The Modeling Section Presents

Modeling Excellence - How to Get There Seminar

August 28, 2019 | Hyatt Regency Denver | Denver, CO

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SOA Antitrust Compliance Guidelines
SOA Presentation Disclaimer
Modeling Excellence – How to Get There Seminar

Dianne Banaszak (MetLife) & Brenna Gardino (ARC)
Modeling Excellence Overview
28 August 2019
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What is your role in your company?

A. Yes, we have centralized all modelling function for development, testing, and production across all lines of business and countries

B. Yes, we have centralized some of the modelling functions across some of the lines of business and countries

C. No, but plans are in the works to centralize modelling functions

D. No, and no plans to centralize

E. Not applicable or don’t know
Where Are We Coming From
Modeling Role

What is your role in your company?

A. Yes, we have centralized all modelling function for development, testing, and production across all lines of business and countries

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D. No, and no plans to centralize

E. Not applicable or don’t know
Modeling Function

Does your company have a centralized modelling function?

A. Yes, we have centralized all modelling function for development, testing, and production across all lines of business and countries

B. Yes, we have centralized some of the modelling functions across some of the lines of business and countries

C. No, but plans are in the works to centralize modelling functions

D. No, and no plans to centralize

E. Not applicable or don’t know
Model Governance & Management

Does your company have an established model governance and management process in place?

A. Yes, it is fully established and documented and used across the company widely
B. Yes, but it requires some improvement
C. No, but plans are in the works to develop
D. No, and no plans to develop
E. Not applicable or don’t know
Multi-Use Models

Has your company moved toward multi-use models?
A. Yes, all uses for multiple lines of business (LOB) and countries are integrated into a single model across the company
B. Yes, for some of our lines of business and/or countries, we have integrated multiple uses into a single model by LOB or country
C. No, but plans are in the works to move toward multi-use models
D. No, and no plans to move toward multi-use models
E. Not applicable or don’t know
Where We Want To Go
"With 46 countries, we had to have standard approaches—if everyone was left on their own, it would have been really messy."

– Andy Rallis, FSA, MAAA, MetLife EVP & Global Chief Actuary, and President-Elect of SOA
Where We’re Headed As Modeling Organizations

**Consistency**
Building consistency of systems, processes, and data

**Centralisation**
Taking advantage of comparative advantage between functions, reducing cost and increased time spent on value added activities

**Streamlined**
Allowing for straight through processing through streamlined, automated, and controlled end-to-end framework

**Innovative**
Partnering with Actuarial IT to make the most of the technology stack available

**Leverage SMEs**
Utilizing specialist skills where necessary when designing and implementing different aspects of the process

**Scalable**
Implementing actuarial solutions and processes that can be leveraged for other actuarial reporting bases
More than Just a Model

MODEL DESIGN
Structural organization of **Model Coding** to efficiently achieve required results to a high degree of accuracy

PRODUCTION DESIGN
Structural organization of **End-to-End Process** to deliver results in an efficient, automated, repeatable, and controlled manner
What We Strive to Achieve in Models

**Protected**
- Protected Integrity of Results
- Locked Down and Controlled
- Repeatable and Reliable

**Standardized**
- Consistent and Standardized
- Scalable Across Countries
- Foundation for Other Bases

**Streamlined**
- Automated and Controlled
- Straight-Through Processing
- “Hands-Free” Production

**Value Added**
- Remove Manual Intervention
- Allow More Time for Analysis and Other Activities

**Innovative**
- Partner with IT for Optimal Solutions
- Utilize Latest Technology Available

**Governed**
- Stable Maintenance Process
- Governance of Changes Providing Comfort and Transparency
How We Will Get There
What We’ll Cover Today

- Data and Assumption Management for Modeling
- The Culture of Model Governance
- Modeling and Assumption Setting ASOP Updates
- R Reclaim Actuary’s Superpower
- Model Validation Best Practices
- A Production Process with End-to-End Automation – Is it Possible?
- Communicating Model Results – A Key to Stakeholder Engagement
Recurring Themes You’ll Hear

Importance of Governance and Controls
- Impacts of Increased Scrutiny and Regulatory Guidance
- Need for Transparency and Confidence in Models, Processes, and Results
- Requirement for Auditability and Ability to Reproduce Results
- Usefulness of Documentation

Demand for Better Ways to Do Things
- Value of Consolidation, Consistency, and Standards
- Emphasis on Considering End-to-End Processing and Using the Right Tools

Evolution of Modeling Organizations
- Advantages of Centralization & Leveraging SMEs
- Necessity of Partnerships
- Undeniable Synergies Between Actuarial and Technology – [https://theactuarymagazine.org/undeniable-synergy/](https://theactuarymagazine.org/undeniable-synergy/)

Understand the What and Why
- Opportunities to Leverage and Reflect on the Basics – Cash Flows Are Key
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The Case for (Good!) Data and Assumption Management

• Consistency of assumptions
  • Across products, functional areas, and models
• Auditability and ability to reproduce results
• Reliability of results (i.e. less errors)
• Increased scrutiny
• ASU 2018-12: Targeted Improvements to the Accounting for Long Duration Contracts (GAAP LDTI)
  • Assumptions once locked in will now be reviewed and possibly changes annually
• Principal Based Reserves (PBR)
  • Prescribed assumptions replaced with company experience specific assumptions and multiple assumption sets
• New methods of assumptions setting (predictive analytics)
First Step: Know Your Inputs

• A key first step is understanding:
  • What models are in scope and what their purpose is
  • Define inputs
    • Compression or other methodology included?
  • A listing of all data inputs and assumptions
    • May include output from other models
  • Frequency and order of model updates and the method used to update
  • Detail which models use which assumption sets
    • Understanding current assumption governance and management processes and owners

• Know your stakeholders – they provide a different kind of input!

• Knowing your current state is the first step in getting to your desired state
Poll Question 1:

Does your company have an established assumption governance and management process in place?

A. Yes, it is fully established and documented and used across the company widely
B. Yes, but it requires some improvement
C. No, but plans are in the works to develop
D. No, and no plans to develop
E. Not applicable or don’t know
Defining the Desired State: Best Practice Considerations

• A second key step in getting to a final state is defining what that looks like
• Consideration will need to be given to ideal practice versus practicality
• May depend on materiality and pervasiveness of use
• Works best with wide participation and management buy in
• Communication is key
Defining the Desired State: Process and Roles

**Working Group**
- Own experience studies
- Monitor industry data and trends
- Propose assumptions
- Provide documentation

**Governance Committee**
- Representation from all functions
- Reviews and approves assumptions
- Ensures consistency

**Executive Committee**
- Strategic guidance
- Final assumption approval

Regular meetings with notes documented
Defining the Desired State: Communication and Documentation

• Documentation should include:
  • Full assumption cycle (flow chart), roles, meeting notes
  • Approvals
  • Experience utilized and rationale for changing (or not changing) assumptions
  • Any simplifications made
  • Changes to assumptions (including structure or any margins) for each model and/or purpose
  • What needs to be updated and when

• Transparency
  • All stakeholders involved
  • Assumptions should be disseminated to all interested parties

• Templates for consistency and clarity

• Continuation of the process and documentation fosters a collective understanding of assumptions and the process to set them
Defining the Desired State: Storage and Model Input

• Assumption repository for approved assumptions
  • Centralized storage of assumptions and model input
• Shared network folder or production databases
• Security with access limited
  • Change management controls in place
• Clearly labeled, easy to find, and backed up
• IT involvement
• Automation and systematic over manual and ad hoc
  • Model input and validations
Poll Question 2:

How are assumptions stored at your company?
A. Centralized database or Excel file(s)
B. Centralized within modeling software
C. Decentralized Excel files (many locations)
D. Decentralized modeling software
E. Semi-centralized (i.e. some combination of the above)
F. Not applicable or don’t know
Model Implementation Considerations

• Ideally, the assumption setting process already:
  • Considered formats required for models
  • Involved collaboration between assumption developers and model developers
• Critical for both groups to communicate and agree on how assumptions are to be applied
• Continued communication as assumptions are implemented
• Consider model setup:
  • Transparency
  • Auditability
  • Repeatability
• Just because an assumption is input, it doesn’t mean it’s being used!
Poll Question 3:

On a scale of 1 to 5, with 1 how would you rate your current data and assumption management processes and controls, including automation?

A. 1
B. 2
C. 3
D. 4
E. 5
F. Not applicable or don’t know

• Not just for PBR
AAA’s Model Governance Checklist – August 2016

• Many important assumption management focused considerations, for example:
  • Are assumptions archived and maintained in a known, centralized database/repository? Is write-access to this repository controlled/limited?
  • Are all data sources well defined and documented?
  • Is there a process in place to estimate the impacts of proposed assumptions?
  • Are assumptions ranked or prioritized based on materiality/significance/impact/frequency of change/etc.?
  • Do the assumptions input into the model match the source documents?
  • Are assumptions documented and approved (signed off) in accordance with a specified process?
Moving Forward

• Rome wasn’t built in a day
• Ranking models and inputs by purpose and materiality can be helpful in focusing efforts
• Continual improvement should be strived for
• Independent validations of process and inputs
Modeling Excellence – How to Get There Seminar

Sisi Chen, FSA, MAAA, CERA
Data and Assumption Management for Modeling
August 28, 2019
Data and Assumption Management for Modeling

Sisi Chen, FSA, MAAA, CERA
PwC
# Data Management Excellence

The following 7 areas support a robust data management to its modeling processes:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data Governance</strong>&lt;br&gt;Maintain high-level of data integrity, control, and accountability</td>
<td><strong>Data Quality</strong>&lt;br&gt;Make sure there is data accuracy and completeness while eliminating data redundancy</td>
<td><strong>Metadata Management</strong>&lt;br&gt;Capture, store, and report information about data and data flows</td>
<td><strong>Master/Reference Data Management</strong>&lt;br&gt;Develop a master framework for managing data across the technology architecture</td>
<td><strong>Data Integration &amp; Data Model</strong>&lt;br&gt;Create a data model that is scalable with integrated/automated data controls and handoffs</td>
<td><strong>Data Management and Big Data</strong>&lt;br&gt;Utilize big data and solutions to capture internal, external, and historic information that can be leveraged to provide greater insights</td>
<td><strong>Reporting, BI, Analytics</strong>&lt;br&gt;Leverage techniques including advanced analytics and data science to provide deep insights and differentiated analysis</td>
</tr>
</tbody>
</table>

