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Effective Documentation in Model Risk Management

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By Bob Crompton

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Letter from the Editor

By Phil Schechter

We are up to our third newsletter as a section and are gathering steam. I think that anyone who works with models will find something interesting and useful in these pages; the articles in this issue span from the philosophical to the immediate and from hands-on modeling to governance.

We all know that documentation is important; Bob Crompton offers ideas on how to make documentation effective.

Many of our members have expressed interest in model efficiency, and we feel that this will be a key area for sharing ideas and encouraging research. I anticipate a fair amount of ink devoted to this topic in future issues. Tony Dardis sets the stage with a historic overview and survey of techniques currently in use. Our chairperson, Trevor Howes, also explores this topic, offering thoughts on the governance challenges presented by alterations made to the model or the modeling environment in search of faster run times.

Appropriate assumptions are key to effective modeling, and policyholder behavior can be tricky to capture realistically. Ying Zhao and Nick Komissarov give a concrete example of how to set a meaningful assumption for premium persistency.

It seems that no matter how sophisticated our modeling environments, spreadsheets continue to find a place in our reporting and analysis; their flexibility and power make them ubiquitous, but can lead to poorly governed processes and results. Mary Pat Campbell reports on a session from the 2015 SOA Annual Meeting & Exhibit, with advice on how to give spreadsheets the level of professionalism and reliability we demand from our other modeling tools.

The role of stochastic models continues to expand. These models allow for robust analysis, but the selection of the scenarios can have a subtle or not-so-subtle impact on model outcomes. Bruce Rosner discusses how to review a scenario set to see that it is reasonable and appropriate to the purpose for which it is being used.

Models, no matter how well constructed, do not fully reflect reality, and model users and developers would do best to periodically reflect on appropriate uses and limitations of their models. Frank Grossman provides a framework for this introspection.

I am very pleased with the range of articles, and I thank the authors for their contributions. If there are any topics you would like to see covered in this newsletter, or articles you would be interested in writing, I would be glad to hear from you. ■

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Effective Documentation in Model Risk Management

By Bob Crompton

One of the critical elements in effective model risk management is the development and maintenance of documentation that is responsive to the needs of those charged with implementing and maintaining model integrity.

Perhaps the most authoritative guidance on model risk management is found in FRB SR 11-7/OCC Bulletin 2011-12. This was jointly developed by the Office of the Comptroller of the Currency and by the Board of Governors of the Federal Reserve System.[1] This document addresses all aspects of model risk management, summarized in the following three areas:

- Model development, implementation and use
- Model validation
- Model governance, polices and controls

SR 11-7 is applicable to banks, insurers that own banks and insurers designated as "systemically important financial institutions." It is of interest to insurers not subject to its guidance because the framework for model risk management that it includes is considered by many to contain thought leadership on the topic.

Within the SR 11-7 framework, documentation is part of "model governance policies and controls." The attachment to SR 11-7 makes this statement regarding documentation:

> Without adequate documentation, model risk assessment and management will be ineffective. Documentation of model development and validation should be sufficiently detailed so that parties unfamiliar with a model can understand how the model operates. …
>
> Documentation takes time and effort, and model developers and users who know the model well may not appreciate its value. Banks should therefore provide incentives to produce effective and complete model documentation.[2]

Effective documentation is difficult! It is so difficult that the Fed recommends incentivizing model owners and developers to produce effective documentation.

The Fed does not provide any specific guidance on what effective documentation should look like. This articles discusses some of the specific documentation items that experience has taught are likely to be effective for model risk management.

GENERAL MODEL DESCRIPTION

Effective documentation includes a general description of the model. The general description should be of such a nature as to provide a high-level understanding of how the model fits the enterprise's business, of the risks inherent in the model and of the controls implemented to address these risks.

Some of the items useful in the model description include:

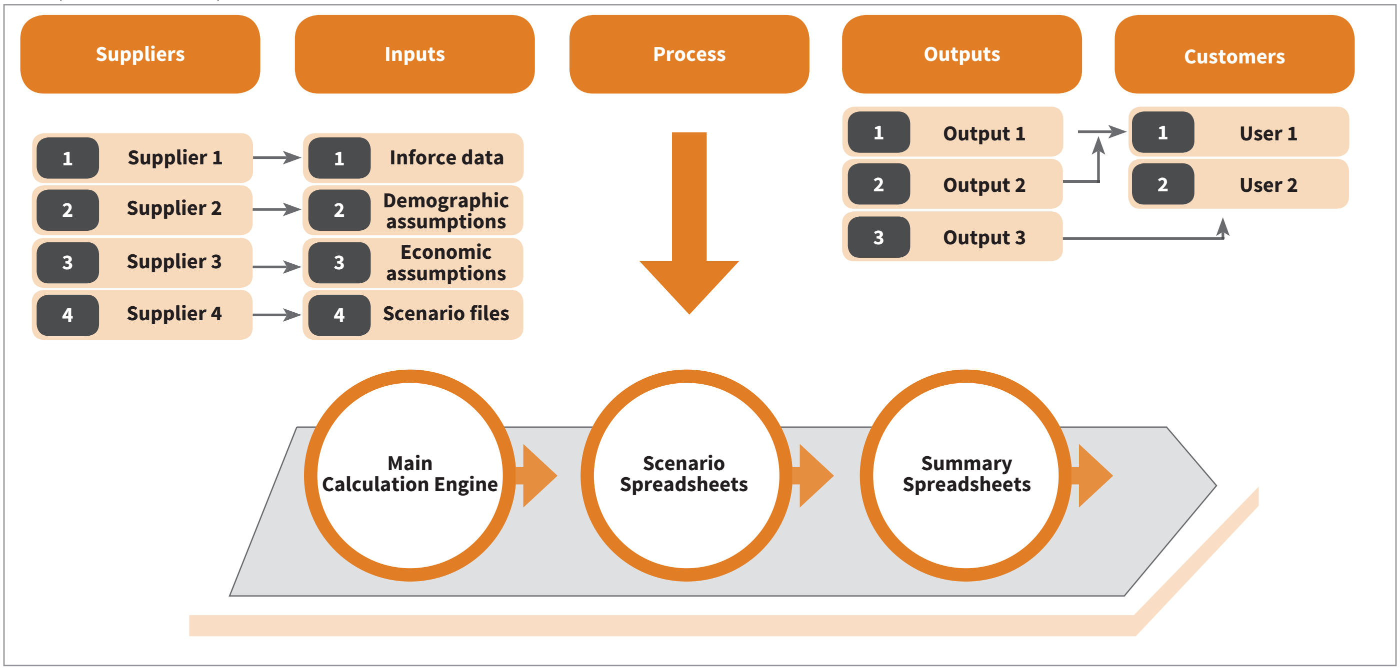
- Model purpose
- Significant model output and intended users
- Model methodology with extended commentary if the methodology is in any way considered unorthodox
- A summary of significant assumptions and their bases
- A summary of model testing
    - At implementation and at model revision
    - Ongoing testing
    - Validation testing, if applicable
- A summary of model controls and why they are considered effective and sufficient

PROCESS MAP

A process map is a visual depiction of the model, including inputs, processing (calculations) and output. A good visual depiction is quickly understood and makes it easy to grasp the scope of the model.

The most widely used template for process maps is the suppliers, inputs, process, outputs and customers (SIPOC) template. A sample SIPOC diagram is shown in Figure 1.

Figure 1
Sample SIPOC Map



For actuarial models, inputs will consist of both data and assumptions. The process will consist of the calculation engine as well as any manual adjustments, overlays, topside adjustments or specialty items. The outputs are the results that are used in some other business process, and the owners of that other process are the customers.

One of the more subtle values of preparing a process map is that it forces us to consider the true extent and scope of the model. Stated like this, the problem doesn't sound difficult. However, one of the trickier items in model management is determining where a model starts, where it stops and what is included in between.

For example, consideration of all the processing that must be completed in order to obtain the output often results in manual items not included in the main calculation engine to be added into the map. Manual items often require special care and consideration in effective model management.

Some documenters also like to include control points in the SIPOC diagram, indicating where model control activities occur, with descriptions in the notes section that discuss each of the control points.

MODEL HISTORY/CHANGE LOG

Model history and change log documents are not as standardized as process maps. Because of their idiosyncratic nature, it is difficult to talk about "typical" documents. Anything that helps in providing a general understanding of the model is fair game to include in these documents.

The purpose of a history document is to provide the background and rationale for the model and any discussion that provides insights into the issues at model implementation and at times of model updates. Issues could include:

- Reasons for model implementation, including a discussion of any predecessor models, and why they were replaced with the current model
- Considerations relating to assumptions and data
- Technical issues
- Software considerations
- Dates and timing of implementation and updates
- Blocks of code or sections of spreadsheets that have been superseded and are no longer used in the model

The purpose of the change log is to provide technical descriptions of model changes, along with a discussion of the rationale relating to resolution of any technical issues associated with the changes.

In addition to providing a general understanding, model histories and change logs are good starting points when tracking down model errors, inefficiencies or anomalies since these documents provide a chronological view of the evolution of models.

MODEL PERFORMANCE METRICS

There are many aspects of model performance and output that are quantifiable. Some of these aspects are material to model utility. Documentation of these material aspects over time provides insight into how "good" the model really is. Metrics can cover various aspects of model performance. Some of these aspects are discussed here.

Model Run Time

Run time is material to production models since they are part of a larger process. Sometimes models occupy part of the critical path of the process—especially for valuation processes. In such cases, run time is a material aspect of the model. Documentation of run time provides information on model efficiency as well as insight on the viability of the critical path.

Real-Time Accuracy

All models strive for accuracy at some level. However some models are used for real-time decision-making, such as underwriting scoring models or pricing models. For this category of models, documentation of model output versus some form of "real world" result, such as market price, or independently scored underwriting category, can be used to determine continuing accuracy of the model.

Data Integrity

Models that process numerous records must have some way of handling data exceptions. A count of exceptions at each processing cycle provides valuable information on the integrity of the underlying data. In addition, this information gives an indication of the amount of manual work required to complete model processing.

MANUAL ITEMS

Manual items are those items processed or calculated outside the major calculation engine, even if they aren't precisely "manual." Typically, such items are handled through spreadsheets but other ancillary methods might be used.

Documentation of manual items is important because these items are not usually subject to the same level of scrutiny at implementation as is the major calculation engine. There is also often casualness about the input and controls associated with the manual portion of a model.

Effective documentation for manual items will include:

- Rationale for not including this in the major calculation engine
- Materiality/significance of amounts determined through manual processes
- Major assumptions and data sources used
- Description of methodology used in calculations
- Description of controls

Make documentation proportional to risk. If manual items are insignificant, documentation of immateriality might be all that is required.

DATA SOURCES

Knowledge of model data sources is important for risk management because we need to know if the data is appropriate for the model. We also need to know if the data is transformed in any way or if it is used by the model in its raw form.

The data sources documentation should discuss these two issues, addressing the rationale for sources and why they provide appropriate information.

The documentation's effectiveness is improved by including a discussion of the extract process, with particular attention to any transformations. The purpose and propriety of these transformations should be discussed in the documentation.

ASSUMPTION SUMMARY

The assumption summary provides a more complete description of assumptions and sources than found in the general model description.

