32, 1 and 4–8.

Section 2: Executive Summary

Stochastic modeling is used wherever the value of one or more significant modeling parameters varies randomly from one period to the next. While stochastic modeling may be used for almost any parameter in an actuarial model, its most common use within a life and annuity product portfolio is for “interest-sensitive” products where financial results are heavily dependent on the economic scenario. Nested stochastic modeling is theoretically required wherever one stochastically calculated parameter is dependent on the value of another stochastically calculated parameter. An example would be a stochastic calculation of required capital where reserves and/or hedging results are also calculated with stochastic models. As the industry practice continues to move toward more and more detailed modeling of stochastic components, the computational burden will grow exponentially with the increasing complexity of nested simulations.

Despite the growing demand for nested stochastic modeling, very few publications or technical reports have been written on the subject matter, particularly in the context of insurance industry. This survey aims to be a first step

toward a better understanding of current industrial practice on nested stochastic modeling in the life insurance industry.

Here we summarize the findings from each part of the survey.

2.1 Context of Survey Participants

- As software vendors and consulting firms, which have comparative advantages of modeling techniques for business, are excluded, the survey is not intended to collect information on the most advanced technology on the subject, but rather the development of technology in the context of the general insurance industry.
- Eighteen insurance companies participated in the survey, and the majority of them focus on life and annuities.
- There are six public companies, eight mutual/fraternal companies, three privately held stock companies and one self-identified as reciprocal exchange.
- There are six companies with total statutory assets over \$100 billion, while the majority of companies hold assets between \$10 and \$70 billion. There appears to be a fair representation of companies of varying sizes, from small and medium-sized to large insurance companies.
- Based on the self-reported data on asset mix, 12 insurance companies have more than 50% of assets backing product lines that are subject to significant investment risks. The observation is consistent with the number of companies interested in nested stochastic modeling.

2.2 Infrastructure and Practice on General Stochastic Modeling

- The majority of companies have an IT infrastructure of fewer than 1,000 CPU cores dedicated to stochastic modeling. It appears to be common among participating insurance companies to have only a modest infrastructure for financial reporting purposes.
- Two companies use separate computer farms/cloud computing. One company stated, however, it was not purchased for financial reporting purposes.
- Fourteen companies are able to complete all required stochastic modeling on a timely basis, while three are not.
- Seven companies have more than 10 financial reporting actuaries to support stochastic modeling, while 10 companies have fewer than 10 financial reporting actuaries for stochastic modeling.

2.3 Circumstances for Nested Stochastic Modeling

All survey respondents appear to be taking a cautious approach in regard to the implementation of nested stochastic modeling. The majority plan to use it in the future, but none adopt the technology for regular use at the moment. As a large percentage of respondents in the survey are small and medium-sized companies, the data appear to suggest that nested stochastic modeling has not yet become a standard technology for industry-wide applications, in particular for smaller companies.

Note, however, due to the small sample size, the survey results may not be an absolute representation of reality for all insurance companies, particularly large companies.

- Only one company with 30% in variable annuities and 10% universal life uses nested simulation for research purposes.

- Nine companies do not currently use nested stochastic modeling but plan to use it in the future, while six companies do not see any need to do so.
- The majority identified “run time” and “difficult to model” as the primary reasons for not using nested models. Many expressed concerns that “the technology is not ready” and that they “do not have the budget.”
- Among those who plan to use nested stochastic modeling, the top three situations are asset adequacy testing, principle-based reserve for life products and Solvency II/economic capital.

2.4 Implementation of Nested Stochastic Modeling

- Despite the discussions in professional newsletters by consultants, the development of nested stochastics appears to be limited among small and medium-sized companies.
- The only company that does nested stochastic modeling expressed concerns about implementation challenges. It has the most difficulty with “computing power, run-time and data storage,” “analyzing and explaining results” and “validating the models.”