To achieve these goals:

- **Knowledge of leading practices** and industry examples using information and analytics to develop an information advantage
- **Optimized architecture & data and technology capabilities** required in the information-enabled future state
- **Engagement and alignment** of actuarial and finance data in the strategy and roadmap and with the enterprise information strategy
- **Conceptual data architecture and a data model blueprint** that leverages existing data assets and leading technologies
- **A Future State vision and operating model** to maintain the evolving finance information strategy
# Data Management: Assumptions

## Modernized reference architecture for experience studies + advanced analytics and assumption management

<table>
<thead>
<tr>
<th>Source Systems</th>
<th>Data Preparation</th>
<th>Data management</th>
<th>Calculation Layer</th>
<th>Automated outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workflow and document management</td>
<td>Data Lake</td>
<td>Advanced Analytics</td>
<td>Visualization</td>
<td>Governance and controls driven by assumptions</td>
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<td>Staging area</td>
<td>Advanced Analytics</td>
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</table>

### Core components

1. Data storage
2. Automated experience studies
3. Advanced analytics
4. New views of results

*Advanced analytics may be free standing as shown here or, depending on platform, may be integrated into ES calculation engine*

### Core components (continued)

5. Assumptions Repository
6. Production and ad hoc calculations

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**Data Warehouse or Data Mart**

**ES calculation engine**

**Executive dashboards**

**Standard reports**

**Automated experience studies outputs**

**ES reports**

**Assumptions Repository**

**Inventories of current & archived assumptions**

**Valuation & modeling calculation engine(s)**

**Assumptions from assumption committees**

**Assumptions review & approvals**

**Workflow and document management**

**Assumptions Mgt**

**Valuation & projections**
Data Management as an Enabler

**Data Strategy**
Is a vision and foundation to establish

- Framework and standards for Finance to access high quality data assets across the enterprise
- Comprehensive set of goals and objectives to extract the value of data to drive analytical capabilities and insight
- Processes to ensure appropriate access to dependable data determined by the business

**Data Governance**

- Processes and guidelines for ensuring data quality and integrity
- Processes and standards to effectively manage the quality of reference data through a common taxonomy and information classification
- A framework and a set of principles that are consistently applied across the enterprise to improve and maintain data assets
Data Strategy

Organizations have to generate global definition and apply it at local level at each application, enhancement and bug fix

Define

Define measurable goals for
Data strategy - Define business terminology concisely - Define infrastructure to make data accessible and available - align it to Business strategy and Corporate vision

Catalog

Build a repository of Business glossary with
concise definitions - eliminate redundancy - identify current state challenges and issues - generate plans to improve

Remediate

Define and refine business glossary, centralize reusable repositories - Remediation of data quality issues as part of IT Governance organization - Create central repositories instead of silos.

Finance Data Strategy

Executive dashboards and Reports

Define monthly, quarterly and annual goals by application and department. Report the progress as part of executive dashboards and ensure attention is paid to achieve the enterprise goals
Enablers of the Data Strategy

Data Management must be tightly integrated with overall business strategy to enable the future state operating model

1. Business Value & Insights
   - Improve performance with better insights in decision making
   - Monetize data and analytics capabilities in products and services and new businesses
   - Reduce TCO while improving effectiveness

2. Organization and Operations
   - Build COEs to serve strategic and operational needs
   - Improve agility of information management and Governance functions
   - Maximize return on talent

3. Data & Analytics Technology
   - Emerging and traditional information architectures
   - Customized algorithms and heuristics
   - Data and analytics innovation
   - Business intelligence and data visualization

4. Execution
   - Deliver quick-wins with targeted pilots - operationalize models
   - Launch change management and support Analytics COEs and IM operating models
   - Develop appropriate visualizations to maximize business use
   - Design and build scalable infrastructure and solutions
Data Governance

The critical success factor for an analytics driven organization is to establish Finance Data Governance with the representation from all the core business units across the organization.

**Data Governance Key Considerations**

*Data ownership* is defined as accountability for accuracy and completeness of data throughout the information lifecycle to support a particular data domain.

- Define a **common business language** for core data categories and establish authoritative data sources.
- Improve the ability of enterprise to proactively control and measure the **quality of data** through metric based analysis and address root causes.
- Define and enforce policies, and standards pertaining to **efficient retention, archival, and destruction** of data.
- Partner with data architecture team to establish **single view of enterprise data** with focus on promoting the right source and eliminating redundancy.

Develop, enforce, and improve **governance policies and standards** that provide a comprehensive framework for effectively managing data.

- Define and enforce procedures, and standards pertaining to **protecting information** from unauthorized collection, use.
- Create a self-service **canonical data model** and underlying data dictionary across the enterprise.

SOCIETY OF ACTUARIES®
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Ryan Krisac, FSA, MAAA
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Why Is It So Important?
Importance of Model Governance

• The practical reasons:
  • Effectively required by VM-G
  • More confidence in regulatory models
  • Simpler audit trails
  • Fewer data transformations / sources
Importance of Model Governance

• The additional benefits:
  • Improved model literacy among actuaries
  • Complete view of “status quo” of model risk
  • Production environment for calculations
  • Clearer prioritization of model enhancements
  • Better definition of model standards
  • Understanding the “model life cycle”
The Siloed Environment

Data Inputs

Assumptions

Reserve-Only Code

Vx Calcs

Product Rates

Assumptions

Data Inputs

Forecast-Only Code

CFT

Profit Models

Assumptions

Product Rates
The Production Environment

- Assumptions
- Data Inputs
- Product Rates
- Common Production Code
- Vx Calcs
- Profit Models
- CFT
How to Promote the Culture of Model Governance
Dispelling Myths about Model Governance

“It is a separate process and makes busy work”

“It’s static and becomes irrelevant too quickly”

“It’s just more audit work”

“We don’t have time and we don’t have resources”

“We haven’t had problems so far; why bother?”
Get on the Model Governance Hype Train!

• Get everyone to contribute and invested in your model governance policy
• Buy-in from the top
• Make it a priority, but phase it in
Make It Easy

• Standardization
• Consolidate systems (remove redundancies)
• Tools to streamline documentation: develop tools in-house or ask your software vendor
• Be flexible
• Make regular time for it
Taking the 1st Step: Model Inventory
Why Build an Inventory?

• Prevent silos of modeling work
• Foster consistency in quality, efficiency, transparency of models
• Enforce production environment
  • Inventory acts as list of models to be tested for any production changes
• Improve communication across actuarial teams
• Steer the conversation during audits
  • Entrée to company-wide model change management policy
• Focus model improvement work more effectively
What is a Model Inventory?

• Comprehensive list of models identifying...
  • Owner
  • Purpose/Intended uses
  • Limitations
  • Audit trails
  • Several attributes of model risk
  • Confidence

• Constructed based on conversations with Owners
# Model Risk: Sample Rubric

<table>
<thead>
<tr>
<th>Score</th>
<th>Audience</th>
<th>Manual Adjustments</th>
<th>Reliability of Calculations</th>
<th>Capability of Attribution Analysis</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Internal Only</td>
<td>None</td>
<td>Highly reliable that model ran correctly</td>
<td>Rollforward process exists, easily built from production run</td>
<td>Little user intervention, timely results</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Few</td>
<td>Reliable after analysis</td>
<td>Rollforward process exists, can be pulled from production run</td>
<td>Some user intervention, generally timely</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Some</td>
<td>Somewhat reliable after analysis</td>
<td>Rollforward process exists, but requires some additional work</td>
<td>User intervention, acceptable processing time</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Several</td>
<td>Somewhat unreliable; using proxy</td>
<td>Rollforward process exists, but requires significant work</td>
<td>Lots of user intervention, long but predictable processing time</td>
</tr>
<tr>
<td>5</td>
<td>External</td>
<td>Mostly manual</td>
<td>Unreliable; comfort from trending</td>
<td>Rollforward process does not exist or is unreliable</td>
<td>Lots of user intervention, unpredictable processing time</td>
</tr>
</tbody>
</table>
Model Risk: Mind the Gaps

• Score models on as consistent and objective a scale as possible
  • 1 (low risk) to 5 (high risk) applied below (for illustration purposes)
• Analyze gap between overall operational risk against overall confidence

<table>
<thead>
<tr>
<th>Model</th>
<th>Audience</th>
<th>Manual Adjustments</th>
<th>Reliability of Calcs</th>
<th>Capability of Attrib.</th>
<th>Efficiency</th>
<th>Overall Risk</th>
<th>Overall Confidence</th>
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<tbody>
<tr>
<td>Illustration Actuary</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>3.0</td>
<td>4</td>
</tr>
<tr>
<td>Pricing Model</td>
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<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3.4</td>
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<tr>
<td>Stat Vx</td>
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<td>1</td>
<td>5</td>
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</table>
How to Implement Good Model Governance
How to Implement Good Model Governance

• Establish clear modeling roles
• Clarity in the Model Inventory
  • Dimensions of risk should be observable, objective
  • Define a consistent scale with clear meanings
  • Try to mitigate bias in risk scoring from Owners
• Fold in with broader company risk mitigation procedures
• Willingness to adhere to model life cycle
Modeling Roles

• By clearly defining roles, align human capital with model tasks

• More complex models require more delineated roles to ensure *validity, accuracy, applicability*

• Having only certain personnel permitted to do certain sub-tasks of the whole modeling process also promotes *consistency* of results across the organization
Modeling Roles

User
- Can run production models (or copy of production models)
- Has access to change model inputs
- Typically, an actuary early in their career; may not be an actuary at all

Developer
- Has access to change formula or programming code
- Does not generate “real” runs (all runs are for testing purposes)
- Typically, a more experienced actuary
Modeling Roles

**Owner**
- Oversees Users and Developers
- Responsible for Model Maintenance and Results Reporting
- Ensures Appropriateness of Model for Application / Use

**Steward**
- Gatekeeper of Production Environment; Grants Appropriate Model Access
- Maintains Model Inventory
- Independent; Monitors Effectiveness of Governance
Model Life Cycle

Concept
• Define purpose, scope, ownership

Design
• Initial development, vetting, implementation

Production
• Available for use, subject to audit/review

Modification
• Separate testing environment for enhancements

Retirement
• Document findings, identify new resources
Considerations and Cautionary Tales
Considerations (1/2)

