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Making Spreadsheets Great Again

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By Bob Crompton

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Letter From the Editors

By Phillip Schechter and Mary Pat Campbell

Mary Pat and I are pleased to present this issue—the sixth—of *The Modeling Platform*. In my constant quest for improved productivity, I've been trying the Self Journal, a day planner for achieving three-month goals. (Yes, Facebook advertising works—at least on me.) The journal includes daily quotes and one caught my eye, attributed to Benjamin Franklin: "Either write something worth reading or do something worth writing."

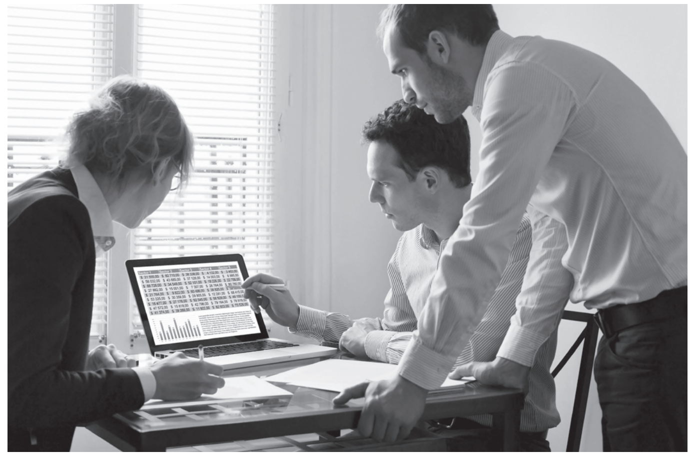
In the name of journalistic integrity, I tried to verify the attribution and came to the full quote, which is far more colorful. From the 1738 edition of *Poor Richard's Almanack*[1]: "If you would not be forgotten as soon as you are dead and rotten, either write things worth reading, or do things worth writing."

Let that serve as our biannual call for authors.

One of the benefits of editing a newsletter is advance exposure. I started using ideas from Bob Crompton's article "Making Spreadsheets Great Again" well before the edits were finished. In the past, we've talked about how to apply proper governance to Excel models, but in the meantime, we are likely to be confronted with Excel files—surely not from section members—that do not have clean structure or documentation. This article suggests approaches to reviewing and correcting such spreadsheets.

In order to discuss models, it helps to define what a model is. William Cember and Jeff Yoon contribute "Actuarial Model Component Design." Here they lay out items that fall into the scope of actuarial models, not limited to the calculation engine, and talk about key considerations for each component.

Modeling systems need to be flexible enough to reflect a range of products and strategies, and locked down enough to be reliable; this conflict is reflected through a range of "open" vs. "closed" products in the marketplace. James Christou, Ravi Bhagat and Alex Zaidlin help sort through the competing strengths and concerns of each approach. This has been a hot topic for quite a while; the fall issue of *CompAct*, which will be available by the time you read this, has an article on the same topic, but most likely from a different perspective, by Van Beach; it might be interesting to compare and contrast.



In a prior issue we put out a request for thoughts on model validation. Winston Tuner Hall, Michael Minnes and Veltcho Natchev answered that call, contributing "Adding Value with Model Validation." This article explores the benefits—and necessary organizational considerations—of setting up a beneficial validation program.

In a highly anticipated sequel, Linda Chow, Jeremy Levitt, Yuan Yuan and Laura Donnelly give us part two of the Long-Term Care Modeling trilogy, this installment discussing the pros and cons, nuts and bolts of first-principles modeling.

Actuarial models do not exist in a vacuum. If a model runs in the forest and nobody hears, there has been a lot of wasted effort. In his valedictory as section chair, Bruce Rosner gives some guidance on communicating model results.

The editors appreciate the work of the authors, and we trust you will too. ■

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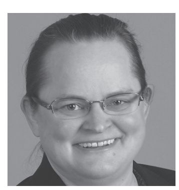

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ENDNOTE

1 Or more completely, *Poor Richard, An Almanack for the Year of Christ 1738, Being the Second after LEAP YEAR*, written and published by Benjamin Franklin.