2.5 Methodologies for Nested Stochastic Modeling

As pointed out earlier, this part of the survey has very limited findings due to the fact that only one respondent implemented nested stochastic modeling.

- The company identified only one major category of techniques being used: “clustering/grid bundling techniques.”
- “Mapping techniques” were used to reduce cell counts.

2.6 Parting Comments

The three most important factors that affect an insurance company’s decision to adopt a new stochastic modeling technique are (in order of importance by average rating):

- Timeliness of result delivery
- Accuracy
- Ability to interpret results

Those who do not currently use but plan to use nested stochastic modeling have a slightly different ordering of the top three factors:

- Ability to interpret results
- Accuracy
- Timeliness of result delivery

Among those who have a clear top priority (giving no more than two ratings of 5), cost of implementation and regulatory requirement are also identified as topic choices.

Section 3: Detailed Data Analysis

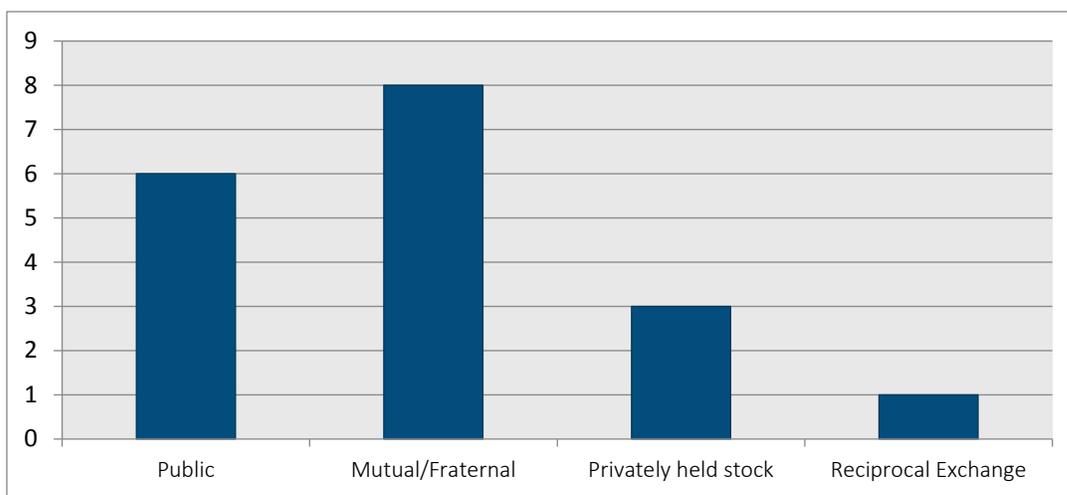
Part I: Context of Survey Participants

1. What best describes your company? (If you work for a subsidiary of a diversified parent, please respond based on the primary focus of the subsidiary.)

All 18 respondents offer life insurance and/or annuity products, and two of them are multiline companies.

Primary line of business	Number	Percentage
Life/Annuities	16	89%
Multi-line	2	11%
Total	18	100%

2. Is your company publicly held or private (i.e., mutual or fraternal)?



Type	Number	Percentage
Public	6	33%
Mutual/Fraternal	8	44%
Privately held stock	3	17%
Reciprocal exchange	1	6%
Total	18	100%