• Looking at risk from all angles: involve as many people as possible
• Be able to reproduce results and be prepared to provide evidence supporting modeling decisions
• Minimize the effort needed for documentation. Look for shortcuts and take them!
• Regulator requests: read between the lines
Considerations (2/2)

• How often do you want to update documentation?
• How to enforce protocols and controls?
• New models vs existing models
• Separate environments for development, testing, review, and production
• Version control
• Collaboration & Synchronization
• Branching & Merging
• Backup and Restore
• Differencing
• Track Changes
• Track Ownership (traceability)
• Undo (short-term vs long-term)
• Test environment (sandboxing)
Version Management Example (SVN)

• Define a central repository managed by IT:

• How it looks when navigating your C drive:
Version Management Example (SVN)

• Contents of “production location”
Version Management Example (SVN)
BONUS SLIDES: Working with Model Validation Teams
Be ready with this documentation (1/2)

• Provide timeline of routine work cycle (e.g., black out dates)
• Intended purpose and uses of the model and its output
• Model sub-versions (e.g., CFT, planning, dividend analysis)
• Process flowchart with model owners and process controls identified
• Evidence of compliance with process controls
Be ready with this documentation (2/2)

• Methodology, actuarial judgments, custom model code
• Model change history with financial impacts and evidence of testing and review
• Known simplifications, limitations, or other model issues
• List of planned model improvements with timeline for implementation
AAA’s Model Governance Practice Note for Life Actuaries (April 2017)

9. Principle-Based Reserve Model Governance Considerations

Q9.1: What are some examples of a model in a PBR environment?
A: The stochastic reserve methodology and deterministic reserve methodology for life insurance reserves are examples of models in a PBR environment. The Stochastic Reserve Exclusion Test (SET) and margin determination could use models in the PBR process.

Q9.2: What legal documents, guidance, and reference materials might actuaries look to for building and maintaining a model in compliance with PBR requirements?
A: Following are some of the sources of information and reference materials that actuaries typically consult when building a model (please note that the VM-xx below refers to sections of the Valuation Manual):

- Section VM-20 of the Valuation Manual describes the requirements for stochastic and deterministic models for life insurance products;
- Section VM-G of the Valuation Manual provides guidance for governance and controls for PBR models;
- Section VM-21 of the Valuation Manual describes the requirements for variable annuity products;
- ASOP exposure draft, Principle-Based Reserves for Life Products (exposure draft dated June 2015);
- ASOP exposure draft, Modeling (exposure draft dated June 2016);
- Draft VM-20 practice note (expected release in 2017);
- The Federal Reserve System’s Model Risk Management Documents; and
- Actuarial Modeling Controls, a research report sponsored by the Society of Actuaries (published December 2012).
AAA’s Model Governance Checklist
for Life Actuaries (August 2016)

• 19 pages long
• Link: https://www.actuary.org/sites/default/files/files/publications/PBRChecklist_Final.pdf
SOA Survey on Model Governance and Industry Evolution

- Survey of
  - current state/recent developments
  - leading practices
  - industry assessments & next steps
ASB’s Modeling ASOP *(Fourth Exposure Draft)*

- More general guidance for modelers; not specifically about model governance
- Helpful when thinking about model risk, testing, documentation, etc.
IAA’s IASP 1A Governance of Models
(adopted November 2016)

• International Actuarial Association
• Short, but sweet (4 pages)
• Link:

https://www.actuaires.org/index.cfm?lang=EN&DSP=PUBLICATIONS&ACT=STANDARDS_ISAP1A
Institute and Faculty of Actuaries (IFoA) Report on Model Risk

- Longer paper (79 pages) on model risk
- Includes case-studies
Other Resources

• SOA sponsored webcasts and presentations (slides and/or recorded), articles from the Modeling Section newsletter

• Ask your friendly neighborhood consulting firm for their relevant white papers on Model Governance

Discussion Topics
Topics

1. Where is your company at culture-wise?
   • Advanced
   • Intermediate / Work In Progress
   • Beginner

2. A success story or a horror story

3. How did you get buy-in from management or team members?
Modeling Excellence – How to Get There Seminar

Trevor Howes and Andrew Erman
Modeling and Assumption Setting ASOP Updates
August 28, 2019
Active participation in the Society of Actuaries is an important aspect of membership. While the positive contributions of professional societies and associations are well-recognized and encouraged, association activities are vulnerable to close antitrust scrutiny. By their very nature, associations bring together industry competitors and other market participants.

The United States antitrust laws aim to protect consumers by preserving the free economy and prohibiting anti-competitive business practices; they promote competition. There are both state and federal antitrust laws, although state antitrust laws closely follow federal law. The Sherman Act, is the primary U.S. antitrust law pertaining to association activities. The Sherman Act prohibits every contract, combination or conspiracy that places an unreasonable restraint on trade. There are, however, some activities that are illegal under all circumstances, such as price fixing, market allocation and collusive bidding.

There is no safe harbor under the antitrust law for professional association activities. Therefore, association meeting participants should refrain from discussing any activity that could potentially be construed as having an anti-competitive effect. Discussions relating to product or service pricing, market allocations, membership restrictions, product standardization or other conditions on trade could arguably be perceived as a restraint on trade and may expose the SOA and its members to antitrust enforcement procedures.

While participating in all SOA in person meetings, webinars, teleconferences or side discussions, you should avoid discussing competitively sensitive information with competitors and follow these guidelines:

• *Do not* discuss prices for services or products or anything else that might affect prices
• *Do not* discuss what you or other entities plan to do in a particular geographic or product markets or with particular customers.
• *Do not* speak on behalf of the SOA or any of its committees unless specifically authorized to do so.
• *Do* leave a meeting where any anticompetitive pricing or market allocation discussion occurs.
• *Do* alert SOA staff and/or legal counsel to any concerning discussions
• *Do* consult with legal counsel before raising any matter or making a statement that may involve competitively sensitive information.

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Presentations are intended for educational purposes only and do not replace independent professional judgment. Statements of fact and opinions expressed are those of the participants individually and, unless expressly stated to the contrary, are not the opinion or position of the Society of Actuaries, its cosponsors or its committees. The Society of Actuaries does not endorse or approve, and assumes no responsibility for, the content, accuracy or completeness of the information presented. Attendees should note that the sessions are audio-recorded and may be published in various media, including print, audio and video formats without further notice.

Presenters’ comments are personal comments and do not reflect the views of their employers or any committees of which they are members (such as the ASB General Committee).
Speakers

• Trevor Howes
  • Director – Actuary, Moody’s Analytics
  • Former Modeling Section Chair

• Andrew Erman
  • Sr. Director, ALM & Hedging, Transamerica
  • Member, General Committee, Actuarial Standards Board
Agenda

1. Introduction - Trevor
2. Actuarial Standards of Practice (ASOPs) - Andrew
3. Practical Perspectives - Trevor
4. Group Discussions
Introduction
Background

Environmental Factors
- Economic stress:
  Market volatility, low interest rates
- Regulatory changes:
  VM 20/21, AG 43, US GAAP LDTI, IFRS 17, C3 Ph2, ORSA, CCAR
- Technology disruption:
  Cloud-based technology, big data, predictive analytics

Impact on Actuaries
- Financial reporting compliance:
  New complex methods, new roles and workflows
- New products and pricing:
  Volatile risks, capital and earnings stress, competition
- Management demands:
  More information, faster response, control costs

Implications for Modeling Function
- Rapid changes:
  Data and assumptions, computation load, volume & complexity of results
- Increased scrutiny:
  New role in capital and financial reporting
- Pressure to transform:
  Demand for efficiency, new operating model, burden of legacy systems and manual processes
Context

• A generic value chain for the actuarial function:

Data ➔ Assumptions ➔ Models ➔ Communication

• Quality “modeling” depends on the entire chain
Global Progress on Actuarial Modeling SOPs

Revisions to General Standards to Reflect the Use of Models
• released January 2017; effective January 2018

ISAP 1A – Model Governance
ISAP 5 – Insurer Enterprise Risk Models
• both adopted November, 2016

Technical Actuarial Standard M – Modelling
• effective April, 2010; replaced by revised standards 2017

Proposed ASOP on “Modeling” (4th Exposure Draft)
• released December 2018; comment period ended 15/05/2019
How should we react to new ASOPs?

• Emergence of ASOPs reflect the increasing importance of Actuary’s role, especially the reliance of the public on the important modeling we do

• Model Risk has become a hot topic; some well known cases of “model failure”

• Pride in our work and in our profession

• Self-protection
Our Code of Professional Conduct

• **PRECEPT 1.** An Actuary shall act honestly, with integrity and competence, and in a manner to fulfill the profession’s responsibility to the public and to uphold the reputation of the actuarial profession.
  - ANNOTATION 1-1. An Actuary shall perform Actuarial Services with skill and care.

• **PRECEPT 2.** An Actuary shall perform Actuarial Services only when the Actuary is qualified to do so

• **PRECEPT 3.** An Actuary shall ensure that Actuarial Services performed by or under the direction of the Actuary satisfy applicable standards of practice.