Effective documentation will discuss the source of each major assumption. Possibilities include experience data, experience from analogous situations, population data, expert judgment or industry data.

To properly understand the risks associated with assumptions, the documentation needs to highlight where judgment has been applied. This includes selection of analogous items and other indirect experience items as well as direct application of professional judgment to assumptions.

References, or even better, links to tables containing the assumptions, provide additional value to the documentation.

Sensitivity of assumptions is another item that assists with the analysis of risks relating to model assumptions. A well-designed sensitivity analysis points out which assumptions are critical to overall model results. If sensitivities can be combined with historical volatility of the assumptions, the value of the documentation is improved even further.

CONTROLS

One of the important determinants of model risk is the existence of effective controls. Controls are described as follows by the Committee of Sponsoring Organizations of the Treadway Commission (COSO), a joint initiative of five private sector organizations to provide guidance and thought leadership on governance, ethics, enterprise risk management, fraud, internal controls and financial reporting:

> Control activities are the policies and procedures that help ensure management directives are carried out. They help ensure that necessary actions are taken to address risks to achievement of the entity's objectives. Control activities occur throughout the organization, at all levels and in all functions. They include a range of activities as diverse as approvals, authorizations, verifications, reconciliations, reviews of operating performance, security of assets and segregation of duties.[3]

Part of effective model documentation is a discussion of model controls, the model risks that they mitigate and why the controls are considered sufficient.

If there are model risks that do not have associated controls, effective documentation will address the rationale for not having such controls.

This is an area in which many models could use improvement. Many controls are poorly considered. Some do not address the intended model risk in any direct way, or only in a cursory manner.

DOCUMENTATION LIFECYCLE

Most models are dynamic, undergoing changes and updates to reflect underlying business conditions. Effective documentation is similarly dynamic.

Effective model documentation is revised and updated whenever the model is revised and updated. Any other schedule runs the risk of incomplete or out-of-date documentation.

HOME SWEET HOME FOR DOCUMENTATION

The most common practice in the insurance industry is to have documentation reside with the model owners. This is a reasonable approach with several advantages, such as:

> "Without adequate documentation, model risk assessment and management will be ineffective."

- Convenience: simply save the documentation to a likely spot on the server, no need to go through any formal document log-in
- Accessibility
- Flexibility: this covers a number of aspects of documentation including format, content and distribution

However, this is not the only possible home for documentation. Since part of documentation is document management, shared services document management is another possibility. This approach allows for a more directed application of document management expertise in such areas as versioning, indexing, cataloging, document access control/distribution and document security.

This centralized approach may be preferable to actuaries since there are numerous anecdotes of lost documentation, version confusion and outdated documents. A centralized approach to documentation control allows actuaries to offload the tedium as compensation for handing over control of the documentation.

CONCLUSION

Effective documentation is an integral component of risk management. This article presents several examples of documentation that have proven to be effective in practice. Incorporation of some or all of these forms of documentation will facilitate model governance. ■

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ENDNOTES

[1] The Bulletin can be accessed at *http://www.federalreserve.gov/bankinforeg/srletters/sr1107.pdf.*

[2] This attachment can be accessed at *http://www.federalreserve.gov/bankinforeg/srletters/sr1107a1.pdf.*

[3] From the document "Internal Control—Integrated Framework" on COSO's website at *http://www.coso.org/documents/990025P_Executive_Summary_final_may20_e.pdf.*

Chairperson's Corner

"And What About Model Efficiency Governance?"

By Trevor Howes

So model efficiency may come at the price of increased uncertainty and reduced confidence.

No, the above headline is not a mistake! Although, it does reflect some indecision on my part while preparing to write this column. Should I talk about model governance, a topic attracting attention all around the world from regulators, auditors, chief risk officers, boards of directors as well as actuaries? Or should I look closely at another key focus point of the Modeling Section in 2016: model efficiency?

At first glance, these two primary interest areas of our section seem to apply to different stages of the modeling process and to be working in opposite directions. Model governance applies a framework of rules, validations and outside authority to the modeling function, slowing down the modeling process and adding expense. Model efficiency, on the other hand, considers the inner workings of the model and attempts to address the ever-increasing cost of running increasingly complex models. How best can we speed these models up, make them less expensive to run and consume fewer thousands of core hours?

Model governance and model efficiency may seem unrelated, yet there is an intersection of these two concepts that has received very little attention or discussion: how to properly govern the application of model efficiency techniques.

Model efficiency techniques are attracting increasing research dollars, newsletter articles and presentations at conferences, much of which our section is helping to organize and deliver. These techniques in general aim to address model performance by finding an alternative approach to the model calculations or a simplification of the model data or of the assumptions the model uses, so the adjusted model is quicker to run but still produces answers reasonably close to what the base model would provide. In other words, an approximation that is good enough for the purpose.

We all know a stochastic model using Monte Carlo techniques by definition provides estimates of the intended numeric result that involve some level of statistical error, which depends on the number of random trials. Mathematics tells us the standard error for a pure Monte Carlo simulation and that fewer trials increase that uncertainty. But is that standard error material or immaterial for a given purpose? And when we find innovative techniques to build smaller representative scenario sets or clustered samples of generated scenarios, how then does that error estimate change?

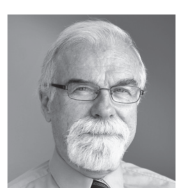
Similarly, if we cluster model data into a condensed model, we know the reduced model will have different answers but usually we can only guess at the net impact of the technique, perhaps based on past experience. So model efficiency may come at the price of increased uncertainty and reduced confidence. This sounds like model risk; we are adding greater possibility that the results of the model may not be sufficiently accurate and may drive an inappropriate decision or strategy because the technique had greater distortion on the model results than anticipated.

How can we identify, quantify and disclose the nature of this model risk? Should it not be treated explicitly in the description of our work? And, most importantly, how can we mitigate this risk?

This leaves us with two important questions as we move forward with our exploration of these modeling topics:

1. What innovative model efficiency techniques can be developed to greatly reduce the computation load in the area of nested stochastics?
2. How can we manage and control the model risk introduced by our model efficiency techniques, and provide our stakeholders with a justifiable level of confidence in our modeling work?

In summary, how will we appropriately govern the increasing use of innovative efficiency techniques in our modeling?



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Model Efficiency in the U.S. Life Insurance Industry

By Tony Dardis

In a life insurance industry where there seems to be an insatiable desire for analytics, practitioners are increasingly under pressure to produce more numbers, and to produce them quicker.

This in turn has led to a cottage industry in itself—the world of "model efficiency."

Model efficiency refers to the development of financial models that yield results with a minimum of time and effort. Model efficiency might be achieved through well-written code, creative application of mathematical and actuarial techniques, or state-of-the-art technology.

Its emergence as a field of practice in the life insurance industry is rooted in the fact that models of life insurance companies can be complicated:

- Life insurance products, and the assets backing them, can be complex.
- Millions of contracts may need to be modeled, each contract with its own special characteristics.
- Long-term projections are involved and may be performed over hundreds of thousands of different projection paths.

In time, model efficiency has emerged as both a science and an art, involving elements of creative thinking and technical know-how.

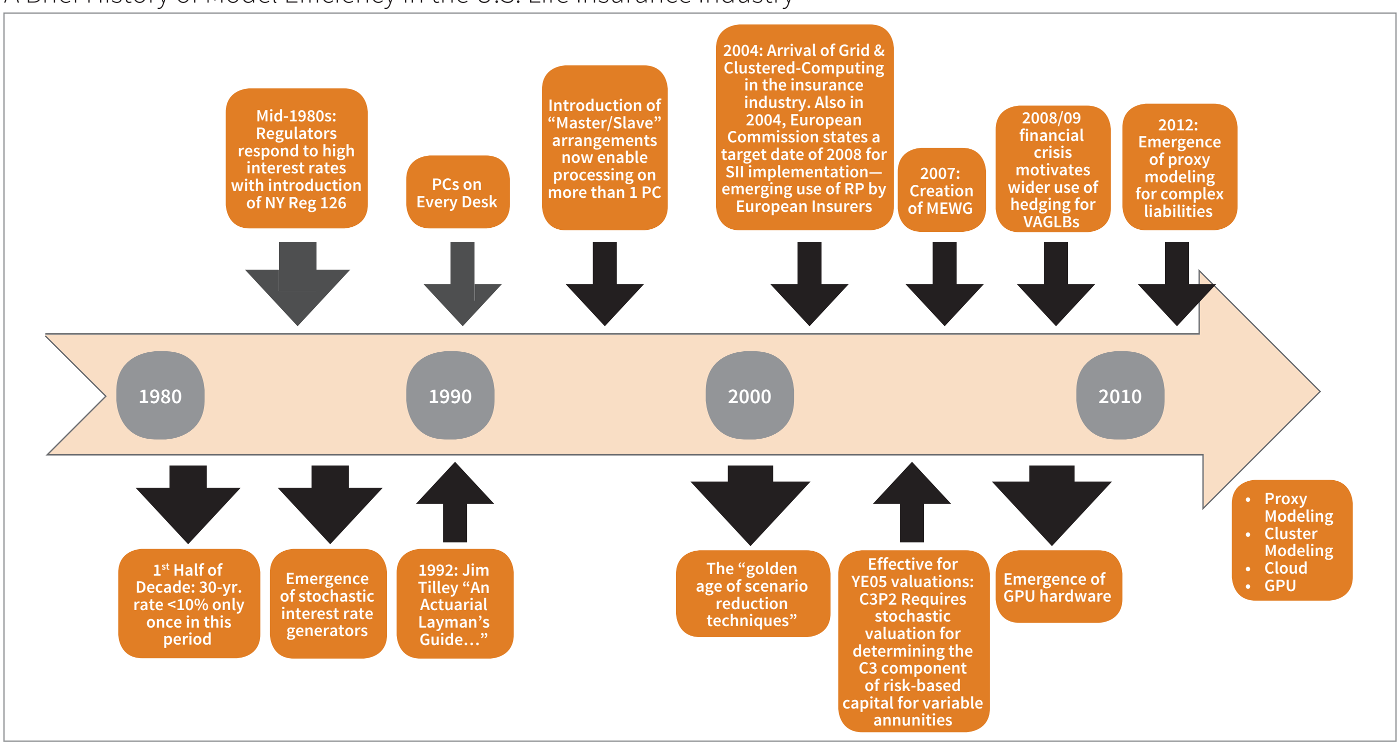
In this article I walk through the history of model efficiency in the U.S. life insurance industry, examine the current application of model efficiency, and look ahead to what we might expect to see in the future. I would like to think that, for those who stay with me through this article, you will get some useful insights that may in turn prove to be helpful to you in developing your own efficient models.

A HISTORY OF MODEL EFFICIENCY IN THE U.S. LIFE INSURANCE INDUSTRY

Figure 1 gives a summary timeline of key milestones for model efficiency in the U.S. life insurance industry over the years.