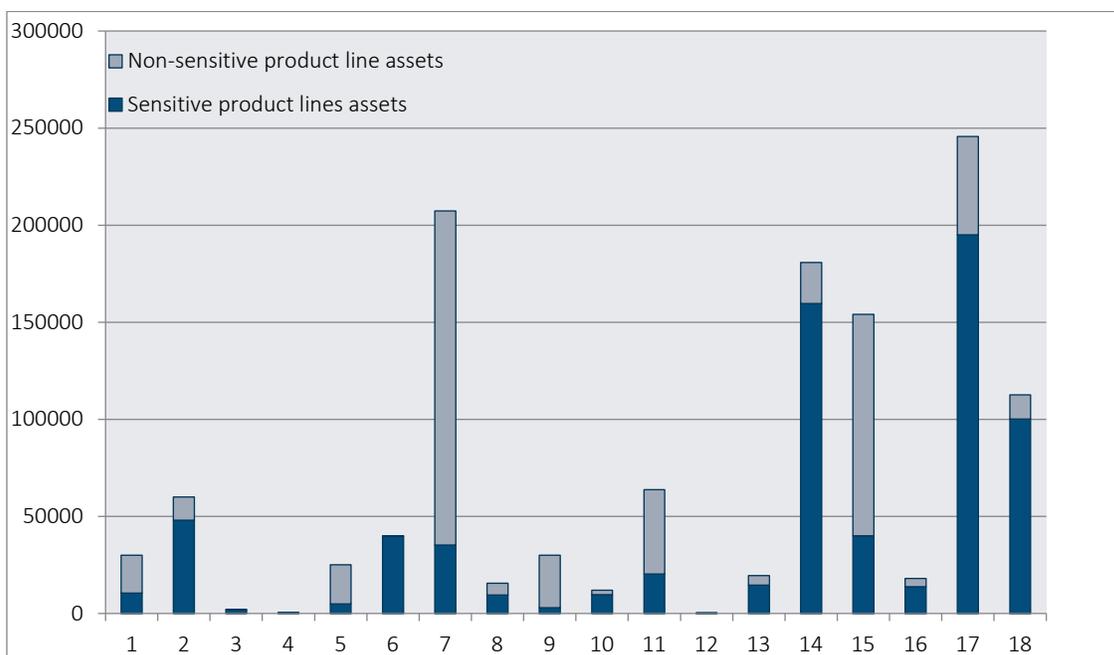
3. What were your company's total statutory assets at 12/31/2014, including separate accounts?

Total statutory assets	Number	Percentage
Less than 10 billions	3	17%
10-100 billions	10	55%
Greater than 100 billions	5	28%
Total	18	100%

4. What is the approximate breakdown of assets backing each major product line (including separate accounts)?

Company #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Variable annuities	0	30	0	0	0	0	7	23	0	50	1	30	16	66.7	6	25	49	51
Variable universal life	0	0	0	0	0	0	3	2	0	0	1	0	1	0	2	5	5.4	8
Fixed annuities	21	20	67	69	0	1.5	6	27	10	10	17	5	32	10.4	13	24	6.5	7
Fixed universal life	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	8	10
Equity-indexed annuities	0	30	0	0	0	98	0	6	0	0	0	0	0	6.5	0	4	4.7	2
Equity-indexed Universal Life	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	1	0.2	3
Universal Life	8	0	18	0	20	0	1	3	0	20	13	10	12	4.7	0	13	0	8
Universal life secondary guarantees	6	0	0	0	0	0	0	0	0	0	0	0	3	0	4	4	5.6	0
Traditional whole life and term	11	10	15	1	80	0.5	66	13	70	20	45	0	11	2.7	4	6	2.7	1
Long term care	6	0	0	0	0	0	1	3	10	0	0	5	0	0	0	0	3.1	0
Disability	4	0	0	0	0	0	2	3	0	0	0	0	0	0	1	2	0.7	0
Other products	10	0	0	5	0	0	1	1	10	0	0	0	0	2.8	62	3	4.4	4
Non-product liabilities	26	0	0	2	0	0	3	9	0	0	0	50	5	3.7	4	0	7.4	0
Capital & surplus	8	10	0	23	0	0	10	10	0	0	23	0	9	2.5	3	13	2.3	6

We consider the first nine categories of product lines as sensitive to investment risks, which may require sophisticated stochastic modeling. The following table gives estimated percentages and assets for all companies that may be subject to nested stochastics.