• A professional actuary takes personal responsibility for the quality of his work, discloses the basis of his work and any reliance, uncertainty or limitations in that work.
Actuarial Standards of Practice (ASOPs)
Structure of the Actuarial Standards Board (ASB)

• 9 members
• Broadly representative of all areas of actuarial practice
• Standard-setting role, not advocacy role
• Serve the profession rather than any individual interest groups or coalitions
Standard-Setting Principles

• ASOPs provide guidance for appropriate practice
  • Not meant to codify current practice
  • Not best practice, either

• Set principles to guide actuaries

• Does not replace professional judgment

• Apply as broadly as possible

• Disclosure is cornerstone of compliance
Cross-Practice ASOPs

- ASOP 1 – Introductory ASOP
- ASOP 23 – Data Quality
- ASOP 25 – Credibility Procedures
- Exposure Draft – Assumptions
- Exposure Draft – Modeling
- ASOP 41 – Actuarial Communication
- ASOP 12 – Risk Classification
- ASOP 17 – Expert Testimony
- ASOP 21 – Assisting Auditors
- ASOP 32 – Social Insurance
Practice-Specific ASOPs

Casualty
ASOP 7, 13, 19, 20, 29, 30, 36, 38, 39, 43, 53

ERM
ASOP 46, 47, 55

Health
ASOP 3, 5, 6, 7, 8, 11, 18, 19, 22, 26, 28, 42, 45, 49, 50

Life
ASOP 2, 7, 10, 11, 15, 19, 22, 24, 33, 37, 40, 48, 52, 54

Pension
ASOP 4, 6, 27, 34, 35, 44, 51

Selected Life ASOPs
ASOP 2 – Nonguaranteed charges
ASOP 7 – Analysis of cash flows
ASOP 10 – US GAAP
ASOP 11 – Financial statement of reins

ASOP 22 – Asset adequacy opinion
ASOP 40 – Deficiency reserve mortality
ASOP 52 – PBR for life products
ASOP 54 – Pricing of life and annuities
Actuarial Standards Setting Process

1. Project Proposal
2. Board Assigns to Committee or Task Force
3. Committee Discusses & Prepares Exposure Draft and Transmittal Letter
4. Board Review
5. Board Approves
6. Exposure Draft Issued
7. Comment Period
8. Committee Discusses Comments, Revises, Responds
9. Board Review
10. Board Approves
11. Issues as Final

Exposure Drafts for Setting Assumptions and Modeling are Currently Here
## History of Exposure Drafts for Modeling and Setting Assumptions

<table>
<thead>
<tr>
<th>Date</th>
<th>Exposure Draft</th>
<th>Comment Deadline</th>
<th>Comment Letters Received</th>
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<td>2/2012</td>
<td>First Draft Modeling in Life Ins &amp; Annuities</td>
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<td>First Draft Modeling</td>
<td>9/30/2013</td>
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<td>10/31/2016</td>
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<td>First Draft Setting Assumptions</td>
<td>4/30/2017</td>
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<td>12/2018</td>
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Key Provisions

• Applies to setting assumptions (not using) performed 12 months after adoption... 12 month lag because some assumptions only set once per year
• Assumption defined as a value that represents expectations, represents possibilities based on professional judgment, or may be prescribed by law or by others
• The actuary should take into account the purpose of the assignment, ASOP 23 on data quality, and ASOP 25 on credibility procedures
• Use actual experience, industry experience, market data, or other relevant sources

(continued...)

Setting Assumptions
2nd Exposure Draft
Key Provisions

• If purpose allows for margins, consider the degree of uncertainty and whether that varies over time
• If setting multiple assumptions, they should be reasonable in aggregate
• Communicate subsequent events that could result in a material change
• Various reliance, communications, and disclosures are discussed (as with all ASOPs)
• These bullet points do not replace the full Exposure Draft! Please review in entirety...

Personal Observation & Opinion: Most Actuaries Should See Limited Impacts
Comments That Caught My Eye…

• Several comments indicating that gaps do not exist in the current guidance, the proposed guidance may compel an actuary to list every assumption (too much busy-work), and too much overlap with other ASOPs
  • Reviewers disagree, citing how fundamental assumption setting is for actuaries
  • Current exposure draft clarifies that where there is overlap with practice-specific ASOPs, the practice-specific ASOP governs

• Overlap with ASOP 1 regarding definitions (ASOP 1, §2) & materiality (ASOP 1, §2.6)

• Comments on prescribed assumptions set by law… Mostly for pensions

• Comments whether the title, “Setting Assumptions” is sufficiently broad, suggesting “Determining Assumptions” or “Assumptions Used” or “Actuarial Assumptions”
  • Reviewers disagree and kept “Setting Assumptions” as the title
Key Provisions

• Applies to designing, developing, selecting, modifying, using, reviewing, or evaluating models
  • Scope *includes* an actuary using a model developed by others in which actuary is responsible for the model output

• Effective for work performed on or after nine months after adoption by ASB

• Model defined as a simplified representation of relationships among real world variables, entities, or events using statistical, financial, economic, mathematical, or scientific concepts and equations, consisting of three components:
  • An information input component, which delivers assumptions, data, and sometimes parameters to the model,
  • A processing component, which transforms input into output, and
  • A results component, which translates output into useful business information

(continued...)
Key Provisions

• Models are used to help explain a system, to study the effects of different parts of a system, to predict the behavior of a system, or to derive estimates and guide decisions

• Actuary should understand and consider the model’s intended purpose

• Actuary should consider data quality, margins, ranges of assumptions and corresponding model iterations, consistency of assumptions, and reasonableness of assumptions in aggregate

• Draft includes discussion of managing model risk, including testing and validation

• Various reliance, communications, and disclosures are discussed (as with all ASOPs)

• These bullet points do not replace the full Exposure Draft! Please review in entirety…

Personal Observation & Opinion: Many Actuaries Should See Limited Impacts
Comments That Caught My Eye...

• Earlier drafts were too shallow for P&C and predictive models
  • Changes made to draft and appropriate SME was added to task force

• Lots of comments on exclusion of “simple models” from scope, which has since been removed from exposure draft

• Comment that actuaries need to be aware of laws
  • Covered by the Code of Professional Conduct and not needed in ASOP

• In the spirit of innovation, one commenter requested that models can be allowed to be used outside of intended purpose, with disclosure
  • Reviewers maintain that guidance requires model to meet current intended purpose

• Comments for more disclosure on margins
  • Reviewers disagree... A personal opinion is that the assumptions ASOP is the better home for such requirements
Practical Perspectives
Scope of Proposed Modeling ASOP

1.2 Scope—This standard applies to actuaries in any practice area when performing actuarial services with respect to designing, developing, selecting, modifying, or using all types of models.

Note this ASOP applies:
• whether or not actuary is part of the modeling team or the model is developed by others outside the organization
• whether you are the signing actuary in a formal role or working on the development or maintenance of a model for others to use
• to all models (with appropriate judgement re the extent of reliance by the intended user and the materiality of the financial effect)
Key Principles of Proposed Modeling ASOP (4th Exposure Draft)

• The actuary should select, design, build, modify, develop, or use a model that meets the intended purpose.

• The actuary should evaluate model risk and, if appropriate, take reasonable steps to mitigate it.

Definition of Model risk - the risk of adverse consequences (e.g. loss) resulting from reliance on a model that does not adequately represent that which is being modeled or that is misused or misrepresented.

Risk Mitigation tools:
1. Perform both initial and ongoing model validation
2. Implement appropriate model governance and controls
## Apply Governance Tools to all Components

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<th>Technique</th>
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<td>Analytic Controls and Variance Reports</td>
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<tr>
<td>Attribution Analysis, Reconciliation</td>
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Approaches to Actuarial Software

User coded models require:

- Specification of model logic
- Coding logic in software
- Compiling and debugging

Vendor coded models require:

- Loading of business data
- Definition & managing assumptions
- Model configuration
Financial Models in Life Insurance

Admin System Extracts → EVT → Bus. Data Repository → Assumptions History → Results Archive

Experience Data Sources ➔ Master Object Library

Actuarial Modeling Engine

Business Data Models | Temporary Results

- Model Configuration
- Model Executable (Code Vers xx)

Model Archive
Code Archive
Disciplined Maintenance and Update Process

• Separation of development, test, research and production environments
• Restrict access and assign independent roles
• Production versions must be approved
• Plan regular maintenance and updates, including vendor releases
  – apply incrementally and verify/quantify impact

Note:
• Apply rules to all components of the total model (actuarial, data, IT)
• Validate/verify changes in 3rd party software
Model Transparency

• Transparency is critical for efficient review & audit and for overall confidence
  – What assumptions are applied for what purpose? To which business?
  – Avoid choosing or defining assumptions within code
    › Risky and cumbersome to update
    › Difficult to review, audit or document
  – Using objects that contain assumptions is preferable to code, provided:
    › Objects are reviewed, tested and locked against further change
    › Names of objects are clear and meaningful as to contents and purpose
    › Assumption updates are not performed by changing object contents

• Transparency can take more effort and can impact model performance
Technology Can Enable Model Governance

• Moving models off desktop PCs to centralized infrastructure enables standard IT controls & safeguards and vendor provided tools
  – Multiple environments and workspaces; simple migration
  – Permissions based on standard Windows logons or selectable roles
  – Version control on all components of a model
  – Identification of approved versions of models and software
  – Automated attribution analysis by model version/change
  – Standard tools for regression testing of results comparing models, software releases, assumptions changes, IT environment changes
Questions and Concerns

• Is any ASOP really needed? Can the actuary’s judgement justify little or no extra work?
• Does the open definition of a model and wide scope of ASOP impact simple calculations in various practice areas?
• What is actuary’s duty when relying on others (actuaries or non-actuaries, vendors or colleagues) to develop or maintain the model?
• Is model design, construction, maintenance actuarial work?
• What is the actuary’s duty when he or she is doing non-actuarial work such as coding software?
Appendix – Setting Assumptions
Section 1

• **Purpose**: Provides guidance to actuaries when performing actuarial services that involve setting assumptions

• **Scope**: Applies to actuaries taking responsibility, giving advice on setting assumptions, or assessing reasonableness of assumptions

• **Does Not Apply To**:
  • Judgmental adjustments to data... See ASOP 23
  • Topics discussed in a practice-area ASOP... Practice-area ASOP governs

• **Cross References**: Referenced documents may be amended or restated; actuary should consider the guidance in this standard to the extent it is applicable and appropriate

• **Effective Date**: Effective for any actuarial work involved in setting assumptions performed on or after 12 months after adoption by ASB
Section 2 – Definitions

• Terms defined:
  • Assumption
  • Data
  • Information Date
  • Prescribed Assumption Set by Another Party
  • Prescribed Assumption Set by Law
Section 3

• **General Considerations**: Consider purpose of assignment, guidance in ASOP 23, and guidance in ASOP 25

• **Information Used**: Consider the following:
  • Actual experience adjusted to current conditions, to the extent available,
  • Other relevant and reliable experience such as industry experience, properly modified,
  • Future estimates based on market data, and
  • Other relevant sources

• **Assumption Margins**: If purpose allows for margins, consider:
  • Degree of uncertainty due to lack of relevant, credible data
  • Whether uncertainty varies over different time periods
Section 3 (continued)

- **Reasonableness of Assumptions**: For the assumption for which the actuary is taking responsibility, assumptions should be reasonable:
  - Fit for purpose
  - Reflects actuary’s professional judgment
  - Takes into account experience (see Information Used)
  - Expected to have no significant bias, except when margin is used

- **Consistency of Assumptions**: If setting multiple assumptions, assumptions should be reasonably consistent with one another