Before the widespread availability of computing power, insurance calculations were performed manually. Commutation

Figure 1
A Brief History of Model Efficiency in the U.S. Life Insurance Industry



functions were a primary tool for actuarial work until well into the 1980s. These could summarize in a single number the present value of discounted life contingent cash flow projections for a given rate of interest. The precise form and value of a particular function would depend on the nature of the projection and on age and duration, as well as the rate of interest; large books of commutation tables were a fixture in life offices. Commutation functions were undoubtedly ingenious, a testament to the actuarial profession of yesteryear, and indeed might be viewed as a model efficiency technique, saving the actuary from tedious calculation. (See Figure 2.) They also fostered a wonderful common language within the actuarial profession, and continue to serve as a convenient shorthand even in today's high-tech world.

Figure 2
Commutation Functions as a Modeling Efficiency Technique

$$\mathit{Whole\ Life\ Policy} = A_x = \frac{M_x}{D_x} = \frac{\sum_{t=x}^{\infty} C_t}{D_x} = \frac{\sum_{t=x}^{\infty} v^{t+1} d_t}{v^x l_x}$$

The emergence of the desktop micro-computer or "PC" in the early 1980s effectively revolutionized actuarial work. PCs could be accessed at will, and enabled multiple iterations of code so that a production process could be put in place at a fraction of the time it would take to get a mainframe process fully up and running. Although the early PCs certainly had significant limitations around data storage and processing power, they paved the way for actuaries to build models of insurance business and readily perform cash flow projections. This allowed for the development of "profit models" in product pricing.

From this point on, the world of actuarial modeling moved forward quickly. Changes in the economic environment necessitated better models, the development of increasingly complex insurance products and asset/liability profiles stressed the models and drove the need for efficiency, and advances in technology enabled increased usage of actuarial models.

Economic Environment and Increasing Complexity

Only once during the **first half of the 1980s** did the 30-year rate in the U.S. dip below 10 percent. High interest rates drove disintermediation, in which policyholders drew down the value of their policies, forcing insurers to sell assets at a loss. At the same time, products were being issued with high interest rate guarantees, putting insurers at risk of decline in interest rates. Regulators responded to this emerging risk by requiring cash flow testing for annuities using deterministic scenarios. This was the first widespread use of interest rate scenarios in an actuarial setting. By the mid-1980s, New York regulators required testing using the now familiar "New York 7" scenarios, first for annuities and eventually for most life insurance business.

During the **second half of the 1980s**, we started to see a handful of insurers using stochastic interest rate scenarios in addition to the deterministic scenarios required for cash flow testing under New York Regulation 126. Actuarial literature started to deal with the development of stochastic interest rate generators. Jim Tilley's classic 1992 paper, "An Actuarial Layman's Guide to Building Stochastic Interest Rate Generators," heralded the start of widespread stochastic modeling in the U.S. insurance industry.

2005 saw the introduction of the C3 Phase II requirement for variable annuity capital, adopted by the National Association of Insurance Commissioners (NAIC) on Oct. 14, 2005, and effective for year-end 2005 valuations. This required stochastic valuation for determining the C3 component of risk-based capital for variable annuities. Suddenly model efficiency became of critical importance to all VA writers.

In **2008-09**, the financial crisis alerted insurers to the very real risks associated with variable annuities with guarantees and motivated much wider use of hedging as a means to better manage these risks. This is itself further exacerbated the processing requirements of variable annuity business, already brought to a new level by the introduction of C3 Phase II a few years earlier, e.g., the need to do full- scale hedge effectiveness testing to get credit for dynamic hedging in the C3 Phase II valuation.

Innovations in Efficiency

Around **the mid-1990s**, actuaries started to look at how to run fewer scenarios that were representative of a larger set for stochastic modeling, as a means of managing the run-time issues associated with running many scenarios. In the decade to follow, some very imaginative ways of tackling the issue were proposed and in some cases used successfully in practice—the "golden age of scenario reduction techniques":

- Alistair Longley-Cook proposed a rather novel approach using least squares to fit 1,000 stochastic scenarios to the New York 7 scenarios in his paper "Probabilities of 'Required 7' Scenarios (and a Few More)," *The Financial Reporter* (July 1996).
- In her paper "Representative Interest Rate Scenarios," *North American Actuarial Journal*, vol 2, no. 3 (July 1998), Sarah Christiansen developed a practical approach to picking representative scenarios from a stochastically generated set by testing multiple subsets from the full set and choosing the subset that best meets various criteria (e.g., best matches the mean of each term rate in the scenario, extremes, standard deviations, etc.).
- Yvonne Chueh used distancing techniques to establish a reduced scenario set in her paper "Efficient Stochastic Mod-

eling for Large and Consolidated Insurance Business: Interest Rate Sampling Algorithms," *North American Actuarial Journal*, vol. 6, no. 3 (July 2002), a methodology that has been used quite widely throughout the industry over the past decade in one form or another.

- In their 2005 paper "Variance of the CTE Estimator," *North American Actuarial Journal*, vol. 9, no. 2 (April 2005), John Manistre and Geoff Hancock propose an approach for choosing a representative scenario set that works well in the tails of distributions.

In **2004**, the European Commission stated a target date of 2008 for new Solvency II regulations to be effective, upping the bar and demanding that companies squeeze yet more out of their models. In response, ING pioneered the approach of using a replicating portfolio as means of reducing liability model runtime associated with Solvency II-type capital calculations; other European insurers followed suit.

In **2007**, the American Academy of Actuaries established the Model Efficiency Work Group, or MEWG, as it was affectionately known as by its members, a subgroup of AAA's Life Financial Soundness/Risk Management (FS/RM) Committee, which in turn was responsible at the time for making proposals for the implementation of a principles-based approach (PBA) to reserves and capital for life insurance in the United States. The FS/RM Committee recognized that for some companies, the requirements of PBA could lead to onerous calculation requirements, and wanted to have expert input from a separate group focusing on ways to mitigate this burden and hence make calculations more manageable without compromising on accuracy. This group had some successes in promoting model efficiency as a practice area around the industry, notably:

- Two surveys of model efficiency practices in the U.S. life insurance industry, the first being published in November 2007, summarizing responses from 30 companies, and the most recent being published in April 2013, based on responses from 51 companies.

- The publication of "Modeling Efficiency Bibliography for Practicing Actuaries," last updated December 2011, which lists the publicly available documents in the area, categorized according to "actuarial modeling techniques" and "technology," and a handful of further subdivisions within each of these broad headings (more on this below).

- At the Society of Actuaries' Life 2008 Spring Meeting in Quebec City, a "conference within a conference" was presented, with a series of four panels related to model efficiency under the banner of "Introduction to Modeling Efficiency and Scenario Reduction." This was the first large-scale "event" for the U.S. actuarial profession dedicated to the topic of modeling efficiency.

In **2012 and beyond**, increasing attention is paid to the use of liability proxy models, whereby the value of a liability is expressed as a polynomial function, as a way to speed up run model time by not having to run a full "heavy" actuarial model.

Technological Innovation

Many of the early actuarial models had been built by individual actuaries using the programming language APL either on a mainframe or PC environment. During the late '80s and early '90s, commercial software running on the PC became increasingly common. In the **mid-1990s**, commercial actuarial systems originally designed to run on a single PC evolved to take advantage of more than one computer. This was typically realized in a "master/slave" arrangement whereby the software running on one PC, the master, was programmed to off-load some of its work to the same program running in slave mode on other PCs. While this paradigm lacked the sophisticated resource management of cluster, grid and cloud technologies to follow—typically leveraging only a handful of computers—this early form of distributed computing offered a means of significantly reducing elapsed runtime.

Computer processing power has been increasing steadily since the introduction of the PC with the escalation in chip speed. Other technological breakthroughs in computing capacity began to take root in the **early 2000s**, with the introduction of Intel's Hyper-Threading Technology in **2002** and the subsequent emergence of dual-core and, later, quad-core central processing units (CPUs) beginning in **2005**. These advances opened up the ability to run sequences of instructions concurrently on a single computer, although it would take some vendors several years to natively leverage these capabilities within their software applications.

2004 saw the arrival of grid- and clustered-computing technology in the insurance industry, including DataSynapse GridServer and Milliman C-Squared, with Windows Compute Cluster from Microsoft (now HPC Server) and Symphony from Platform Computing following shortly after. These solutions enabled developers of actuarial systems to distribute workload over hundreds of CPUs. In addition to raising the ceiling on distributed computing capacity by one or two orders of magnitude compared to master/slave arrangements, grid technology opened the door for information technology specialists to play a role in the adoption, configuration and maintenance of actuarial systems that had previously been localized to end-user workstations.

The mid-to-late **2000s** heralded the introduction of graphics processor unit (GPU) hardware as a practical means of off-loading highly parallel computations from conventional CPUs. This powerful and innovative technology was made accessible to software developers through technologies like

OpenCL from Khronos Group, CUDA from NVidia and DirectCompute from Microsoft, and to quantitative and model developers through integration with systems like MatLab from MathWorks.

The launch of Amazon Web Services in **2006** and Microsoft Azure in **2010** ushered in the era of cloud computing as a means of accessing CPU resources on a scale capable of far exceeding the capacity available in most on-premises solutions. With technologies like Elastic MapReduce from Amazon, HPC Pack with Azure "burst" capabilities from Microsoft and GridStep Cloud Edition from Milliman, grid-enabled models could access the CPU cycles (and storage) needed for seriatim valuation, nested stochastics, and forward and backward projections—simultaneously.

THE CURRENT STATE OF MODEL EFFICIENCY

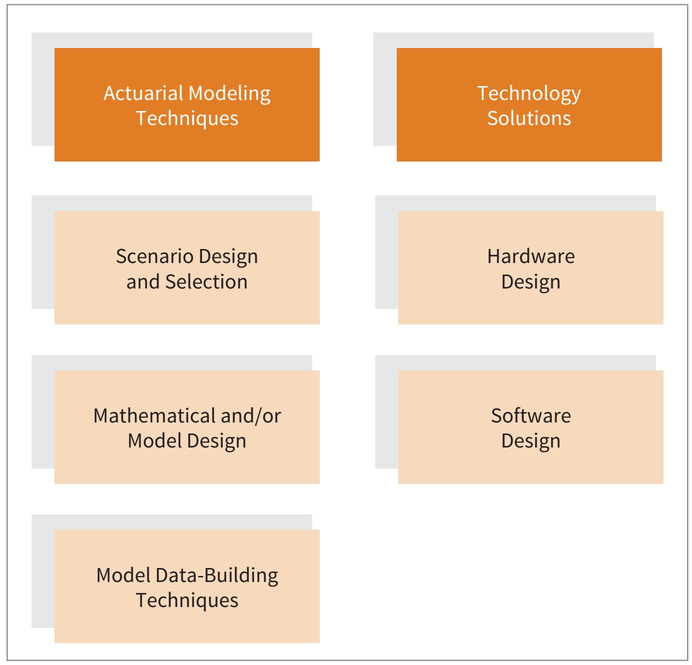
Having stepped back and viewed model efficiency from a historical perspective, where are we today and what does the future hold? In this section of the article, I'll consider today's perspective under three headings:

- Model efficiency taxonomy
- Model data-building techniques: replicating portfolio, proxy modeling and cluster modeling
- Technology

Model Efficiency Taxonomy

One of the outcomes of the work done by MEWG was the establishment of a general taxonomy, designed to categorize the various model efficiency techniques and thus to provide a framework for a common dialogue among practitioners. This framework is summarized in Figure 3.