Part II: Infrastructure and Practice on General Stochastic Modeling

1. What techniques do you use for stochastic scenario generation? (Not necessarily for nested simulations.)

Basic Monte Carlo (Brute force simulations)	12
Variance reduction techniques	7
Cluster modeling	3

2. What sources of stochastic scenario generation do you use? (Not necessarily for nested simulations.)

Internally developed scenario generator	9
Scenario generating vendor (Barrie Hibbert)	4
Scenario generating vendor (MG-Hedge)	1
Scenario generating vendor (Milliman)	1
Scenario generating vendor (MoSes and CAPLink)	1
Academy pre-packaged scenarios	14

3. Which of the following risk drivers/ risk factors are modeled stochastically?

Short term interest rate	15
Long term interest rate	14
Interest rate Volatility	9
Equity Value	14
Equity Volatility	7
Corporate bond default rate	6
Mortality rate	4
Lapse rate	1
Expense	1

4. What is the size of the IT infrastructure dedicated to actuarial teams running stochastic modeling?

	Number	Percentage
Less than 100 CPU cores	5	28%
Between 100 and 1000 CPU cores	8	44%
Between 1000 and 5000 CPU cores	2	11%
Greater than 5000 CPU cores	2	11%
GPU computing	1	6%

- The survey appears to suggest that most life insurance companies employ a very modest computing facility.
- This is an observation consistent with the later finding that nested stochastic modeling has not yet been adopted in the life insurance industry.

5. Does your company use separate computer farms/cloud computing?

	Number	Percentage
Yes	2	11%
No	16	89%

- The majority of companies do not use external computing facilities.
- Among the two that explicitly said using computer farms/cloud computing, one of them added that none is purchased for financial reporting purposes.
- It is clear from the survey that it is a rare practice to use external computing facilities for financial reporting with the current technology.

6. With the computing facilities currently available to you, are you able to complete all required stochastic modeling on a timely basis?

	Number	Percentage
Yes	15	83%
No	3	17%

7. How many actuaries are there to support stochastic modeling?

Number of financial reporting actuaries:

	Number	Percentage
Less than 5 actuaries	9	50%
Between 5 and 10 actuaries	4	22%
Between 11 and 20 actuaries	2	11%
30 actuaries	1	6%
40 actuaries	2	11%

Other actuaries:

	Number	Percentage
Less than 5 actuaries	10	56%
Between 5 and 10 actuaries	7	39%
Between 11 and 20 actuaries	0	0%
60 actuaries	1	6%

- Financial reporting actuaries appear to be the largest group of actuaries in most insurance companies in supporting stochastic modeling. With the exception of four companies, the number of financial reporting actuaries exceeds the number of other supporting actuaries.

Part III: Circumstances for Nested Stochastic Modeling

1. How do you describe your company with regard to nested stochastic modeling?

	Number	Percentage
We do not use nested stochastic modeling and do not plan to use it.	6	33%
We do not currently use nested stochastic modeling but plan to use in the future.	11	61%
We currently use nested stochastic modeling	1	6%

- The life insurance industry appears to be taking a very cautious approach with regard to nested stochastic modeling. While the majority expressed interest in the subject, only one company actually implemented nested stochastic modeling.
- The only company that does nested stochastic modeling indicated that they did it for the purpose of research at the moment.
- As the industry is moving toward increasingly complex financial reporting practice, there appears to be uncertainty and hesitation among insurers with regard to nested stochastic modeling.

2. If you do not use nested stochastic modeling, what are the reasons for this? Check all that apply.

No need for nested stochastic modeling	7
Run time	13
Technology not ready	8
Difficult to model	12
Difficult to understand result	5
Do not have budget	7
Others	1

One respondent stated: “Only a few products that we no longer sell would have a need for nested stochastic modeling. Since they are a small portion of our business, we are not pursuing this modeling.”

- Among the 61% of respondents who plan to use nested stochastic modeling, the vast majority expressed the most concerns with the run time and difficulty with modeling.
- There is a strong indication of a mismatch between the need for and the availability of the new technology for nested stochastic modeling.