- **Reasonable Assumptions in Aggregate**: If setting multiple assumptions, should be reasonable in aggregate

- **Subsequent Events**: Disclose known events subsequent to information date, if could result in material change to assumptions
Section 3 (continued)

• Reliance on Data or Other Information Supplied by Others: Refer to ASOPs 23 and 41
• Reliance on Assumptions Set by Another Actuary: Be reasonably satisfied that other actuary’s setting was up to standards and disclose extent of reliance
• Reliance on Assumptions Set by Others: Refer to ASOP 41 and disclose extent of reliance
• Documentation: Prepare and retain documentation to support compliance with ASOP
Section 4 – Communications & Disclosures

• **Required Disclosures**: Refer to ASOPs 23, 25, and 41 and disclose:
  • Description of each significant assumption
  • Information and analysis used for setting each significant assumption
  • Material changes since most recent communication

• **Additional Disclosures**: Include the following, as applicable:
  • Provisions for margins
  • Extent of reliance on assumptions set by another actuary and on assumptions set by others
  • Prescribed assumptions set by law or by another party per ASOP 41, §4.2
  • Disclaiming of responsibility for any material assumption selected by another party per ASOP 41, §4.3
  • Deviations from the guidance per ASOP 41, §4.4

• **Confidential Information**: Not intended to require the actuary to disclose confidential information
Appendix – Modeling
Outline of 4th Exposure Draft for Modeling

Section 1
- Purpose
- Scope
- Cross References
- Effective Date

Section 2
- Definitions

Section 3
- Analysis of Issues and Recommended Practices
  - Intended Purpose
  - Reliance(s)
  - Mitigation of Model Risk
  - Documentation

Section 4
- Communication and Disclosures
  - Required Disclosures
  - Additional Disclosures
  - Confidential Information
Section 1

• **Purpose:** Provides guidance to actuaries when performing actuarial services with respect to designing, developing, selecting, modifying, using, reviewing, or evaluating models

• **Scope:**
  - Applies to actuaries when performing services with respect to designing, developing, selecting, modifying, or using all types of models
  - For reviewing or evaluating models, use the guidance in the standard to extent practicable within the scope of the actuary’s assignment
  - Applies when intended users of model rely on output of model and has a material effect for the intended user, in the actuary’s professional judgment
  - Scope may include insurance pricing models (including predictive), reserving models, and financial planning models
  - Only applies to the extent of the actuary’s responsibility
Section 1 (continued)

• Does Not Apply To:
  • Pension benefit calculations as described in ASOP 4 §1.2
  • Topics discussed in a practice-area ASOP... Practice-area ASOP governs

• Cross References: Referenced documents may be amended or restated; actuary should consider the guidance in this standard to the extent it is applicable and appropriate

• Effective Date: Effective for any actuarial work performed nine months after adoption by ASB
Section 2 – Definitions

• Terms defined:
  • Assumption
  • Data
  • Governance and Controls
  • Input
  • Intended Purpose
  • Intended User

• Model
  • Model Risk
  • Model Run
  • Output
  • Overfitting
  • Parameter
Section 3

- **Model Meeting Intended Purpose**: Actuary should understand and consider the model’s intended purpose
  - When designing, developing, or modifying a model, confirm capability of model consistent with intended purpose, including level of detail built into model, dependencies recognized, and model’s ability to identify volatility around expected values
  - When selecting, reviewing, or evaluating a model, confirm the model reasonably meets the intended purpose, including revisions to input and formulas, documentation, governance, validation, and presentation of output
  - Actuary should understand important aspects of model being used, known weaknesses/limitations in model (assumptions, parameters, inputs, or methods), and limitations of data or other practical constraints
  - Assess whether structure of model is appropriate for intended purpose, including form of model (projection vs predictive), potential for overfitting, optionality, etc.
  - Confirm appropriateness of data, referring to ASOP 23
Section 3 (continued)

• **Model Meeting Intended Purpose** (continued): Actuary should confirm appropriateness of assumptions and parameters:
  - When setting assumptions, consider actual experience, industry experience, estimates inherent in market data, or other relevant sources (which parallels the draft for Setting Assumptions)
  - If model adjusts an assumption to include a margin, margins should be reasonable and actuary should consider potential impact to model output to ensure intended impact in aggregate
  - Consider a range of assumptions and whether the needed model runs are consistent with intended purpose
  - Assumptions and parameters should be consistent with one another, disclosing any inconsistencies and the reasons for the inconsistencies
  - Actuary should assess whether the assumptions and parameters are reasonable in the aggregate
Section 3 (continued)

• Reliance on Data or Other Information Supplied by Others: Refer to ASOPs 23 and 41

• Reliance on Models Developed by Others: Disclose extent of reliance and make reasonable attempt to have a basic understanding of model including developer’s intended purpose, general operation of model, major sensitivities and dependencies within model, and key strengths and limitations of model

• Reliance on Experts: Consider expertise of those upon which the actuary is relying, extent to which model has been reviewed or validated, whether industry standards apply, and whether the science underlying the expertise is likely to produce useful models for the intended purpose; disclose the extent of such reliance
Section 3 (continued)

• Mitigation of Model Risk: Evaluate model risk and, if appropriate, mitigate the model risk depending on model’s intended purpose, nature and complexity of model, operating environment and governance and controls, whether there have been changes to the model or model environment, and balance between cost of mitigation efforts and the reduction in potential model risk
  • Actuary should perform sufficient model testing including reconciling input values to source information, checking formulas, and reconciling output to prior model runs
  • Actuary should take steps to validate model output including back-testing, statistical tests, varying key assumptions, and comparing to alternative models
  • Consider peer review, ensure appropriate governance and controls, and mitigate possible misuse and misinterpretation of model using ASOP 41, §3.4.1 and §3.7
• Documentation: Prepare and retain documentation to support compliance with ASOP
Section 4 – Communications & Disclosures

• **Required Disclosures**: Refer to ASOPs 23 and 41 and disclose:
  • Intended purpose of model
  • Material limitations and material inconsistencies among assumptions and parameters
  • Unreasonable output resulting from aggregation of assumptions and parameters
  • Extent of reliance on models developed by others and of reliance on experts

• **Additional Disclosures**: Include the following, as applicable:
  • Prescribed assumptions set by law or by another party per ASOP 41, §4.2
  • Disclaiming of responsibility for any material assumption selected by another party per ASOP 41, §4.3
  • Deviations from the guidance per ASOP 41, §4.4

• **Confidential Information**: Not intended to require the actuary to disclose confidential information
Modeling Excellence – How to Get There Seminar

Reclaim Actuary’s Superpower

Edward Kuo, FSA, FCIA
DATE: AUGUST 28, 2019
SOA Antitrust Compliance Guidelines

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An Actuary’s Modeling Dilemma

Environmental Trends for Actuarial Modeling:
1. Model complexity is increasing.
2. Algorithms and data volumes are demanding more computation power.
3. Information technology is becoming more sophisticated.

Dilemma over choice of modeling tool:
1. Building **own in-house models** or relying on **commercial software**?
2. (Actuary) being a **model architect** or **model technician**?
Why is R the ideal tool for building actuarial models?

- **R Development Environment**
  - R Licensing
  - R Ecosystem
  - Development Support

- **Model Implementation Tactics**
  - Vectorized Operation
  - Object-Oriented Approach
  - I/O Handling
  - Parallel Processing

- **Model Management**
  - Documentation
  - Version Control
  - Team Project
R Development Environment
R is Free Software

What does “free” mean?
• “Free” as in “Freedom”
Freedom – Guaranteed by Open Source License

- Freedom to run
- Freedom to study
- Freedom to modify
- Freedom to distribute
Freedom – Imagine an actuarial model that is...

- **Free to run**: Easy to deploy, platform independent
- **Free to study**: Transparent, no black box.
- **Free to modify**: Fully customizable
- **Free to distribute**: Accessible, cost effective
R Ecosystem – Packages

Number of Packages Published in CRAN

Source: https://cran.r-project.org/web/packages/available_packages_by_date.html (as at July 14, 2019)
R Development Support – One Language for All

R blurs the boundary between domain experts and software experts:

• A high-level language.
• Function design driven by problem solving in many application areas.
• Serving users with varying levels of programming skill.
• Worldwide resources on web: online books, tutorial, blogs, discussion forums, videos.
Model Implementation Tactics
Vectorized Operation – What is it?

**Vectorized:**

\[ C \leftarrow A + B \]

**Non-vectorized:**

\[
\text{for } (i \text{ in } 1:10) \{
C[i] \leftarrow A[i] + B[i]
\}
\]
Vectorized Operation

“vector” is the most fundamental data type in R.
• All other data types are based on vector.
• There is no “scalar” in R.

Avoid looping!
Vectorized Operation – Annuity Example

Present value of annuity: \[ a_x = \sum_{t=1}^{T} v^t \cdot t p_x \]

Vectorized:
\[
\begin{align*}
v & <- (1 + i)^{-(1:T)} \\
p & <- \text{cumpop}(1 - q) \\
a & <- \text{sum}(v \cdot p)
\end{align*}
\]

Non-vectorized:
\[
\begin{align*}
a & <- 0 \\
p & <- 1 \\
\text{for} \ (t \ \text{in} \ 1:T) \ { \\
& \quad \text{v} <- (1 + i)^{(-t)} \\
& \quad p <- p * (1 - q[t]) \\
& \quad a <- a + v \cdot p
\end{align*}
\]
Vectorized Operation – Insurance Example

Present value of insurance: \( A_x = \sum_{t=0}^{T-1} \nu^{t+1} \cdot t \ p_x \cdot q_{x+t} \)

Vectorized:

\[
\begin{align*}
v & \leftarrow (1 + i)^\cdot-(1:T) \\
p & \leftarrow c(1, 1 - q)[1:T] \\
A & \leftarrow \text{sum}(v \ * \ \text{cumprod}(p) \ * \ q) \\
\end{align*}
\]

Non-vectorized:

\[
\begin{align*}
A & \leftarrow 0 \\
p & \leftarrow 1 \\
\text{for} \ (t \ \text{in} \ 0:(T-1)) \ \{ \\
\quad v & \leftarrow (1 + i)^\cdot(-t-1) \\
\quad A & \leftarrow A + v \ * \ p \ * \ q[t + 1] \\
\quad p & \leftarrow p \ * \ (1 - q[t + 1]) \\
\} \\
\end{align*}
\]
Vectorized Operation – Why?