Chairperson's Column

By Bruce Rosner

By the time you read this, my term as chair of the Modeling Section Council will be coming to an end. Not quite the end of my involvement in the section, but an end nonetheless, and I want to convey what a privilege it has been to work with the council and represent the members of the section. I can rest assured that the future of the section is in the competent hands of Scott Houghton, Brenna Gardino and the rest of the council.

In the long tradition of departures, I would like to share one last thought with all of you. Most modeling actuaries that I have met tend to identify as technically oriented actuaries. We recently set out a schedule of webcasts for the year, and one of the topics was "Communicating Model Results." I took the opportunity to be one of the presenters—specifically, because I thought it was a novelty; how remarkable that a group of technically oriented actuaries went out of their way to ask for this session. It speaks to a degree of self-awareness and, more generally, an awareness that a focus solely on technical skills produces inferior results. All actuaries are far more effective, in any role, if they can communicate effectively.

"Communication skills" is an ambiguous phrase; it can refer to clarity, brevity, persuasion, even listening, depending on the context and the audience. I identified it as clarity: how do you communicate your model results to your audience in a way that maximizes clarity while constrained by attention span and the format of the communique? Another view would be in Actuarial Standard of Practice 41: Actuarial Communications, which (in my interpretation) focuses primarily on appropriate disclosures to minimize risk, and has less guidance on how to present clearly.

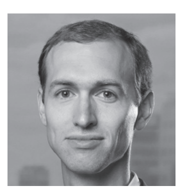
To some degree, these two definitions are conflicting. The most effective communication feels like a story, and the audience does not struggle through extraneous material to get to the point or the key analyses that support the conclusions. However, from a risk perspective, it makes sense to fully disclose your data, data sources, key assumptions, alternatives and a lot more information so that your audience can understand your full process.

If your CFO asks you what the cash-flow testing results look like, do you whip out the actuarial memorandum and start reading?

This illustrates why all effective communication is a balance between priorities—a balance struck appropriately in any given context. So I can't give you a rule book to follow, but certainly, there are principles to keep in mind and lots of tips and trick for different situations. Here are a few of those:

1. **Know your audience.** This is the single most important piece of advice that I've heard in my career. It means many things, including:
    a. How much of your audience's attention span do you have access to?
    b. What does your audience plan to do with this information? Put another way, what business decisions will be made based on the results you delivered?
    c. Does your audience have the technical knowledge to understand you?
    d. Do you expect your audience to challenge your results?
2. **Make good use of modern report structures.** Use the executive summary, the body, and appendixes in such a way that a single report can effectively address multiple audiences. Even within this report structure, the information should be presented like a story unfolding.
3. **A picture is worth a thousand words.** This is another good adage to apply to actuarial communications. A seasoned actuary can look at appropriate graphs and immediately pick out anomalies, whereas tables of numbers don't engage our brains in the same way.

I would like to hear more about the topic of effective communication from all of you. I encourage you to share stories of successes and failures in communication, perhaps in future issues of this newsletter, so we can all learn from each other. ■



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Making Spreadsheets Great Again

By Bob Crompton

One of the most important innovations affecting actuarial work has been the electronic spreadsheet. Spreadsheets are now so ubiquitous that it is hard to realize that there was a time when actuaries did their work without them.

Spreadsheets have been used for almost every conceivable aspect of actuarial work, and actuaries have demonstrated considerable ingenuity, insight and skill in developing spreadsheet solutions in a fraction of the time needed to develop corresponding solutions through more formal channels.

But spreadsheets have no enforced structure or control. Much of what we see in spreadsheet-land is ad hoc and chaotic, put together in the heat of the moment. Many spreadsheets are large and unwieldy, difficult to control and subject to bouts of unexplainable behavior—much like a St. Bernard or a teenager just learning to drive.

This bad behavior results in recriminations and finger-pointing, with actuaries bearing the burden of blame for mistakes attributable to spreadsheets. Owners of actuarial spreadsheets need to be more proactive in ensuring the accuracy of spreadsheet results.