3. In what situations do you plan to use nested stochastic modeling in the future?

US GAAP, SOP 03-1	3
US GAAP, FAS 133	3
IFRS Liability adequacy testing	0
Solvency II / Economic capital	4
Asset adequacy testing	7
AG43 and C3 Phase II	3
Embedded value	1
Canadian GAAP (CGAAP/CALM)	1
Principles-based reserve for life products	7
Other: ALM/Asset valuation	1
Other: Pricing	2
Other: Internal deterministic scenario projection	1

4. For which products do you plan to use nested stochastic modeling?

VA with guaranteed minimum accumulation benefit (GMAB)	2
VA with guaranteed minimum withdrawal benefit (GMWB)	5
VA with guaranteed minimum income benefit (GMIB)	1
VA with guaranteed minimum death benefit (GMDB)	3
VA with guaranteed minimum maturity benefit (GMMB)	1
VA with combined GMIB and GMDB	1
Universal life secondary guarantees	5
Fixed annuity	2
Equity indexed annuity	2
Equity indexed annuity with GMWB	2
Equity indexed universal life	3
Other: reinsurance treaty modeling	1
Other: whole life and term insurance	1
Other: long-term saving plans with high guarantee	1
Other: with no guaranteed benefits, with guaranteed annuity payment floor and all combinations	1

There is only one respondent who reported that nested stochastic modeling has been implemented in the company. Hence the following answers reflect opinions only from this particular company.

5. In what situations, is nested stochastic modeling currently used in your company?

- ✓ Research.

6. In what situations, is nested stochastic modeling currently used in your company?

- ✓ Variable annuities

Part IV: Implementation of Nested Stochastic Modeling

1. What systems are used for nested stochastic modeling?

- ✓ Internally developed system.

2. If vendor software, please identify software platforms.

- ✓ N/A

3. What challenges have you faced when implementing nested stochastic modeling? Please rate them on a scale of 1–3 where 1 = least difficulty, 3 = most difficulty. Select N/A if you do not face that challenge.

Building nested projection models	2
Validating the models	3
Generating scenarios on the fly	1
Computing power, run-time, and data storage	3
Analyzing and explaining results	3

4. Please elaborate on the challenges you encountered and describe your plans of attack or actions taken.
 ✓ N/A

No response was provided for this question.

5. Please provide the following information for your models. Please list models used for financial reporting first.

	Financial Reporting Model #1	Additional Model Model #2	Additional Model Model #3
Purpose of model (e.g. AG-43, pricing, hedging)			
Risk factors (e.g. interest rates, equity values)			
Items calculated by the inner loops (e.g. value of assets, value of hedges, these are the items requiring a nested stochastic model)			
Liability cell count			
Asset cell count			
Inner-loop scenario count			
Outer-loop scenario count			
Inner-loop time step and length of projection (e.g. annual for 30 years, quarterly for 10 years)			
Outer-loop time step and length of projection			
Computer resource used (e.g. single PC with n processors / cores, computer grid, cloud computing)			
Run time			

No response was provided for this question.

6. How often do you run nested simulations?
 ✓ Weekly
7. Is nested stochastic modeling subject to an internal process with signoffs, checkpoints and validation requirements?
 ✓ Yes, and informally/loosely documented.
8. Is nested stochastic modeling subject to external auditing or peer review?

No response was provided for this question.