Actuaries deal with vectors all the time.

• Expression is more actuarially friendly.
• Codes are more succinct.
• Program logic is easier to understand.
• Execution is more efficient.
Object-Oriented Programming (OOP) Approach

What is an object?

- An object has its own unique set of *data* and *methods*.
- *Data* describe the attributes and the state of the object.
- *Methods* define the object’s behaviors and how it interacts with other objects.

Object X

- Data 1
- Data 2
- Data ...
- Method 1
- Method 2
- Method ...
OOP Implementation – Actuarial Model Objects

An actuarial model may include the following types of object:

- Products
- Coverage
- Actuarial tables
- Assumptions (mortality, lapse, interest, expense)
- Reinsurance treaties
- Actuarial methods
- ...
OOP Implementation – Example 1

Example: 20-year level term ("20T")

Object: product "T20"

Data:
- Coverage period
- Premium rates
- Modal factors
- Commission schedule

Methods:
- Get coverage period
- Project premium
- Project death benefit
- Project commission

```
setClass(
  Class = "T20",
  slots = c(
    CovYears = "integer",
    PremRates = "numeric",
    ModFactors = "numeric",
    CommSchd = "numeric"
  )
)
...
```

```
setMethod(f = "Get_Cov_Years", ...) {...})
setMethod(f = "Proj_Prem", ...) {...})
setMethod(f = "Proj_Death_Ben", ...) {...})
setMethod(f = "Proj_Comm", ...) {...})
```
OOP Principle #1: Encapsulation

For each object, data and implementation details are held privately inside the boundary of class definition.

Other objects do not have direct access to the internal details. They can only interact with the object by calling the exposed methods.
OOP Principle #2: Abstraction

An object shall only reveal high-level information that is relevant to the use by other objects through methods.

Those methods shall hide all private information regarding how the class is implemented.

All objects shall be able to interact with one another without regard to the internal details of any class.
OOP Implementation – Example 2

RPT20: 20-year level term with refund of premium feature at maturity.

```
setClass(Class = "RPT20", contains = "T20")
```

**Parent class: product "T20"**

- Data
  - ...
  - ...
- Methods
  - Get coverage period
  - Project premium
  - Project death benefit
  - Project commission

**Child class: product "RPT20"**

- T20 Data and Methods
  - Project maturity benefit

- The child class RPT20 inherits all the data and methods from the parent class T20.
- A new method specific to RPT20 is created to project the return of premium at maturity.
OOP Implementation – Example 3

DT20: 20-year mortgage protection (decreasing term).

```
setClass(Class = "DT20", contains = "T20")
```

**Parent class: product "T20"**

- Data
  - ...
  - ...

- Methods
  - Get coverage period
  - Project premium
  - Project death benefit
  - Project commission

**Child class: product "DT20"**

- T20 Data and Methods
  - Re-implement "Project death benefit"

- The child class DT20 inherits all the data and methods from the parent class T20, except the method for projecting death benefit.
- The method for projecting death benefit is re-implemented to reflect the decreasing death benefit amount.
OOP Principle #3: Inheritance

A hierarchical relationship can be assigned to different classes so that a child class will possess all the features of its parent class while it can also have its own unique features at the same time.
Valuation model does not need to know the exact type of product of each individual policy in order to calculate reserve correctly as long as those products are from the same inheritance hierarchy.
OOP Principle #4: Polymorphism

• An object to be processed by a procedure may take multiple forms as long as those forms are defined in the same inheritance hierarchical relationship.
# OOP Implementation – Four Principles

<table>
<thead>
<tr>
<th>OOP Principle</th>
<th>Implication on Actuarial Modeling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encapsulation</td>
<td>• Allow division of work.</td>
</tr>
<tr>
<td></td>
<td>• Promote more focused design and development.</td>
</tr>
<tr>
<td>Abstraction</td>
<td>• Manage code change and model improvement over time more efficiently.</td>
</tr>
<tr>
<td>Inheritance</td>
<td>• Force more thorough model component analysis.</td>
</tr>
<tr>
<td></td>
<td>• Increase code reusability.</td>
</tr>
<tr>
<td>Polymorphism</td>
<td>• Reduce development time.</td>
</tr>
</tbody>
</table>
Input/output Handling

Packages for data import/export

Model

And many more...
## Input/output Handling – List of Packages

<table>
<thead>
<tr>
<th>Database</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amazon Redshift</td>
<td>ODBC</td>
</tr>
<tr>
<td>Apache Hive</td>
<td>ODBC</td>
</tr>
<tr>
<td>Apache Impala</td>
<td>ODBC</td>
</tr>
<tr>
<td>Google BigQuery</td>
<td>bigquery</td>
</tr>
<tr>
<td>Microsoft SQL Server</td>
<td>ODBC, RODBC</td>
</tr>
<tr>
<td>MonetDB</td>
<td>MonetDBLite</td>
</tr>
<tr>
<td>MySQL</td>
<td>RMariaDB, ODBC, RODBC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Oracle</td>
<td>ODBC</td>
</tr>
<tr>
<td>PostgreSQL</td>
<td>RPostgreSQL</td>
</tr>
<tr>
<td>SQLite</td>
<td>RSQLite</td>
</tr>
<tr>
<td>Salesforce</td>
<td>ODBC</td>
</tr>
<tr>
<td>Teradata</td>
<td>ODBC</td>
</tr>
<tr>
<td>Excel</td>
<td>rio, openxlsx, readxl</td>
</tr>
<tr>
<td>CSV</td>
<td>readr, vroom, utils</td>
</tr>
</tbody>
</table>
Input/output Handling – Actuarial Modeling

Scenario: a model reads data from multiple sources.
Input/output Handling – Actuarial Modeling

Scenario: a model exports results to multiple destinations.
Input/output Handling – Actuarial Modeling

Scenario: it is possible to eliminate “middle-tier” data source.
Parallel Processing

• Ideal for performing a computing task on a large number of similar objects in which the results are mutually independent, for example, valuation.

• Recommended packages: parallel, foreach. The packages allow a user to set up a parallel processing job with simple functions.

• Key message: YOU CAN EASILY DO IT (as an actuary).
Parallel Processing – Performance Test

Test case:

• Reserve calculation using gross premium method on 100,000 coverage records including traditional life and universal life.

• Computing platform: MacBook Pro, 2.6 GHz Intel Core i7, 6 cores (12 logical cores), 16 GB RAM
Parallel Processing – Considerations

• Hardware specifications (CPU, memory).
• Amount of data to be processed.
• The steps where repetitive tasks are involved.
• Decreasing marginal performance gain as more cores are assigned.
• Background jobs such as OS, database services and other running software.
Model Management
Documentation – Inline Documentation

• R package: roxygen2

• For documenting classes, methods, functions and datasets.

• Documentation is embedded in the source codes. When building the project, the documentation will be automatically transformed into R help topics.

• Users utilize R commands to look up topics of interest.
Documentation – Long-Form Documentation

• R package: rmarkdown

• Creating user guide style documents.

• Composing documents using Markdown, a markup language.

• Allowing intermingling of text, codes and results.

• Transforming documents into HTML or PDF documents.
Version Control

• Solo Project: R Studio + git

• Team project: R Studio + git + GitHub
Team Project – Illustration

The image illustrates a project management diagram with roles and responsibilities. Here are the main points:

- **Project Repository (GitHub)**: This is the central hub for development and maintenance of the project's classes.
- **Product Team**, **Assumption Team**, and **Reinsurance Team**: These teams are responsible for developing and maintaining their respective classes.
- **Project Manager**: Coordinates and monitors the project's progress.
- **Data Management Team**: Prepares, validates, and manages the database.
- **Computing Platform**: Handles deployment and running of the model.
- **Push results** ↔ **Deploy and run model**: Indicates the flow of results from development to deployment.

### Responsibilities
- Product Team:
  - Develop / maintain classes.
  - Push changes.
- Assumption Team:
  - Develop / maintain classes.
  - Report / track / resolve issues.
  - Unit tests.
  - Class documentation.
- Reinsurance Team:
  - Develop / maintain classes.
  - Push changes.

*Note: Divide work according to object types in the model.*
Final Word on R

Every actuary should learn R.
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Poll: Model Validation Concerns

Which of the following best describes your model risk management responsibilities?

a) Work with models but do not follow formal model risk policies
b) Work with models and follow formal risk policies
c) Establish or approve model risk policies
d) Audit role to ensure policies are followed
e) Other
Poll: Model Validation Concerns

What is your primary concern regarding model validation?

a) Cost of project
b) Time it takes to complete
c) Finding qualified resources
d) Not sure how to approach
e) Other
Choose and prioritize models
Choose your validation team
Develop test plan based on MV framework
Remediate model deficiency through change management and maintain model based on model governance best practice
Develop opinion and summarize findings
Test and validate

Modeling Excellence – How to Get There

Model Validation
Model Validation Practical Aspects

Grace Chang, FSA, MAAA
Milliman
August 28, 2019
Objectives

1. Determine whether a model fits the intended purpose
2. Determine whether a model is working correctly and providing reliable information
3. Assess and communicate risks associated with the model
Elements of Model Risk

Model intention vs. whether the intention is appropriately implemented
Conceptual Risk

- Is the intended purpose, intended users, and their use of model outputs appropriate?

- What are the risks?
  - Risk coverage
  - Risk ranking

- What is the appropriate modeling methodology?
  - Reference to external sources
  - Limitation and reliance
Implementation Risk

- **Was modeling concept appropriately implemented?**
  - Appropriate algorithm
  - Code
  - Proper versioning and test procedure
  - Separation of duties – developer and tester
  - Types of testing – unit testing, stress testing
Input Risk

- Raw data vs. Assumptions

**Complete**
Is the whole population covered? Are there any non-model elements? Does grouping introduce unintended consequences?