Figure 3
Model Efficiency Taxonomy



Under the heading of **Actuarial Modeling Techniques**:

- **Scenario design and selection** covers how we choose or design our scenarios and includes the wide array of scenario reduction techniques.
- **Mathematical and/or model design** covers how the choice of a mathematical approach to a model can simplify calculations and/or reduce the time required to perform these calculations. For example, for runs that require an estimate of future market prices, instead of having to generate a set of market consistent scenarios at each future point in time, we may be able to use a closed form mathematical solution, such as Black-Scholes.
- **Model data-building techniques** include traditional approaches to building actuarial models, involving the development of model points designed to bucket seriatim data by homogenous groupings, such as issue age, contract duration, contract features, etc., plus the use of emerging state-of-the-art techniques to make models even more efficient, such as cluster modeling (more on this later).

Under the heading of **Technology Solutions**:

- **Hardware design** covers the broad spectrum of using today's technology to its fullest extent to best meet actuarial processing needs, including the use of grid and cloud computing.
- **Software design** covers using efficient programming code design to best meet the requirements of a particular appli-

cation, and optimized for the underlying technology. For example, for multicore solutions with multithreading, and for GPU applications, the software must be written with considerable technical knowledge of the hardware in mind. Another issue here is that the choice of language can significantly impact performance, e.g., Excel workbooks implemented using spreadsheet formulas in combination with Visual Basic for Applications (VBA) logic are commonplace on actuarial desktops, but not readily scalable to a production environment and VBA code runs much slower than compiled C or C++ or .Net languages like C#.

It is also worth noting there are some approaches that are not readily categorized under any of the headings highlighted above, such as a hybrid modeling approach developed by Steve Craighead, which uses a mix of representative scenario techniques to create training data for a predictive model.[1] Emerging techniques such as proxy modeling may also be viewed as falling under the "hybrid" category.

Indeed, implementing efficient models often calls for combination approaches, and real success requires both actuarial and technology expertise. The former is necessary to leverage techniques such as replicating portfolio, proxy models and cluster models. The latter is necessary to ensure the selected algorithms execute as quickly as possible and model performance is not degraded by inefficient access to data.

Another related point to make here is that while model efficiency may require a blend of approaches, there is a balance to be struck between increasing complexity and ensuring a smooth process that can be maintained on an ongoing basis. Generally speaking, the more aggressive the approach to maximize performance, the more complex the process with associated potential increases in bug rate, as well as a shrinkage in the pool of sufficiently knowledgeable resources to debug, maintain and enhance the model.

The remainder of this article focuses on the areas where we have seen the most rapid developments in model efficiency most recently, looking separately at developments from the actuarial modeling and technology perspectives, and looks ahead to what we may expect to see in the future.

Recent Developments in Actuarial Modeling Techniques: Replicating Portfolio, Proxy Modeling and Cluster Modeling

So far as actuarial modeling techniques are concerned, the most rapid developments in recent years have been around the use of the replicating portfolio (RP) and, most recently, proxy modeling and cluster modeling.

The essence of the RP technique is to find a basket of assets that matches the value of a liability inventory over a wide range of shocks and then use this portfolio as a surrogate for the value of the liabilities in further analysis. The advantage of this approach is the analysis of this RP will be more manageable than working with the liability models, especially if the assets in the basket have closed-form solutions for market valuation.

As an example, the liabilities model could be run through 100 different shocked scenario sets to come up with the sensitivity of the liability market value to 100 different shocks, and the RP would be calibrated to those results. Then the RP could be run through a much larger number of shocks than would be practical for the liabilities, to come up with conditional tail expectations.

The practical application of RP first began at ING, spearheaded by Tom Wilson (now chief risk officer at Allianz) in the mid-2000s as a way to support their internal economic capital calculations based on looking at the performance of the market consistent value of the balance sheet in the tails under many real-world stochastic scenarios, similar to the Solvency II view on capital. The ING RP approach soon became de rigueur with a number of the other large multinational insurers.

RPs have certainly proved to be very useful for certain applications, but not for all. One of the limitations of the RP approach is that if based purely on liquid and analytically tractable instruments, there can be accuracy limits for some products. The need for ever-increasingly complex tail-risk orientated calculations have become more prominent—such as the calculation and projection of economic capital—and has led practitioners to look at alternative approaches to approximating liabilities. One such alternative approach is proxy modeling, which is already being used extensively in Europe to help manage the calculations required for Solvency II, and is beginning to get some traction in the United States.

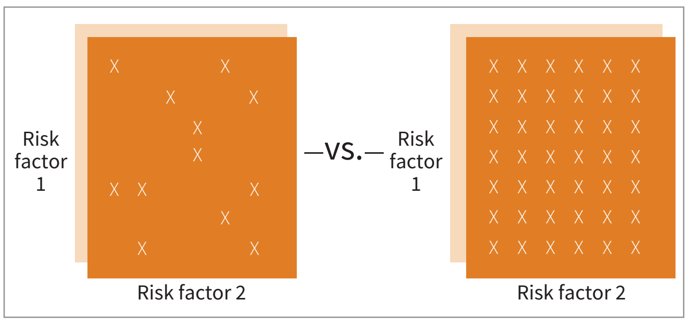
The essence of the proxy modeling approach is that a function (proxy) is fitted to the liabilities, with that function expressing the liabilities in terms of the underlying risks to which the liability is exposed. Thus, for a variable annuity portfolio, we might say our liabilities are a function of equity returns, movements in the yield curve, and equity and interest rate volatility. The exercise then becomes a question of fitting that function to the liabilities to give a result that is accurate, even in the tails, and does not require frequent re-fitting.

There are a number of ways of fitting such functions but all involve essentially four steps:

- **Step 1.** Determine what risks to consider and generate "fitting points." This the key part of the exercise; getting this wrong may mean you end up with a meaningless function. After determining the risks to consider, you need to establish the points to which you are going to fit the proxy model. Figure 4 summarizes the issue under consideration here.

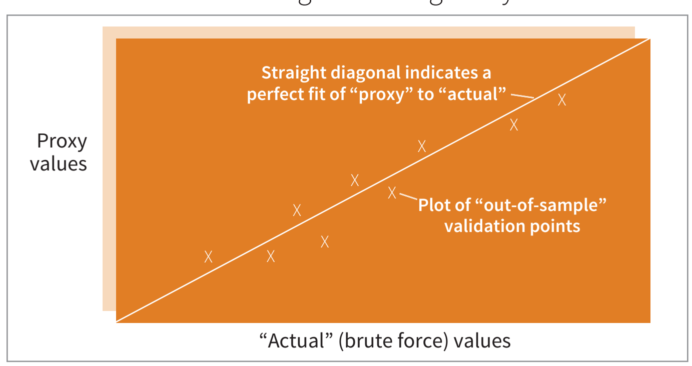
Ideally, you would like to be able to cast a very wide net, and calculate many accurate values (from the underlying heavy model) against which a function can be fitted. In practice, it may not always be possible to generate as many fitting points as we would like as the underlying heavy model may take too long to run. For some applications, the optimal solution might be to create a series of carefully selected, accurately calculated values and use interpolation (as in the case of radial basis functions and curve fitting); for other applications, we might be able to get good results by calculating approximate values for every point across the risk space and fitting a proxy function to these approximate values, as in the case of least squares Monte Carlo (more on all of this in a moment).

Figure 4
The Essence of Best-in-Class Proxy Modeling—Covering the Risk Space



- **Step 2.** Calculate the target metric for each fitting point by using the underlying heavy model. The choice of target metric is dependent on the application under consideration, e.g., market value of liability, or net liability value (assets less liabilities).
- **Step 3.** We will now have a series of fitting values for each fitting point (which in turn represents a combination of the various risks that we are exposed to). We can now readily fit a function through those points, via an optimization routine using agreed fitting criteria. Simple curve fitting techniques, where a relatively simple curve is fitted to a series of accurately calculated values and then linear interpolation used to fit values outside the fitted value, can be a useful "starter pack." However, for better results that permit interpolation in a high dimensional space, the radial basis function approach has been demonstrated to give extremely good results. Under the radial basis approach, we establish a series of accurately calculated points, these points having been carefully selected to cover the entire spectrum, and then all sample points get considered when interpolating to a given point, enabling us to better capture the shape of complex underlying functions. Another approach is least squares Monte Carlo, where we generate fitting values that cover the entire risk space but each individual fitting point on its own is inaccurate—the success of the methodology hinges on being able to generate so many points that when you fit a curve through the points, the errors on average cancel each other. Least squares Monte Carlo works very well where the points are unbiased and independent, but is more challenging when applied to estimating CTE-based measures such as those required for Actuarial Guideline 43/C3 Phase II, for which one may need to address bias in estimates.[2]
- **Step 4.** The final part of the process is to validate the proxy function. This will include looking at out-of-sample validations. The process here is similar to what was done for the fitting points, i.e., we first establish the validation points we want to test, and we then have to go back to the heavy model to calculate the targeted metric values for each point. The validation is then a straightforward task of comparing the value generated from the heavy model versus the value generated by the proxy function. Figure 5 illustrates the point nicely—if proxy values are plotted on the y-axis, and actual values on the x-axis, then a straight line diagonal at 45 degrees is reflective of a perfect fit. Plotting the values actually generated at each validation point then gives us a very simple at-a-glance view of how good the proxy model is—and is also something senior management can quickly understand. Another key test is to perform dynamic validations of the proxy function—how well does the function behave over time? This type of dynamic test isn't something that is necessarily always done rigorously when developing proxy functions, but it needs to be.

Figure 5
The Proof-in-the-Pudding: Validating Proxy Models



Another important development in recent years in the area of model data building has been the emergence of the cluster modeling technique. This has been applied by a number of U.S. insurers very successfully, and may be viewed as a straightforward extension of more traditional actuarial model point development.

Cluster modeling involves establishing the importance of individual data points and mapping less important points into the more important ones and continuing that reduction process until the desired number of model cells has been reached. The process thus begins at the individual policy record level, mapping policies of lesser importance into those policies of greater importance, and continuing that mapping process until the desired level of compression has been achieved. "Importance" in this instance is defined as size times distance, where size would be typically face amount for life insurance and account value for deferred annuities, and distance is determined relative to a policy's or cell's nearest neighbor with reference to whatever we deem to be the key metrics that characterize the policy, e.g., present value of future profits per unit, or reserves at projection date per unit.

There have been some papers written on cluster modeling and some presentations given at industry events—for an excellent introduction to the topic, a Milliman report by Avi Freedman and Craig Reynolds, "Cluster Analysis: A Spatial Approach to Actuarial Modeling" (2008),[3] is well worth reading.

Cluster modeling continues to hold much promise for the industry. Moreover, to the extent runtime issues will still exist around proxy modeling in having to calculate "actual" values for fitting and validation purposes, cluster modeling can be a very useful supplement to proxy modeling, and again we are aware of some practitioners in the industry considering application of the techniques in tandem—a kind of "hybrid" approach to model efficiency.

Recent Developments in Technology

Technology advances rapidly, and insurers who fail to keep pace with those developments face the combined risks of increased inefficiency and decreased competitiveness. There are many aspects of emerging technology that are exciting, but perhaps two that hold the most promise for insurance companies to make difficult and time-consuming calculations more manageable are cloud computing and GPU technology.