Part V: Methodologies for Nested Stochastic Modeling

9. What techniques does your team use to speed up nested stochastic modeling?
 ✓ Clustering/grid bundling techniques

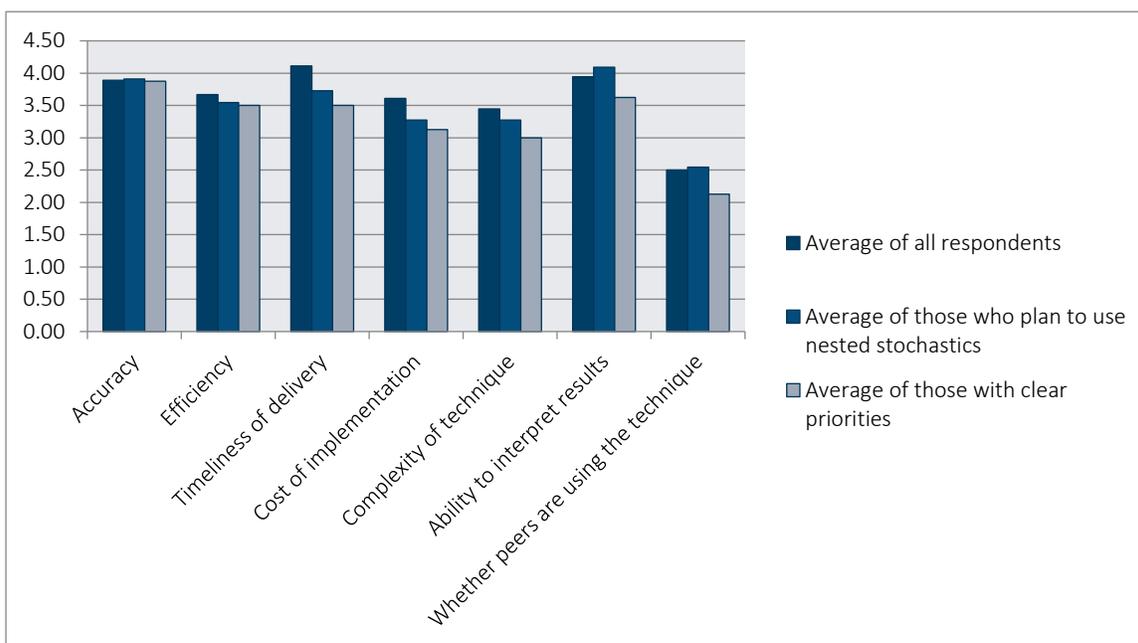
10. Many of the previously mentioned techniques are approximation methods. How does your team check the accuracy of your results?
 - ✓ Check against full nested stochastic models.
 - ✓ Test accuracy on a small scale (a sample policy/a subblock)
 - ✓ Use reasonableness check

11. Model efficiency is a common issue with nested simulations. Other than techniques you identified above, please describe additional mechanisms you use to reduce run time.
 - ✓ Reduce liability cell count
 - ✓ Reduce inner-loop scenario count
 - ✓ Reduce outer-loop scenario count
 - ✓ Longer time step/shorter length of projection for inner loop
 - ✓ Utilize faster more computing facilities
 - ✓ Improve model scalability for parallel computing (e.g., computing grid)

12. What techniques do you use to reduce cell counts?
 - ✓ Mapping techniques.

Part VI: Parting Comments

13. There are often possible competing factors that affect your decision to adopt a new stochastic modeling technique (e.g., a trade-off between efficiency and accuracy). Please identify the relevant factors on a scale of 1 to 5, where 1 = least important at all, 5 = most important.



- While each company has different priorities, we consider the average rating of respondents according to three categories:
 - Average of all 18 respondents
 - Average of 10 respondents who do not currently use but plan to use stochastic modeling
 - Average of 11 respondents with clear priorities. (If one chooses no more than one rating of 5, then it is considered a respondent with clear priorities.)
 - All groups tend to have similar patterns of priorities.

- The three most important factors that affect an insurance company's decision to adopt a new stochastic modeling technique are (in order of importance by average rating):
 - Timeliness of result delivery
 - Accuracy
 - Ability to interpret results

- Those who do not currently use but plan to use nested stochastic modeling have slightly different ordering of the top three factors:
 - Ability to interpret results
 - Accuracy
 - Timeliness of result delivery

- Those who have clear priorities rank the following four factors as their top factors to be considered:
 - Accuracy
 - Ability to interpret results
 - Efficiency
 - Timeliness of delivery of results

- Two companies identified an additional factor as their top choice:
 - Regulatory requirement