**Accurate**
Are critical data elements populated with reasonable values? Outliers? Stale inputs?

**Appropriate**
How is source data used? Are the assumptions reasonable compared to industry study/company experience?
Output Risk

- Does the model produces meaningful output?
- Identify the materiality of input parameters – important feedback for assumption development
- Validation of the dynamic behavior of the model
- Types of testing – regression testing, back testing, sensitivity testing
Reporting Risk

- Does the report provide useful and meaningful information for its intended audience?
  - The manner and order of presentation should not be misleading
  - Model and data limitation should be communicated
  - Frequency and timing should fit the business need
# Process Risk

| Implementation          | ▪ Change management  
<table>
<thead>
<tr>
<th></th>
<th>▪ Proper documentation of testing procedure</th>
</tr>
</thead>
</table>
| Input                   | ▪ Source data vs. input reconciliation  
|                         | ▪ Periodic input review  
|                         | ▪ Change management / adequate documentation |
| Output                  | ▪ Input vs. output reconciliation  
|                         | ▪ Proper warning if input parameter limits are breached  
|                         | ▪ Control to prevent unintentional manual adjustment |
| Reporting               | ▪ Clear indication of model and output data version |
Model Validation Key Points

PBR Model Governance Checklist

A. Governance Standards
B. Modeling Process
C. Assumptions Setting
D. Input Data/Tables/Mapping
E. Access Controls
F. System/Model Changes
G. Model Selection/Versioning
H. Consolidation of Results
I. Reporting
J. Analysis/Validation

Conceptual Risk
Implementation Risk
Input Risk
Output Risk
Reporting Risk
Process Risk
Model Validation Key Points
North American CRO Council

A. Model design and build need to be consistent with the model’s intended purpose

B. Ensure that model validation is an independent process

C. Establish an owner of model validation

D. Ensure appropriateness of established model governance

E. Make model validation efforts proportional to evidenced areas of materiality and complexity

F. Validate the model components:
   - Input components
   - Calculation components
   - Output components

G. Address limitations of model validation
Model Validation Key Points

Solvency II Criteria for Regulatory Approval of Internal Models

A. Use test
B. Statistical quality
C. Calibration
D. Profit & loss attribution
E. Make model validation efforts proportional to evidenced areas of materiality and complexity
F. Validation standards
G. Documentation standards
The quality of the documentation is essential to model validation

If governance standards are not complied with, model validation loses its purpose
Right-sizing Model Validation Efforts

Linley Baker, FSA, MAAA, MM, ALMI
Transamerica
August 28, 2019
Topics to Cover

- Right-sizing validations
  - Choosing and prioritizing models
  - When to validate your model
  - Choosing your validation team
  - Designing efficient validation projects
  - Defining tolerances
Choosing and Prioritizing Models

- Overall risk level of the model (High/Medium/Low)
- Models that directly feed public results
- Models that may make a good pilot for new platforms or automations
- Consider company risk policy
- Is there an easier one to do first because of expertise of validation team?
- Should some models never be validated?
When to validate?

Choosing wisely can make the most value of your work

- When you are concerned about model performance
- Be aware of regulatory requirements that may influence timing
- Before, during, or after conversions?
- Consider company prioritization and resource availability
Poll: Choosing your Validation Team

Who should validate your model?

a) The LOB modeling team?
b) A modeling or validation center of excellence?
c) Outside consultants?
d) Independent Risk team?
e) Combination of the above?
Choosing your Validation Team
Who should work on validating your model?

- Final objective is an independent risk validation, but it may be better to utilize a center of excellence or modeling team as well.

- An independent validation doesn’t require that everything is done by that team.
Challenges in setting validation team

- We have a set-up where much of the legwork is done by the first-line and center of excellence
- Challenges of the poll options
  - LOB modeling team lacks validation expertise, and usually time
  - Center of excellence lacks product and model-specific expertise
  - Outside consultants take their knowledge with them and may identify less material changes
  - Combination of first two or all three may be optimal
Designing Efficient Validation Projects

If you are planning less than a ‘normal’ validation, be sure your management and risk functions are on board

- Figure out which blocks of your model have already been validated
- Analyze the scope of the changes since the last validation
- Skip or leverage parts of validations already done on those blocks to be sure your validation activities are value-add
Defining Tolerances

- You probably have a chart like this:

<table>
<thead>
<tr>
<th>Model Conversion Tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater of:</td>
</tr>
<tr>
<td>Single Policy Testing</td>
</tr>
<tr>
<td>Parallel to Production</td>
</tr>
</tbody>
</table>

- Things to consider
  - Risk appetite
  - What numbers really make sense for your company
  - What procedures are in place for when out of tolerance
Your Ideas
Q & A
Poll: Session Feedback

How has this presentation helped you?

a) Overview of practical aspects
b) Risk perspective on validation elements
c) Considerations for right-sizing validations
d) Considerations for planning validation projects
e) Other
f) It has not
Reference


Internal Model Validation – Model Validation Guidance, Lloyd’s, July 2017

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Modeling Excellence – How to Get There Seminar

Cheryl Angstadt / Andrew Weaks
A Production Process with End-to-End Automation – Is it Possible?
August 28, 2019
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Agenda

• What is end-to-end automation?
  • Environment
  • Process

• Steps in Building an End-to-End Process

• Case Study
  • Considerations
  • Process Flow
  • Challenges
  • Lessons Learned
  • Benefits Realized
Production Process with End to End Automation

• Features
  • Significant automation with minimal human intervention
  • Governed processes with appropriate access to each environment
  • Controls incorporated into the end-to-end process

• Use of a Data Warehouse
  • Secure location(s) where input and output are stored
  • Governance applied, e.g., naming conventions, data format, etc.
  • Efficient storage – hot vs. cold
  • Retention limits defined and adhered to
Fully Automated and Governed Environment

**Model Development**
- Optimal number of models/engines
- Version control
- Backups
- Formal change requests
- Regression testing
- Approval and sign-off process

**Data Sources**
- Fully optimized data extraction work flow

**Model Execution**
- Centralized environment
- Automated run execution
- Version control and backup of all runs
- Ensure a repeatable process
- Model and input sign-off

**Reporting**
- Central data warehouse where data standardized and stored
- Dynamic report generation
- Data retention and backup policy
- Formal adjustment request and sign-off
- Approval and sign-off of results
Fully Automated and Governed Process

Control Point: Inputs reviewed and approved before projections kicked off
Step 1 Understand Your Business

- Choose manageable block
  - Well understood and material size

- Choose knowledgeable staff
  - Backfill BAU to allow staff to focus on future state
  - Instills ownership and passion

- Inventory projections, sensitivities, reporting bases, tools, platforms, etc.

- Define reporting requirements
  - Frequency (monthly, quarterly, annually, ad-hoc)
  - Granularity (seriatim, cohort, block, division)

- Identify required inputs
  - Identify similarities and differences between the various projections
  - Consider plan code consolidation

- Define infrastructure requirements
  - **Storage needs** – based on reporting requirements
  - **Grid** – size, location – based on runtime requirements
  - **Retention period** – check with Legal, Business, etc.
  - **Scheduled submissions** – leverage same process, which allows limited modifications e.g., assumption changes, for all projections
  - **Specify modeling environments** – Development, Sandbox / Testing, Pre-Production, Production, Post-Production

- Identify current Key Performance Indicators (KPIs)
  - Use to measure success, e.g. days to report results, number of manual adjustments, etc.
Step 2 Develop a Vision

- Automate data feeds
  - Leverage ability of your platform to automate admin data and assumption feeds
    - Policy data such as issue date, gender, face amount, plan code, loan amounts, etc.
    - Fund data – current, shadow, separate account(s)
    - Tabular data from the admin system, such as COI rates, premiums, etc.
    - Asset data from investment area
  - Automate feeds from other sources such as Experience Studies, Pricing, Ledger, etc.
  - Design data feeds to minimize maintenance
    - Formulaically populate input fields, e.g. exp_qx_<plan>_<gender>_<smoking>_<risk>_<band>_YYYYMMDD.tbl

- Automate reports and reported results
  - Integrate model output with financial systems
    - Source of Earnings report that connects ledger data to model output
  - Automate feed of model output to ledger

- Develop production process
  - Use workflow tool to automate submissions, control reports, spreadsheets, file copies, etc.
    - Use it for all submissions – production and development
  - Build in audit trail
    - Assign run ids. Tag input and output to allow you to trace from results to source files
    - Use repository to version files and provide audit trail
Step 3 Everything Else

• Revisit your plan periodically
• Allow time to roll-forward automated models to date they become production
• Governance and Controls
  • Clearly define roles, responsibilities, access, etc. for modeling environments
  • Development, Testing, Model Office, Production
• Partnership between IT and Actuarial
• Modeling Center of Excellence to establish and apply modeling standards
• Potential pitfalls, e.g. inconsistency between admin data and model inputs
• People Management
• Expectations Management – you won’t get the process 100% correct on the first try
Case Study
Considerations

• Requirements
  • Data
  • Reporting

• Process Design
  • Specialized vs. enterprise-wide

• Actuarial Model Design
  • Internalized vs. externalized model elements
  • Static, semi-dynamic, or fully dynamic
  • Standards and consistency

• Software
• Infrastructure
• Controls
Process Flow

**Source Systems & Processes**
1) Administration System and other data collected by IT.

**Data Preparation Systems & Processes**
2) Data preparation process kicked off based on user instructions
   - Assembly of inforce, economic information, product feature tables, and assumption tables
   - Load inforce, economic information, model mapping, and tabular data into the actuarial model

**Model Calculations**
3) Valuation and projection model runs

**Back End Systems & Processes**
4) Post-processing and report creation

**Reporting**
5) Analysis and financial reporting
Challenges

- Scope creep
- Hitting a moving target
- Tight deadlines
- Data volume
- Transparency vs. automation
- Training and documentation
- Dealing with unknowns and uncertainty
- Partnership with IT
- Changing the status-quo
Lessons Learned

1. Integrate subject-matter experts (SMEs) into each element
2. Communicate
3. Have dedicated resources
4. Governance needs to be a key consideration
5. It takes time
Benefits Realized

• Reduced expenses
• Faster and more accurate results
• Enhanced focus on analysis
• Improved controls and reduced risk
• Enriched employee experience
Modeling Excellence – How to Get There Seminar

Eric Schwartz (Gen Re) & Uri Sobel (Milliman)
Communicating Model Results – A Key to Stakeholder Engagement
August 28, 2019
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Communicating Model Results – A Key to Stakeholder Engagement

“All models are wrong, but some are useful”

– George E.P. Box
Communicating Model Results – A Key to Stakeholder Engagement

“I have seen the future and it is very much like the present, only longer.”
– Kehlog Albran, The Profit

“Prediction is very difficult, especially if it’s about the future.”
– Nils Bohr

“Forecasting is the art of saying what will happen, and then explaining why it didn’t.”
– Anonymous (communicated by Balaji Rajagopalan)
Communicating Model Results – A Key to Stakeholder Engagement

• What is the purpose of the project?
• What are the results?
• What is driving the results?
• How confident are we in the results?
• How to explain what went wrong?
Communicating Model Results – A Key to Stakeholder Engagement

• What is the purpose of the project?
• What are we modeling and why?
Communicating Model Results – A Key to Stakeholder Engagement

• What are the results?
  • Profit/valuation metrics
  • Level of granularity
  • Timing of profits
Communicating Model Results – A Key to Stakeholder Engagement

What are the Results?