We are already seeing widespread use of cloud to help manage very large data and processing requirements in many aspects of the financial services industry, e.g., to conduct day-to-day banking. The insurance industry is far from exhausting the cloud potential, but some insurers are realizing immediate benefits from cloud with regard to computational throughput and large-scale data management. At the 2015 ERM Symposium, Jim Brackett of Milliman presented a very useful talk on some of the developments around cloud (and other) technology.[4]

Also at the 2015 symposium, on the same panel as Jim, we heard Iouri Karpov, of Prudential Financial, give a fascinating presentation on what is emerging around GPU and how the technology could potentially be used more widely.[5]

In this age where the answer to almost any question can be found on the Internet with the click of a button, it seems inconceivable that insurance companies will not soon be doing things much quicker.

Virtually every modern video game console, computer and smart phone has a GPU, and developments in the area have been largely driven by the ever-increasing demand for improved high-definition standards in gaming. General-purpose GPU computing refers to other scientific and business applications. GPU computing works extremely well where there are numerically intensive and parallelizable calculations that need to be done. Clearly, this holds much promise for many insurance-based calculations, such as the massive parallelization that's done in an insurance valuation involving running a significant number of policies with similar payoff definition across multiple scenarios.

Iouri's presentation at the ERM Symposium, based on his own use of GPU technology to help with some of his work at Prudential, certainly created some buzz among those who attended the session. While application of GPUs in the industry currently remains in its infancy, and there are practical issues to address around productionizing a GPU process, it certainly seems to hold huge promise.

WHAT WE MIGHT EXPECT TO SEE IN THE FUTURE

Model efficiency is a field of practice that should continue to develop, as the growing appetite for usable and up-to-date analytics continues unabated.

In this article, we have discussed the emergence of proxy modeling and cluster modeling, and cloud and GPU technology, as powerful developments we can expect to see more widespread use of. But as ever in life, it is probably going to be something we are not even aware of today that ends up taking model efficiency up another level.

In this age where the answer to almost any question can be found on the Internet with the click of a button, it seems inconceivable that insurance companies will not soon be doing things much quicker. Providers of risk and actuarial platforms who make the investment now in the emerging methodologies and technologies stand to take a dominant position and will shape the way the industry does things for many years to come.

As for MEWG, there remains a core group of practitioners that have continued to share information and do some research, but MEWG under the AAA is today more of a "sleeping dog"; it remains "officially" in existence by name but has not performed any work for some time, and there are currently no members of the group, other than its chair, myself, continuing to be listed as a contact point. That said, there is a new subteam of the Society of Actuaries' Modeling Section assisting the Section Council with model efficiency matters that plans to be proactive in the area of research and seminars. This new subteam is again being led by myself, and so far we have recruited Paula Hodges from Ameritas and Mike Beeson from Pacific Life to be on the team. The mandate for the team is somewhat informal, but in essence the objective is to assist the Modeling Section Council in its mission to support the basic and continuing educational, research, networking and other specialized needs of its members within the specific area of model efficiency. If you are interested in getting involved, we would be delighted to hear from you; please contact me at *anthony.dardis@milliman.com*.

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ENDNOTES

1 See Steven Craighead, "PBA Reserves and Capital Modeling Efficiency: Representative Scenarios and Predictive Modeling," *The Financial Reporter*, 73 (June 2008).

2 For a discussion of bias in estimates of a CTE value, see B. John Manistre and Geoffrey H. Hancock, "Variance of the CTE Estimator," *North American Actuarial Journal*, vol. 9, no. 2 (2005): 129–156.

3 *http://www.milliman.com/uploadedFiles/insight/research/life-rr/cluster-analysis-a-spatial-rr08-01-08.pdf.*

4 *http://www.ermsymposium.org/2015/presentations/C-12-Brackett.pdf.*

5 *http://www.ermsymposium.org/2015/presentations/C-12-Karpov.pdf.*

A Practical Approach to an Enhanced Premium Persistency Assumption

By Ying Zhao and Nick Komissarov

Premium persistency for flexible premium life products has been an interesting and challenging area in actuarial modeling. On one hand, most products have a target premium of some sort for each policy that could be and often is used as a future premium assumption. On the other hand, the flexible nature of the products makes it difficult to argue that customers will repeat the same premium paying pattern year after year.

Many practitioners take a simple approach to the premium persistency assumption. According to the 2012 SOA survey on the very topic, most survey participants assumed 100 percent premium persistency for pricing and reserving.[1] Premium persistency factors, when used at all, tended to be developed and applied at the product or product group level; policyholder behavior was not explicitly modeled. There is a risk that this simplified approach to modeling premium persistency could understate (or overstate) the value of certain policy features, such as secondary guarantees.

This article describes a refined approach to premium persistency that takes actual policyholder behavior to the center of the assumption development and modeling, and how this approach was implemented at one company. Unlike conventional dynamic assumptions that tie policyholder behavior to external economic factors such as interest rates, this approach focuses only on premium history at an individual policy level. The examples in this article will focus on a current assumption universal life (CAUL) block. We will also discuss the assumption variation of universal life with secondary guarantees (ULSG).

SETTING UP THE ASSUMPTION

The premium persistency assumption at Resolution Life was developed during the pricing of an acquired block of UL policies. We reviewed models from leading consulting firms and decided on an approach that incorporates past premium payment behavior on an individual policy level.

The assumption uses premium paid to-date as the primary indicator for the future premium behavior. Actual to-date paid premium was compared to to-date target premium to determine a premium funding level, aka funding bucket, a particular policy falls into. Three primary funding buckets were defined to categorize the level of expected future premiums for each policy. Policies without any premium payment in the past 12 months were viewed as implicit zero-pay policies. These policies would be assumed to no longer pay any premium in the future. Single-pay policies were also separated to assume no more future premiums. Premium multipliers were developed for each of the five categories, as shown in Table 1.

Table 1
Original Funding Bucket Assumptions

Funding Bucket	Single Pay	Implicit 0 Pay	Low	Medium	High
Issue-to-date paid premium/ target	n/a	n/a	0–89%	90–110%	111%+
Target premium multiplier	0%	0%	55%	100%	125%

The funding bucket is refreshed for each policy quarterly and is built into the policy inventory file. This enables automatic recalibration of the funding bucket as the model inventory file is refreshed.

ANALYSIS OF ACTUAL EXPERIENCE

A study of actual premium experience was conducted to evaluate the aggregate premium trend as well as premium experience by funding bucket. We studied distribution of policies among the different funding buckets and how a policy moved from one bucket to another during the study period. We also studied the premium amount within each funding bucket.

The review of the actual experience indicated that policies in each funding bucket displayed very different premium paying behavior. In addition, even though policies moved from bucket to bucket (Table 2), the relative population residing in each funding bucket was quite stable, as shown in Figure 1.

Table 2
Distribution of Policy Movement

Movement	Distribution
Up 3 buckets	0.05%
Up 2 buckets	0.40%
Up 1 bucket	3.75%
Same bucket	92.06%
Down 1 bucket	3.36%
Down 2 buckets	0.35%
Down 3 buckets	0.03%

ALTERNATIVES TO KEY PARAMETERS

Upon review of the actual experience, we observed an aggregate actual-to-expected ratio of 116 percent for premiums paid when compared to model prediction. Instead of applying a straight-up scalar to all policies, we considered some alternatives to the key assumption parameters.

- Instead of using issue-to-date paid premium vs. target, a limited period of recent premium history could be used. For policies in later durations, limited period premium history would exclude the initial premium dump-in that might skew the resulting funding bucket. We ended up using the last 24 months in our analysis.
- We divided the low funding bucket into medium-low and low. Actual experience suggested that the policies in the bottom funding quartile displayed different premium paying behavior from those in the higher quartiles.
- Expanding the time period for determining the implicit zero-pay bucket allowed us to consider practical issues such as off-cycle premiums or late payments. For our analysis, we chose the last 24-month premium history as an alternative to the 12-month history. You can see a smaller number of zero-payers under 24-month premium lookback vs. 12-month premium lookback in Figure 2.
- We then calibrated the funding bucket for each policy after these changes to the parameters and refreshed target premium multipliers for each bucket. Premium multipliers developed under the alternative parameters are shown in Table 3.

As a result of these changes, our model fit improved as shown by the ratio of actual/expected in Table 4. The overall financial impact of these updates was minimal.

ULSG VERSUS CAUL

We performed the same analysis for ULSG policies as well. In addition to all the dimensions of CAUL analysis, we developed separate factors for products with specified premium secondary guarantee design vs. shadow account secondary guarantee design. Furthermore, we assumed ULSG policies would always at the minimum pay premiums carrying to maturity with secondary guarantee regardless of funding level (subject to an extra lapse rate). We observed that, in general, ULSG exhibited similar pattern in funding as CAUL but with less movement across different funding buckets throughout time. There was clear evidence that some sophisticated customers really understood the product features and took advantage of the no-lapse guarantees.

NOTES ON IMPLEMENTATION: A MODELER'S PERSPECTIVE

Documentation is extremely important in all actuarial modeling. The cornerstone of good model documentation is clean assumption inputs. It might be easier to code a simple "if" state-

Figure 1
Funding Bucket Movement

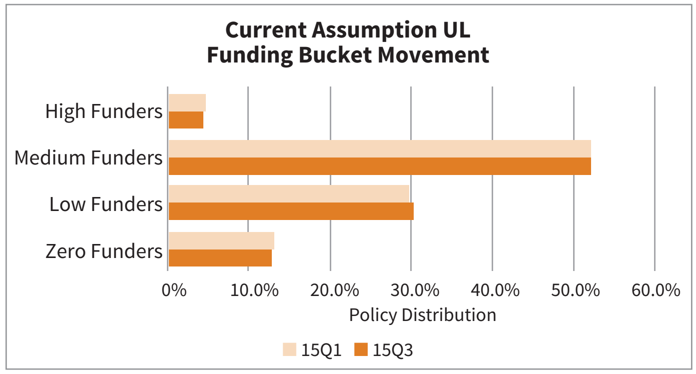

Figure 2
12-Month vs. 24-Month Lookback Period

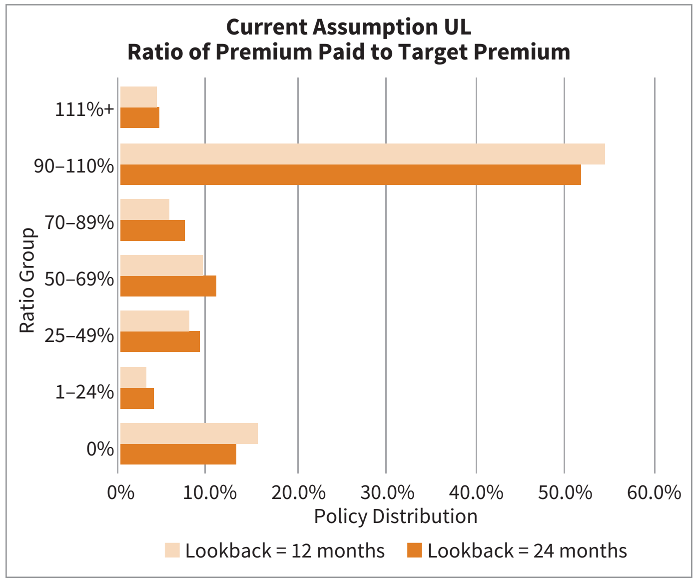

Table 3
Updated Funding Bucket Assumption

Funding Bucket	Single Pay	Implicit 0 Pay	Low	Medium-Low	Medium	High
24-month paid-premium/target	n/a	n/a	0–49%	50–89%	90–110%	111%+
Target premium multiplier	0%	0%	25%	65%	100%	190%

Table 4
Actual to Expected Comparison

A/E (prior method)	116.1%
A/E (updated method)	102.9%

This automatic recalibration allows the model to reflect the new best estimate premium pattern immediately.

ment in the formula tables to force policies that have not paid a premium in the last 24 months to not pay a premium going forward. However, it would be difficult for someone not familiar with the model to find this code. Therefore, once we completed our study, we took the time and made sure to put all of the premium persistency inputs in assumptions tables that would be easily understood by our internal stakeholders and auditors.