This is not an article on best practices; rather, it is an article on how to deal with worst practices and still end up with verifiable results. I discuss some of the ways we have been able to apply structure, identify anomalies, determine architecture and purpose, fix errors and generally make users of spreadsheets comfortable with results.

For spreadsheets of more than a trivial size, manual inspection is a fool's game. There is simply not enough time nor enough human concentration to effectively manually inspect a typical actuarial spreadsheet. This article, therefore, is limited to techniques that address the structure and form of spreadsheets rather than techniques that directly address spreadsheet results. Techniques addressing results are adequately discussed elsewhere. The techniques discussed in this article use the often-dormant power of spreadsheets to analyze themselves and make spreadsheets great again!

FORMULA LISTING

Since the heart and soul (and maybe the pancreas, too) of a spreadsheet are the formulas that are used to determine the results, it is important to have a sense of formulas used. Excel provides a special range of all the formulas in each worksheet. This range can be used to display information about the formulas. In Figure 1, basic formula metrics are displayed. While giving complete sample code to get such analytics is beyond the scope of this article, the sidebar "Notes and Observations About the Code" on pages 10–11 gives a starting point for developing these tools.

Figure 1
Basic Formula Metrics

Worksheet Name	Formula Count
Reserve Summary	497
Trad	49
Acquired	15,867
BOLI	156
Bank	103
Hybrid	4,325
Group Life	552
International	973
Total	**22,522**

It is clear from the formula count that the heavy lifting in this spreadsheet is performed in "Acquired" and "Hybrid." Any spreadsheet review or audit would naturally focus on these two worksheets. But there are more metrics we can create with the range of formulas. A simple listing of formulas, as shown in Figure 2, can reveal important characteristics of the spreadsheet.

This display shows the location of each formula, along with the formula presented as a string and the current value for each formula. We can glean several important observations just by scanning the formula list:

Figure 2
Sample Formula List

	Worksheet Name	Cell	Formula	Current Value
1	Reserve Summary	C9	='Trad'!D45	197,103,261
2	Reserve Summary	D9	='Trad'!E45	193,331,261
3	Reserve Summary	E9	='Trad'!F45	193,943,838
4	Reserve Summary	C10	='Bank'!N72-'Bank'!N83	1,327,193,384
5	Reserve Summary	D10	='Bank'!O72-'Bank'!O83	1,394,889,616
6	Reserve Summary	C11	='Acquired'!N15	41,374,518
7	Reserve Summary	D11	='Acquired'!O15	35,436,540
8	Reserve Summary	S9	=AVERAGE(OFFSET(OFFSET(Q9,0,0,1,-2),0,0,1,-S7))	180,336,812
9	Reserve Summary	S10	=AVERAGE(OFFSET(OFFSET(Q10,0,0,1,-2),0,0,1,-S7))	1,978,348,388
10	Trad	Q8	=16394*0.98*0.98*0.98*0.98*0.98*0.98*0.995	14,450
11	Trad	Q11	=38832*0.98*0.98*0.98*0.98*0.98*0.98*0.98*0.98*0.98*0.98*0.98*0.98*0.98*0.98*0.995	29,119
12	Trad	Q24	=P24+900000	22,500,000
13	Acquired	C26	=#REF!	#REF!
14	Acquired	D26	=#REF!	#REF!

- Some formulas are simple and need little or no review. For example, the first seven formulas listed in Figure 2 are simple references to other cells in the spreadsheet, with or without a simple arithmetic operation.
- Some formulas are complex and may need thorough review. The eighth and ninth formulas in Figure 2 fall into this category. One easy way to spot complexity is to *autofit* the column width of the Formula column, then scan to find the formulas that take up all the space.
- Sometimes formulas hide constants. The 10th, 11th and 12th formulas in Figure 2 are of this nature. These items may also require thorough review to determine if they are truly reflective of the intent of the spreadsheet.
- Sometimes there are broken formulas, such as the last two in Figure 2. Broken formulas typically—but not always—are formulas that are no longer used. But even if broken formulas are not material to spreadsheet results, they signal a casual attitude toward spreadsheet maintenance and should be investigated.

The formula listing provides an overview of spreadsheet complexity as well as where potential issues lie.