• Is this a useful format?
• Is this the right level of detail?
• Should immaterial rows be combined / excluded?
• What is missing, here?

### Table: Sample Projection Output

| Year | PREMIUMS | GROSS INVESTMENT INCOME | REINSURANCE PREMIUMS | AMORTIZATION OF IMR | LESS INVESTMENT EXPENSE | LESS INCOME LOST ON DEFAULTS | TOTAL INCOME | DIRECT DEATH BENEFITS | REINURANCE DEATH BENEFITS | COST OF FINANCING | MAINTENANCE EXPENSE | NET COMMISSIONS | INCREASE IN LOADING | INCREASE IN RESERVES | INCR IN RESERVE FINANCING LIABILITY | TOTAL DISBURSEMENTS | STATUTORY GAIN | CAPITAL GAINS | LESS IMR CAPITALIZATION | BOOK PROFIT | FEDERAL INCOME TAX | PROFITS RELEASED | POLICIES IN FORCE (UNSCALED) | GROSS DEFERRED PREMIUMS |
|------|----------|-------------------------|----------------------|--------------------|--------------------------|------------------------------|---------------|-----------------------|------------------------|------------------|---------------------|------------------|--------------------|---------------------|---------------------------------|------------------|-----------------|-----------------|--------------------------|-----------------|----------------|-----------------|------------------------|
| 2018 | 762      | 730                     | 701                  | 671                | 645                      | 618                          | 581           | 560                   | 543                    | 523              | 504                 | 487              | 470                | 392                | 318                          | 256              | 71              | 32              | 18                      | 32              | 28              |
| 2019 | 758      | 733                     | 705                  | 677                | 651                      | 634                          | 595           | 568                   | 549                    | 529              | 511                 | 493              | 468                | 378                | 305                          | 248              | 48              | 32              | 18                      | 32              | 28              |
| 2020 | 750      | 725                     | 704                  | 677                | 649                      | 631                          | 595           | 568                   | 549                    | 529              | 511                 | 493              | 468                | 378                | 305                          | 248              | 48              | 32              | 18                      | 32              | 28              |
| 2021 | 740      | 715                     | 698                  | 673                | 644                      | 628                          | 592           | 568                   | 549                    | 529              | 511                 | 493              | 468                | 378                | 305                          | 248              | 48              | 32              | 18                      | 32              | 28              |
| 2022 | 730      | 705                     | 693                  | 669                | 639                      | 619                          | 586           | 560                   | 543                    | 523              | 504                 | 487              | 468                | 378                | 305                          | 248              | 48              | 32              | 18                      | 32              | 28              |
| 2023 | 720      | 695                     | 687                  | 663                | 633                      | 618                          | 581           | 560                   | 543                    | 523              | 504                 | 487              | 468                | 378                | 305                          | 248              | 48              | 32              | 18                      | 32              | 28              |
| 2024 | 710      | 685                     | 678                  | 656                | 627                      | 608                          | 581           | 560                   | 543                    | 523              | 504                 | 487              | 468                | 378                | 305                          | 248              | 48              | 32              | 18                      | 32              | 28              |
| 2025 | 700      | 675                     | 670                  | 651                | 622                      | 608                          | 581           | 560                   | 543                    | 523              | 504                 | 487              | 468                | 378                | 305                          | 248              | 48              | 32              | 18                      | 32              | 28              |
| 2026 | 690      | 665                     | 665                  | 649                | 619                      | 606                          | 581           | 560                   | 543                    | 523              | 504                 | 487              | 468                | 378                | 305                          | 248              | 48              | 32              | 18                      | 32              | 28              |
| 2027 | 680      | 655                     | 659                  | 645                | 613                      | 600                          | 581           | 560                   | 543                    | 523              | 504                 | 487              | 468                | 378                | 305                          | 248              | 48              | 32              | 18                      | 32              | 28              |
| 2028 | 670      | 645                     | 653                  | 641                | 605                      | 600                          | 581           | 560                   | 543                    | 523              | 504                 | 487              | 468                | 378                | 305                          | 248              | 48              | 32              | 18                      | 32              | 28              |
| 2029 | 660      | 635                     | 648                  | 637                | 600                      | 595                          | 581           | 560                   | 543                    | 523              | 504                 | 487              | 468                | 378                | 305                          | 248              | 48              | 32              | 18                      | 32              | 28              |

### Notes:
- Sample data for demonstration purposes only.
- Adjustments and calculations may be required for actual reporting.
- Detailed analysis and interpretation are essential for effective communication.
What are the Results?

- Is this a useful format?
- Is this the right level of detail?
- Should immaterial rows be combined / excluded?
- What is missing, here?
Communicating Model Results – A Key to Stakeholder Engagement

What are the Results?

- Is this a useful format?
- Is this the right level of detail?
- What are the advantages of providing analysis tools?
- Are there disadvantages?
Communicating Model Results – A Key to Stakeholder Engagement

• Profit/valuation metrics
  • IRR, ROE, Profit Margin (e.g., PV profits ÷ PV premiums), Embedded Value
  • GAAP, stat, etc.
  • Ultimately it all comes down to cash flow
Communicating Model Results – A Key to Stakeholder Engagement

- Level of granularity
  - Need to show total, major sub-groups
  - But not every policy
  - Find right balance
Communicating Model Results – A Key to Stakeholder Engagement

• Timing of profits
  • Watch out for losses followed by profits (e.g., post level term profits)
  • Uncertainty increases with time
Communicating Model Results – A Key to Stakeholder Engagement

• What is driving the results?
  • Analyze results by attribute
    • Line of business
    • Product
    • Issue era
    • Issue age
    • Duration
    • Risk class
    • Gender
    • Etc, etc, etc
  • Choice of assumptions
Communicating Model Results – A Key to Stakeholder Engagement

• How confident are we in the results?
  • Limitations of the model
  • Model validation
  • Sensitivity testing
  • Confidence intervals
  • Compare prior models to actual results
Communicating Model Results – A Key to Stakeholder Engagement

• Limitations of the model
  • Are there non-modeled elements (small products, riders, etc.)?
  • Non-guaranteed elements (YRT rate increases, COI changes)
  • Model simplifications – e.g., model pointing vs. seriatim, efficiency techniques, etc.
  • Can the impact of these be estimated?
Communicating Model Results – A Key to Stakeholder Engagement

• Model validation
  • There was a separate session on validation
  • Back-casting can be valuable, but be careful about new business, shock lapse, one-time events
  • Similarly, comparing actuals to PRIOR years’ models may highlight biases
  • Can the impact of imperfect validations be estimated?
Communicating Model Results – A Key to Stakeholder Engagement

- Sensitivity testing
  - Assumptions
    - Does the model use the right assumptions?
    - Will the future change from the past?
  - Economic conditions
    - May want to run stochastic scenarios
  - Pick extreme conditions (favorable and unfavorable) to note potential impacts
    - Mortality: temporary shocks, permanent shocks, mortality improvement (or dis-improvement)
    - Lapse: zero lapse, shock lapse, increased lapses with resulting anti-selective mortality
Communicating Model Results – A Key to Stakeholder Engagement

- Uncertainty increases with time
- Actual experience may still fall outside the range of sensitivity tests
- Think about the risk
- Confidence intervals
  - Monte Carlo simulations
Communicating Model Results – A Key to Stakeholder Engagement

• What went wrong (far fewer questions when things go right)?
  • Current year/quarter profit below model projections (income statement)
  • Large increase in reserve/liability, or reduction in value (balance sheet)
    • Appraisal/embedded value lower than prior calculated value
    • Need to put up large reserve due to unlocking or failing cash flow testing/loss recognition testing

“As is the norm, an unexpected problem occurred today.”
Communicating Model Results – A Key to Stakeholder Engagement

• Profits below expectations
  • Did something unexpected (and unpredictable) happen?
    • Economic conditions
    • One-time events (and are they really one-time?)
  • Split model and actuals into subgroups
    • Are there one or a few subgroups driving loss?
    • Don’t cherry pick outlier poor performers without also considering outlier strong performers
    • If issue is more widespread, the problem is likely more systemic
Communicating Model Results – A Key to Stakeholder Engagement

• Was an assumption set improperly?
  • E.g., were lapses too low/high?
    • This can be determined when model is updated with new data
    • Projection may be fine in aggregate, but there may be offsetting errors amongst subgroups of business (e.g., higher lapses for profitable business and lower lapses for unprofitable business)
  • Be careful about assumptions like mortality that are volatile from period to period.
    • Is experience within normal volatility?
    • Is the experience a blip or a trend?
• Compare against sensitivity tests, confidence intervals
Communicating Model Results – A Key to Stakeholder Engagement

• Increase in liability/decrease in valuation
  • Rollforward stepwise analysis
    • First step is the prior determined value
    • Steps to show impact of each model update (corrections, assumptions, etc.)
    • Steps to show impact of new data
    • Steps to show impact of new economic conditions
    • Step to show rollforward from period to period
  • Order matters

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<tr>
<td>Liability Impacts</td>
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<tr>
<td>In-Force Roll-forward and Refresh</td>
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<td>Mortality (excluding improvement)</td>
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<td>Lapses (excluding premium suspension)</td>
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<tr>
<td>Tax-related Changes</td>
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<tr>
<td>Ending (12/31/2019)</td>
</tr>
</tbody>
</table>
Communicating Model Results – A Key to Stakeholder Engagement

• Increase in liability/decrease in valuation
  • Small assumption changes can have big impact
    • If PV premiums and PV claims are largely offsetting; so a change that disproportionately impact PV claims will have a huge leveraging effect; e.g., change mortality improvement
Communicating Model Results – A Key to Stakeholder Engagement