Actuarial modelers oftentimes face pressure to complete tasks as quickly as possible and take shortcuts that do not adhere to modeling best practices. This is just the nature of our work and all of us run into time pressures at some point. But during modeling off-cycles, don't forget to spend some time on model development and tidy up the shortcuts that were taken earlier.

FINAL TAKEAWAYS

Premium persistency is a true policyholder behavior assumption, yet often the analysis of premium payment is done at product or product group level. Our premium persistency approach not only improved model accuracy; it also provided deeper insight into policyholder behavior.

Building this approach into the modeling inventory file allows for dynamic adjustments to the premiums multiplier as soon as the funding bucket is refreshed. This automatic recalibration allows the model to reflect the new best estimate premium pattern immediately.

Other things that we learned along the way:

- Most people are paying what they are billed.
- There are other internal and external factors that might affect policyholder behavior, such as policy duration or competitor rate, yet to be explored.
- Premium persistency assumption can have a significant impact on lapses and the in-the-moneyness of the secondary guarantee.
- Be mindful of REAL policyholder behavior such as initial dump-in, late premium and catch-up premiums. Conversation with operations can be very valuable in determining assumption parameters.
- Be careful of how the premium persistency assumption is implemented, coded and documented. Adhere to modeling best practices.
- Last but not least, data is king. We wouldn't be able to do any of the analysis if we did not have policy-level transaction data. ■

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ENDNOTE

[1] Society of Actuaries, "Report on Premium Persistency Assumptions Study of Flexible Premium Universal Life Products," (May 2012).

How to Keep Your Spreadsheets Out of the Headlines: A Summary

By Mary Pat Campbell

In spring 2012, a prominent trader at JPMorgan was nicknamed the "London Whale" due to the size of the trading positions he took in credit default swaps. The risk management oversight for this trading desk relied on value-at-risk (VaR) limits calculated in a spreadsheet model.

Within this spreadsheet, there was a key error. The formula in calculating the VaR limits inadvertently divided by the SUM of two numbers as opposed to their AVERAGE.[1] As a result, the volatility measure being used in calculating VaR was off by a factor of two. That error led to a significant understatement of the trading risk.

This was unlikely to be the only error in the spreadsheet, though. A report released in 2013 showed there was a series of spreadsheets being used for the risk management controls on these trades that involved several manual processes.[2] Information was copied and pasted manually from one spreadsheet to another.

The result of these errors: $6 billion in trading losses over a two-month period.

To be sure, the risk management and governance problems found in this report went well beyond spreadsheets. However, lax spreadsheet practice did contribute to the loss.

THE SPONSORS AND THE SPEAKERS

A session at the 2015 Society of Actuaries annual meeting, "How to Keep Your Spreadsheets Out of the Headlines!" highlighted the above story, as well as other spreadsheet horrors that serve to focus attention on the need for controls to keep further such stories emerging from our industry.

To underscore the depth of interest in this issue, the session was co-sponsored by the Modeling, Entrepreneurial Actuaries and Joint Risk Management sections, with an eye toward addressing model risk and model governance from perspectives ranging from a large firm to a solo practitioner.

Three speakers presented, representing the range of concerns being addressed.

I am on the Modeling Section Council, and am also a member of the European Spreadsheet Risks Interest Group, which was the source of many of the spreadsheet horror stories in the presentation (see Resources at the end of this article). I was joined by Alex Cires, who consults in the health care field at Milliman, and Sandra To, deputy chief reserving actuary at SCOR Global Life Americas.

In this article, I will summarize our presentations.[3] This was also a virtual session, and had special video recording showing both the slides and the presenters during the talk. You should be able to purchase a recording through the SOA as well.

HOW CAN WE PREVENT SPREADSHEET ERRORS?

Alex Cires spoke first, taking the audience through best practices for spreadsheets creation and review. Proper spreadsheet controls will help to avoid errors, make the spreadsheet easier for others to follow, reduce risk, and improve the efficiency of checking and reviewing the spreadsheets. Controls are more effective if applied throughout the spreadsheet development process rather than at the end.

Some specific advice for spreadsheet creation and control are:

- **Documentation tab(s):** high-level notes on purpose, instructions on proper use, version tracking and control, and a note as to any reviews performed.
- **Documentation within calculation spreadsheets:** document external sources, inputs and assumptions at point of use; create clear column headings and descriptive tab names to improve transparency; organize sheets so that information flows from inputs through calculations through outputs in a logical and easy-to-follow manner. Documentation should occur as the spreadsheet is being developed, not held to the end. (This is a point reinforced by all three presenters.)

- **Formatting as a form of documentation:** differentiate formatting between input, formulas and output; color code tabs; format numbers so they are easier to read and understand.
- **Specific approaches in spreadsheet creation:** break down complex formulas into simpler pieces; avoid links to files; use macros to replace manual copy/paste processes (that would have helped with the London Whale debacle); use data validation, cell protection and other built-in checks to prevent accidental errors.

The completed spreadsheet should be subject to checking and peer review. Checking is the detailed, technical review, including picking apart the formulas. Peer review is a higher level review of the spreadsheet and its results. The extent of these reviews should be commensurate with the materiality of the spreadsheet process.

Ideally, both checking and peer review should be performed by people not involved in the creation of the spreadsheet. A successful review requires adequate time, agreement on level of review, documentation and sign-offs required, and a process to ensure that these reviews actually occur. An impromptu poll of session participants showed about 50 percent being subject to such a policy.

A spreadsheet review should include a check of data integrity. Useful tools for this process include in-formula tracing within the Formula Auditing Toolbox in Excel (found under the Formulas tab for current versions of Excel) and third-party or custom-built utilities. One specific type of helpful tool compares results between two versions of the file, each using different assumption sets, to make sure the changes in assumptions produce the expected qualitative change in result.

The peer reviewer should be involved throughout the project. Timely discussion between the spreadsheet creator and peer reviewer can improve the development of the spreadsheet. With this approach, problems get resolved along the way, and the final review should not reveal problems that could set the project back significantly.

One final issue is version control and archiving. We may have multiple versions of a spreadsheet we work with, developed over time. We should avoid having multiple **working** versions; prior versions can be archived in read-only mode. You need to archive these prior versions to follow professional standards or to meet employer or regulatory document retention policies.

BEST PRACTICES IN EXCEL

Sandra To was the second speaker, covering multiple best practices for Excel spreadsheets. Her presentation was emphasized the "W" question words.

WHO has access to the spreadsheets and what access should they have? Read only? Read/write? Password protecting spreadsheets can prevent accidental changes, which is especially of concern, and of regulatory interest, if the spreadsheets support financial reporting.

WHERE are the spreadsheets going after you create them? Are your "customers" taking your spreadsheets and doing subsequent analysis with them? A discussion of the users' needs during development can help in creating a spreadsheet that meets these needs with no post-processing, and help provide greater control over the use of spreadsheet results.

WHAT is in the spreadsheet? Does everybody know the scope of the spreadsheet? Do users understand your data definitions and labels, or know which blocks of business are included and which aren't? The example Sandra gave from her own work is that SCOR has global business, and if she is given spreadsheets with number values, but no indication whether the values are in U.S. dollars or in euros, this can create a great deal of trouble in financial reporting.

Sandra detailed some of the types of controls she uses in spreadsheet work, primarily following the flow of information through the spreadsheets. First, look at information coming into the spreadsheet: Do inputs tie directly to data from a source file? Are these kept updated? She often puts in an explicit check to make sure the proper inputs tie, such as making sure the spreadsheet inputs match the ledger. When there are multiple input sources, consider adding a column to indicate the source of each piece of input data.

One major issue is that we as actuaries often deal with great masses of data within our spreadsheets and need to find approaches to make reasonable checks on these data. One approach is to aggregate results to higher levels, and to compare period-to-period results in aggregate. Another approach is to graph the data, which can show patterns more effectively than just a table of values.

The goal in spreadsheet development is to have a well-documented and repeatable process. External links can be an issue in reproducing the process; links may not be up-to-date, variable names may have changed in linked files, data definitions may have changed, or the linked file may not be updated with the frequency required.

Pivot tables also present a challenge. Pivot tables are very convenient for aggregating and slicing large amounts of data in different ways, but there can be issues if you don't keep the tables refreshed. Underlying data may have changed without the pivot table being updated. A change in the underlying data may change the dimensions of a pivot table, which may cause problems for any formulas referencing the table.

As Sandra is involved in financial reporting, her spreadsheets are often audited, and the same spreadsheets get reused from period to period. In this situation, it is helpful to capture key information in a printout, as audits often review printed results. The printouts should include the filename and path (using the =CELL("filename") function) and a timestamp (using the =NOW() function).

PREVENT TROUBLE BY LOOKING FOR IT

I was the last speaker, and while I agreed with much of what Alex and Sandra had to say, my focus was on what individuals can do to best check their own work. This would most obviously be applicable to a solo practitioner, but even in a corporate setting, a qualified third-party reviewer may not always be available on demand for spreadsheet review.

The main thrust of my message was that you should expect errors in your work. Earlier in telling some of the spreadsheet horror stories, I looked at the damage made by bona fide experts (such as the Long-Term Capital Management blowup in 1998) and academic research in spreadsheet error (essentially, 100 percent of nontrivial spreadsheets have errors). If one expects no errors, and doesn't look for errors, one will not find any … until the results are catastrophic and undeniable, at any rate. The worst error is the error that is not found, and often it's not found because nobody was looking.

My high-level principles for spreadsheet checking are to anticipate the answer and compare to what the spreadsheet actually gives you, test the boundaries of possible inputs, deliberately break the spreadsheet to find out how it fails, and make sure failure isn't silent. Look at the results you're getting out of your spreadsheets and compare these to your expectations. Make estimates by calculating the results in a different way. If you have no expectation of what your results should be, or how they should change with changing inputs, you will not know if there are errors in your spreadsheet.

One control I build into my spreadsheets is to make them fail in an ugly manner. I make sure that an error visually stands out in the sheet so I can see it. Conditional formatting is a good tool to make this work well within spreadsheets themselves. In Excel's Visual Basic for Applications (VBA), I use message boxes detailing the error to pop up.

Silent errors are very deadly—the most dangerous code in VBA macros is the following statement: On Error Next. This means that if VBA runs into an error, it simply moves onto the next line, ignoring the error. Ideally, you should include real error handling into your macros as well as your formulas.