LISTING LINKS TO OTHER SPREADSHEETS

One of the common attributes of most actuarial spreadsheets is links to other spreadsheets. Links provide a quick and easy way to update data. Links mean that we can create a beautiful cascading waterfall of data transfer, moving massive amounts of data effortlessly downstream to all dependent spreadsheets.

But links can create an extensive update burden if the data sources of the links are updated and given new names every period. Such a burden also creates concern that link updates are performed accurately.

One way to address this concern is to list all of the spreadsheet's links and compare them to the prior period. Excel will provide a list of your spreadsheet links, but there is limited functionality included in the native listing. Instead, we can construct a routine that will compile all links in the spreadsheet.

In Figure 3, we show the current period link address versus the prior period link address. Our expectation is that most of the links will be updated to use a new file consistent with the convention of naming files with the period end date included in the file name. Because some of the links access the same data source as in the prior period, they are flagged with a contrasting cell fill.

Figure 3
Current Period Versus Prior Period Link Addresses

Current Period vs. Prior Period				
Worksheet	Cell	Current Link	Prior Link	Status
Tab 1	Q7	=+'C:\Users\Bob\AppData\Local\Microsoft\	=+'C:\Users\Bob\AppData\Local\Microsoft\	Same File
Tab 1	Q14	=+'C:\Users\Bob\AppData\Local\Microsoft\	=+'C:\Users\Bob\AppData\Local\Microsoft\	Different Date
Tab 1	Q21	=+'C:\Users\Bob\AppData\Local\Microsoft\	=+'C:\Users\Bob\AppData\Local\Microsoft\	Different Date
Tab 1	Q22	=+'C:\Users\Bob\AppData\Local\Microsoft\	=+'C:\Users\Bob\AppData\Local\Microsoft\	Different Date
Tab 1	Q26	=+'C:\2017\03\Wealth\Polysystems\Results\	=+'C:\2017\03\Wealth\Polysystems\Results\	Different Date
Tab 1	Q27	=+'C:\2017\03\Wealth\Polysystems\Results\	=+'C:\2017\03\Wealth\Polysystems\Results\	Different Date
Tab 1	Q33	=+'C:\Users\Bob\AppData\Local\Microsoft\	=+'C:\Users\Bob\AppData\Local\Microsoft\	Different Date
Tab 1	Q39	='C:\2017\03\Life\GWLA Reinsurance\[qry	='C:\2017\03\Life\GWLA Reinsurance\[qry	Same File
Tab 1	Q40	='C:\2017\03\Life\GWLA Reinsurance\[qry	='C:\2017\03\Life\GWLA Reinsurance\[qry	Same File
Tab 1	Q41	='C:\2017\03\Life\GWLA Reinsurance\[qry	='C:\2017\03\Life\GWLA Reinsurance\[qry	Same File
Tab 1	Q51	='C:\2017\03\Wealth\Polysystems\Results\	='C:\2017\03\Wealth\Polysystems\Results\	Same File

A word of warning about this technique—it does not scale well. (This is a common problem with Visual Basic for Applications, or "VBA"). We ran into one spreadsheet that had 20,000 links, and it took well over an hour to list the links with our VBA automation tool.

FORMULA LOCKDOWN

Formula lockdown is an approach we see in a number of end-user computing standards. While we understand the intent behind these types of standards, we believe that any standard that materially impedes workflow will not be successfully implemented. Spreadsheet users and owners, being more vested in the operation of the spreadsheets, will always be able to circumvent standards that make their lives more difficult.

One approach we have taken is to identify formulas that are nonvolatile—that is, we expect these formulas will not be updated except in unusual cases. We then apply formula locking selectively to only these nonvolatile formulas.

If nonvolatile formulas are identifiable in some way, such as special formatting, it is possible to programmatically perform the selective lockdown.

Lockdown can be implemented without a password. This is usually preferable to lockdowns that have passwords. If the proverbial milk truck runs over the spreadsheet owner and no one can find where she wrote down the password, the spreadsheet may become unusable.

Lockdowns with no passwords can also be unlocked programmatically without passwords. This means that unlocking for necessary changes can be accomplished with minimal interruption of workflow.