The worst error is the error that is not found, and often it's not found because nobody was looking.

Always check for errors but prioritize this effort. I concentrate on high-frequency cause for errors and high-severity errors in results.

Manual copying and pasting is a frequently a problem, so I check that the proper items were copied to the correct place, and check that I didn't overwrite formulas with values (or vice versa). Some high-frequency formula errors include items such as not covering a complete range (as with a SUM formula), misuse of absolute and relative cell references, using the wrong function (as with the SUM vs. AVERAGE error at JPMorgan), hard-coded numbers in the formulas, and mega-formulas that are impossible to read or audit well. As mentioned by Alex and Sandra, it is vital to make sure that all data sources are refreshed appropriately. I often have VBA code written for automatic refresh of all data sources to make sure everything is kept current.

To capture high-severity errors, I usually start at the end; that is, I look at the results and trace back the process to the beginning. For formula auditing, I work from the key results and see how they derive from the inputs. However, I need to take special care to note any VBA code being used along the way. I prioritize which results to check by materiality.

AN ACTIVE AUDIENCE

There was obviously a pent-up demand for this topic, as the audience was full of comments and questions.

One of the points of discussion was actually about **not** using Excel and spreadsheets for some work. While the session was on spreadsheet use, Excel is not a controlled environment the way a ledger or formal actuarial software is. Sandra mentioned that at SCOR they were trying to automate certain aspects outside Excel, especially for material blocks of business, and not use Excel for production (i.e., the underlying financial results and reporting) but to use it for subsequent analysis. Alex agreed, saying that Milliman had moved things out of Excel in many cases into more appropriate systems. In my own case, I noted that often actuaries put some extremely important valuations in Excel, and perhaps they shouldn't.

An audience member warned people to be wary when the spreadsheet gives you exactly the result you expected. That is when you will be most likely taken in. I made an analogy to the various models of collateralized debt obligations and similar assets in the financial crisis—that this is not merely spreadsheet risk, but model risk. Be wary when you trust the model because it gives you exactly what you want to see.

One audience member noted that actuarial students, not senior actuaries, do much of the spreadsheet work. How does one "student-proof" spreadsheets? Alex pointed to formal training on the topic; he has seen this training is provided to both new and experienced analysts to reinforce best practices. Sandra agreed, saying SCOR had documented processes on spreadsheet review. In my own case, I tend to make checklists for students when there is a repeatable process to follow. Research from preflight and surgical checklists has shown errors are reduced through standardized checklist use.

IDEAS FOR FUTURE SESSIONS?

One of the important activities of the Modeling Section Council is to plan these kinds of sessions for SOA and other actuarial meetings. In this case, Excel is one of our modeling utilities, and error-prevention and model governance is of great interest to us.

If you have recommendations for future sessions, we'd love to hear them! Feel free to email me at *marypat.campbell@gmail.com* or visit our section webpage at *https://www.soa.org/Professional-Interests/modeling/modeling-detail.aspx* to get more information about the section and its activities.

RESOURCES

European Spreadsheet Risks Interest Group: *http://www.eusprig.org/*

Horror stories: *http://www.eusprig.org/horror-stories.htm*

Best practices: *http://www.eusprig.org/best-practice.htm*

For more resources, see "Spreadsheet Errors: Looking Over Your Own Shoulder," *The Independent Consultant*, May 2015: *https://soa.org/News-and-Publications/Newsletters/The-Independent-Consultant/2015/may/Spreadsheet-Errors--Looking-Over-Your-Own-Shoulder.aspx*

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ENDNOTES

1 James Kwak, "The Importance of Excel," *The Baseline Scenario* blog, February 9, 2013, *http://baselinescenario.com/2013/02/09/the-importance-of-excel/.*

2 Linette Lopez, "How the London Whale Debacle is Partly the Result of an Error Using Excel," *Business Insider*, February 12, 2013, *http://www.businessinsider.com/excel-partly-to-blame-for-trading-loss-2013-2.*

3 Our slides can be found here under session 30, *https://www.soa.org/Professional-Development/Event-Calendar/2015/annual-meeting/Agenda-Day-2.aspx.*

A Framework for ESG Validation

By Bruce Rosner

With all of the modeling changes that have been taking place in the last few years, many companies have undertaken a full validation of their economic scenario generators (ESGs). In this article, I discuss the facets of such a review. As a standard cookie-cutter approach is not possible, I focus on key conceptual topics and questions that should always be a part of the review process, and then cover some of the tools and techniques available.

For the purposes of this discussion, let's first lay out a scope of the review. The scenario generation process might follow this sequence of steps:

Select historical data → Develop parameters → Generate scenarios → Apply returns to cash flow model

Note that the flow will often vary. For example, some risk-neutral models will calibrate the scenarios directly to market prices, there may be model efficiency techniques that introduce additional complexity, and other wrinkles may emerge in the process.

A review would typically include the whole chain and not just check whether the scenario generator produces reasonable scenarios. The review should also help determine whether the generator is using the input parameters in a manner consistent with how they were developed, and that the cash flow model is interpreting the scenarios correctly. It is actually far more common for the process to break at these points of interpretation rather than within one of the subprocesses.

Having established the start and end points of the review, several questions should be asked.

Underlying distribution

- Is the distribution of the underlying process fit for purpose and permitted under applicable guidelines?
- Empirically, are the final scenarios produced by the model consistent with the underlying distribution?

Parameterization

- Are the assumptions fit for purpose (e.g., calibrated to market data for risk-neutral vs. historical data for real world)?
- Where applicable, are the initial parameters consistent with market/historical data?
- Was good judgment exercised in the development of parameters that do not have clear data (e.g., mean reversion patterns)?

Scenario generation

- Are the scenarios produced by the model consistent with the assumptions that were entered?
- Where applicable, did the scenarios effectively reproduce market prices?
- Are the scenarios consistent with applicable calibration criteria?

Other downstream items

- Were scenario reduction techniques fit for their purpose?
- Were scenario reduction techniques implemented correctly?
- Did the company use enough scenarios for the downstream results to converge?
- Is the downstream model interpreting the scenarios correctly?

The remainder of this article will highlight some practices and pitfalls that have emerged in real-life cases.

DISTRIBUTIONS FIT FOR PURPOSE

Equity Index Distribution

The most common equity index distribution used by insurance companies is the lognormal distribution, which is convenient for many reasons. This type of distribution is simple, and it allows for parameters to easily be developed and for analytical solutions for some problems (such as the Black-Scholes option pricing formula).

However, it does not accurately reproduce historical distributions; in particular, it is known to underestimate the likelihood of significant losses. The lognormal distribution also assumes constant volatility, which is contrary to observed market prices for options. For some applications, based on the accuracy requirements and the product being modeled, this approach may be appropriate. However, many insurance industry applications focus on the extreme events, and, as a result, the lognormal distribution is sometimes thought to be overused.

Alternative distributions for equity models include the Heston model, jump diffusion models or regime-switching models.

Interest Rate Distribution

Practices around interest rates vary widely. Common models include:

1. Short-rate models (for example, the Cox-Ingersoll-Ross model, which allows for a drift, mean reversion and volatility proportion to the square root of the short rate)
2. Principal component analyses (in which the level, slope and curvature, and other shape changes, are directly simulated based on historical movements in the yield curve)

Consider the following: Does it incorporate mean reversion? Does it allow for changes in the shape of the yield curve? Ultimately, is it effective at modeling the specific risks in the product?

For further reading on types of interest rate models, take a look at December 2013 guidelines by the Canadian Institute of Actuaries' Committee on Life Insurance Financial Reporting that classifies different types of "acceptable" models: "Calibration of Stochastic Risk-Free Interest Rate Models for Use in CALM Valuation."[1] Focus on Section 7, which is about medium-term rate guidance.

PARAMETERS' CONSISTENCY WITH MARKET/HISTORICAL DATA

There are several ways to derive parameters, and each of these methods has different implications for appropriate validation techniques.

- Real-world generators using historical data: This is the most straightforward category, but there still is a fair amount of judgment to be applied, including how far back to collect data, and how much to rely on the data. One approach is to recalculate the parameters for at least a selection of indices.
- Risk-neutral generators using market data to directly fit parameters (for example, deriving implied volatility from market put option prices): One needs to exercise judgment over how credible the prices are at longer durations, using put option prices that are at a similar level of "moneyness" to the liability in question, and how to develop a long-term volatility assumption.
- Risk-neutral models in which parameters are derived through a calibration process: This may occur in addition to the step above (using market data to directly derive parameters). At this point, there is no further derivation to review; however, one can check how well the model reproduces market prices, and that would function as a single validation process that reviews the final scenario set itself, implicitly checking both the underlying distribution and the parameters at the same time.

In other cases, the results can be visually analyzed for reasonableness, and the analysis can also check whether the model is capable of producing the types of environments that have historically been observed.

The validation should check whether there is a documented rationale for any judgment in the process, and that the calculations are consistent with that documented rationale.

EMPIRICAL TESTING OF SCENARIOS

The final scenario outputs (typically, periodic returns, by scenario) can be summarized into meaningful analytics for validation. For example, in the case of a simple lognormal distribution, it is possible to derive the mean, standard deviation and correlation directly from the scenario data, and check whether those are consistent with the desired distribution.

In other cases, the results can be visually analyzed for reasonableness, and the analysis can also check whether the model is capable of producing the types of environments that have historically been observed. For example, how often does the interest rate generator produce upward-sloping and downward-sloping yield curves?

It is also possible in some cases to apply statistical tests such as the Kolmogorov-Smirnov to check whether the resulting distribution follows the expected distribution. In the simplest case, the lognormal distribution can be tested directly through a one-sided test[2] against a theoretical distribution using specified parameters. Also, any distribution can be tested by creating an independent tool and using the two-sided test to check whether the two ESGs produce results that are statistically the same.

One instance in which these tests catch issues is when a company interprets normal parameters as lognormal parameters and vice versa.

As noted earlier, for a class of risk-neutral models, the ultimate test of the scenarios, including the underlying process and parameters, is how effectively they reproduce market option prices.

SCENARIO REDUCTION TECHNIQUES

It can be very difficult to test scenario reduction. An ideal validation approach would involve a company producing results using the full scenario set and a reduced scenario set, under various market conditions. The results can then be directly compared to determine if the reduced run is close enough for the stated purpose of the analysis. However, real life sometimes calls for more simplicity. For example, if a company is simply unable to produce the full run, the only alternative may be to have a reduced run passing statistical tests and rerun the reduced version a small number of times to demonstrate that the final results converge.

As for pitfalls, the techniques must be considered carefully in light of the situation. If a company is only interested in the mean, a technique where a different set of scenarios is used for each policy may be appropriate. However, if the company is interested in any other point on the distribution, this approach will create invalid results.

A good scenario reduction technique might introduce a bias into the result but the company may consider it acceptable anyway. An example of this is where the technique is known to produce a more conservative result, and the application permits additional conservatism.

CLOSING THOUGHTS

An economic scenario generator can have many facets, and any validation process should consider the reasonableness of the methodology and outputs, as well as how the results are used, and compliance with applicable regulations. It is a critical point in a company's modeling infrastructure, and as a practices evolve, the organization should take the time to review and lock it down as securely as it does with the valuation system and other highly controlled systems. ■

The views expressed herein are those of the author and do not necessarily reflect the views of Ernst & Young LLP or the global EY organization.

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ENDNOTES

1 Document 213107 at the Canadian Institute of Actuaries, *http://www.cia-ica.ca/docs/default-source/2013/213107e.pdf.*

2 A one-sided test checks whether the empirical distribution is consistent with a theoretically correct distribution. A two-sided test checks whether two empirical distributions are consistent with each other.


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Some Toys Are Useful

By Frank Grossman

The advent of the new SOA Modeling Section clearly tapped into a wellspring of actuarial interest. The section's rapid growth over the past 18 months to number more than 1,200 members today has been remarkable. Some of you may have seen the short article penned by Trevor Howes that appeared in the Investment Section's newsletter *Risks & Rewards* last spring.[1] In the best spirit of reciprocity, which is to say exchanging ideas for mutual benefit, the following piece is intended as a counterpart—and possibly a counterpoint—to Trevor's thought-provoking piece about the state of current modeling practice and the way forward for actuarial modelers.

ACTUARIAL TOYS

Financial models as "toys" is a thread that runs throughout Trevor's article. On reflection, it's a very apt metaphor given the allure of models for some actuaries, and their seemingly continual need for "tinkering, adapting and improvement." Yet our models are toy-tools of serious consequence for stakeholders who rely on model-generated projections and valuations. And the way forward for actuarial modelers is not entirely clear of obstacles, as Trevor noted.

Yet it was something Trevor wrote in his lead paragraph that really captured my attention, namely that a model is "a magical toy built on the past that explains the present and predicts the future." Unquestionably, the majority of actuarial models embrace assumptions that have a historical basis. Yet I wonder how well our models are able to explain present circumstances, much less predict the future with any significant degree of accuracy. That might be where the magic comes in.

It may be worth taking a moment to consider the explanatory power of our actuarial models. The perennial need to "true-up" financial reporting models, to align emerging actuals with modeled expected results, is a common occurrence. Yet the familiar becomes somewhat concerning when quarter-end adjustments are both material and consistently in one direction, instead of variously alternating positive and negative adjustments. Another example is the apparent challenge of assembling a comprehensive earnings by source analysis that can be believed. Too often the unexplained residual is the largest line item of a putative earnings analysis.

Harkening back to my apprenticeship days, I recall learning that actuaries were definitely *not* in the "predict the future" business, which was after all a mug's game (per Nassim Taleb's *Fooled by Randomness*[2] et passim, at least as far as financial markets are concerned). Channeling management thinker Peter Drucker, it seems to me that a good cash flow projection model can help reveal the future of today's decisions, which is not the same thing as predicting the future.[3] And by today's decisions, I mean decisions regarding which financial obligations to buy and sell, in what volume and (critically) at what price. Emanuel Derman, the creator of many widely used financial models, has noted in a similar vein: "Financial models begin with current perceptions about the future and use them to move back into the present to estimate current values."

Interestingly, the concept of models as toys also occurs in Derman's book *Models. Behaving. Badly.* In the wake of the 2008 financial crisis, he wrote:

> (N)ever forget that even the best financial model can never be truly valid because, despite the fancy mathematics, a model is a toy. No wonder it often breaks down and causes havoc.[4]

Havoc indeed, bearing in mind the turmoil and significant toll of the crisis and its lasting aftermath.

THE INESCAPABLE R-WORD

Some actuarial modelers may take solace in Derman's observation that even the best financial model *often* breaks down. Not sometimes or rarely, but often. It's a subtle point worth noting, as Trevor pointed out in his article, that "model risk" in certain situations is now attracting more attention than the "modeled risk." Yet, when focusing on model risk, it's important to resist viewing the virtual model in isolation, and thereby fail to acknowledge that it usually resides within a broader and no less complex environment.

Model risk is a variant of the operational risk located at the nexus of people, tools and processes. It obviously includes our toy-tools, but also envelops the modelers who create and use them, as well as the larger systems that they are both part of. Given the influence that actuarial modelers have over their tools and processes, perhaps "modeler risk" would be more apropos—but that's most likely drawing too fine a distinction. My point is simply that the three elements comprising model risk interact and inevitably influence each other.

Yet it's the human aspect of model risk—the decisions we make and the trade-offs we broker—and not our models per se, that is frequently underrated as a factor contributing to model break down. Assigning the responsibility for technical work to too low a level in the echelon, for example, risks substituting the cost of inadvertent errors for the benefit of payroll savings. Deciding to skip peer review or failing to implement proper model hygiene can also influence model risk. And failing to build redundancy or margins into resource planning inevitably makes it more difficult to deal with the unexpected when (not if) it happens.

Adopting a more systematic approach to actuarial modeling seems necessary. And that means making the various assumptions, compromises and limitations of our models plain to see. Trevor made the case for taking a more holistic approach as follows:

> It is simpler to rebuild a new more sophisticated model for a specific purpose or specific type of asset or liability than it is to create a fully integrated asset liability model. But a collection of small inconsistent models increases risk, drags performance and complicates ongoing system evolution.

Truly, even a little model can be a dangerous thing. Given the past record of model break down generally, greater model integrity is assuredly the way of the future.

FINANCIAL MODELERS, UNITE!

In days past—at least in Canadian actuarial circles—one heard reference made to a maxim that originated with the statistician George Box: All models are wrong, but some are useful. At first blush this may seem a subversive thought. But perhaps you'll agree, on reflection, that it's simply a matter of degree—exactly how wrong is a given model and just how useful? A more elegant expression of this basic idea is set out by Box and Norman Draper in *Empirical Model-Building and Response Surfaces:*

> Remember that all models are wrong; the practical question is how wrong do they have to be to not be useful.[5]

The point being that a model, by definition, is a mere representation of reality, and the inherent simplifications that make a model usable tend at the same time to hamper its usefulness.

In January 2009, amid the global financial storm, Paul Wilmott and Derman jointly published "The Financial Modelers' Manifesto" online, targeting both fallible models and their equally fallible modelers. As is the case with most polemics, its authors adopted heightened language to get their points across:

> Whenever we make a model of something involving human beings, we are trying to force the ugly stepsister's foot into Cinderella's pretty glass slipper. It doesn't fit without cutting off some essential parts. And in cutting off parts for the sake of beauty and precision, models inevitably mask the true risk rather than exposing it. The most important question about any financial model is how wrong it is likely to be and how useful it is despite its assumptions. You must start with models and then overlay them with common sense and experience.[6]

Despite its Charles Addams–like stray bits and pieces imagery, this passage is entirely in sync with Box's aphorism. And it goes even further to make a vital point: the need for good judgment when working with models and interpreting their outputs.

At length, the manifesto turns to the risk of self-deception, which has the potential to imperil the work of financial modelers everywhere.

> The greatest danger is the age-old sin of idolatry. Financial markets are alive but a model, however beautiful, is an artifice. No matter how hard you try, you will not be able to breathe life into it. To confuse the model with the world is to embrace a future disaster driven by the belief that humans obey mathematical rules.

Considering how deeply vested some actuaries that I've met are in the models they have nurtured, and how personally they can take constructive feedback about their work, Wilmott and Derman's admonition stands as fair comment.

At the conclusion of the manifesto, Wilmott and Derman present "The Modelers' Hippocratic Oath," which outlines essential criteria for good modeling practice. Derman subsequently republished the oath (with modest revisions), and it includes the following twin declarations.

> I will not give the people who use my models false comfort about their accuracy.
>
> I will make the (model's) assumptions and oversights explicit to all who use them.

Good modeling practice really doesn't get any more fundamental than managing stakeholder expectations and promoting full transparency, including the articulation of model limitations.

ROUGHLY RIGHT

Trevor's article concludes with a cautionary statement: "We can still keep our toys if we play this right." Taking another moment—while there is still time—to reconsider the present state of our modeling practice seems a very good idea. A couple of challenging "opportunities" spring immediately to mind.

The complexity of many insurance and pension products poses a challenge to modeling practice. Some new products harness market returns and yet include investment guarantees at the same time, drawing into question the risk appetites of both the consumer and provider of these offerings. Other products include risks that are unhedgeable using liquid market instruments, thereby hampering the calibration of their models. Too frequently, the compound options and asymmetrical benefits embedded in contracts are both difficult and expensive to model well in practice—much less explain to others.

While the case for a product differentiation strategy can certainly be made, from time to time I wonder how well stakeholders grasp in whose pocket the risks of certain "novel" product features ultimately reside—and that includes model risk. Derman also offers some thoughts about the risk of excessive product complexity in *Models. Behaving. Badly.*

> (T)he designers of financial products should create securities whose purpose, exposure, and risks are clear. Unnecessarily bundled complex products whose risks are obscure are often more profitable than simple ones because their value is hard to estimate. If products were transparent, good modeling would be easier.

Whether a product actually stands a reasonable chance of being profitable—or it just seems that way—relies utterly on the skills of the actuarial modeler, and how well his/her model can illustrate the future of today's product design and pricing decisions.

A second challenge is the deep need some actuaries have to get things "right"—to specify the *right* model, to set the *right* assumptions and ultimately to deliver the *right* answer. This apparent virtue may seem second nature to many actuaries and has been a traditional strength. But it can be a potential weakness too, especially given the pressure to make optimal use of available resources (both time and money) in the contemporary workplace.

It's pretty clear useful models are those that are fit for purpose. Bearing in mind Box's aphorism—that all models are wrong but some are useful—the acceptable degree of model accuracy needs to be broached and confirmed with one's stakeholders. It's possible that being fit for purpose depends more on the reliable delivery of timely and intelligible results. The absolute accuracy of model outputs—their "rightness"—may not be the sole or even a key measure of success if your models are still running after the ledger closes.

Given the vital role of judgement when preparing actuarial estimates, the words of a certain defunct economist might be worth bearing in mind. According to John Maynard Keynes, "It is better to be roughly right than precisely wrong." Our future success as actuarial modelers will rest on our ability to both respond to the increasing demands being made of our models, as well as bridle our innate desire for precision. Sometimes close enough is simply good enough. I've every confidence that the members of the new SOA Modeling Section will lead the way forward in the development and delivery of *useful* toys.

Frank Grossman, FSA, FCIA, MAAA, is the past chairperson of the SOA Investment Section council, and may be reached at *Craigmore54@hotmail.ca.*

ENDNOTES

1 Trevor Howes, "Mind Your Modeling," *Risk & Rewards*, 65 (March 2015): 24–25.

2 Nassim Nicholas Taleb, *Fooled by Randomness: The Hidden Role of Change in the Markets and in Life* (New York: Texere, 2001).

3 Some 40 years ago, Peter Drucker observed in his book *Management: Tasks, Responsibilities, Practices* (New York: Harper & Row, 1973): "Strategic planning does not deal with future decisions. It deals with the futurity of present decisions."

4 Emanuel Derman, *Models. Behaving. Badly.: Why Confusing Illusion With Reality Can Lead to Disaster, on Wall Street and in Life* (New York: Free Press, 2011).

5 George Box and Norman Draper, *Empirical Model-Building and Response Surfaces* (New York: Wiley, 1987).

6 *http://www.wilmott.com/blogs/paul/index.cfm/2009/1/8/Financial-Modelers-Manifesto.*

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