Such an approach will not stop deliberate maliciousness, nor will it stop determined stupidity. However, the implementation of formula locking will mean that any changes require intentionality on the part of the one updating the spreadsheet, so at least some casual errors would be prevented.

HIGHLIGHTING CONSTANTS (AKA HARD-CODED NUMBERS)

For some reason, almost all spreadsheets of any size have constants. Perhaps spreadsheet gnomes sprinkle these throughout the spreadsheet while the owner is asleep.

We have seen constants put into the middle of a column or row of formulas as test values, then not changed. We have seen constants put in as manual adjustments, then not changed. We have seen constants put in as true-up values, then not changed. Excel allows you to be as boneheaded as you truly are.

Figure 4
Highlighting Cells With Constants

	6/30/16	9/30/16	12/31/16	3/31/17
Traditional	61,610,504	62,220,911	62,830,632	63,448,005
UL	152,868,104	159,319,432	162,543,593	176,438,180
VUL	318,894	333,619	383,290	492,108
Total	**214,797,502**	**221,873,962**	**225,757,515**	**240,378,293**

However, Excel also provides a special range of all the constants in each worksheet, so it is a straightforward exercise to programmatically highlight cells with constants. In Figure 4, constant cells are highlighted with gray fill so that they contrast with cells containing formulas.

But we can do even better than this! We can write a routine (macro) that allows the spreadsheet user to select a range of columns or rows and inspect all constants in the range that exceed a specified threshold. This improves efficiency, especially when the spreadsheet user knows where the critical cells are.

FINDING CONSTANTS HIDDEN IN FORMULA CELLS

As the formula-listing technique demonstrated, sometimes constants are included in formula cells. Because Excel does not have a native method of identifying this type of formula, such cells are not easy to find. In fact, this is the second most difficult technique discussed in this article. We had to jump through several hoops in order to automate locating these cells.

However, once the automation is in place, we can treat these cells like constant cells. We can apply contrasting formatting if we wish. We can also incorporate a routine that will allow the spreadsheet user to inspect all such cells and update them as required.

FINDING BROKEN FORMULAS

Like constants, but unlike constants hidden in formulas, broken formulas can be discovered using native Excel capabilities. This means that anything we implement for constants we can implement with equal facility for broken formulas.

We can put special formatting on broken formulas to highlight their locations. We can implement routines that will inspect all broken formulas. And we can implement routines to inspect broken formula dependencies.

VALIDATION CONTROLS FOR MANUAL ENTRIES

A typical requirement for many end-user computing standards is some form of validation applied to keypunched data entries in a spreadsheet. Although this form of data entry is not widespread in most actuarial spreadsheets, we have heard of instances of some outrageous spreadsheet results generated from such things as the entry of "No" rather than "N" or vice versa.

Once again we can use Excel's native abilities to help out. Figure 5 shows a listing of all constants with dependencies. We can use this chart to determine if any of our manual entries need validation controls. By examining the form of the dependency formulas, we can construct appropriate validation limits. Manual entries without dependencies need no validation controls.

This was the most difficult of all the routines discussed in this article. However, we followed the process used by astute programmers: we searched the internet to see if anyone had done this before. A BIG THANKS to the obsessive souls who take the time to put this sort of thing out on the web for the public.[1]

A final note on this routine: The Range.Dependents property shows dependencies only on the same worksheet. In order to capture dependencies existing on other worksheets, the ActiveCell.ShowDependents method must be used.

FINDING DEPENDENT WORKBOOKS

With the extensive use of spreadsheet links, an additional risk that spreadsheet users face is that changes to "upstream" workbooks will break the links in a "downstream" workbook, or—even worse—cause the links to access unintended data.

There is no direct way to detect downstream connections from a workbook. However, if the directory or directories of all (or nearly all) potential downstream connections can be enumerated, it is possible to construct a routine that will check for downstream dependencies.

This approach involves opening all workbooks in the indicated directories and checking for links to the upstream file. Since the search must look at each formula in each workbook in the search directories, this can be a time-consuming process just for one upstream file. Perhaps this approach should be considered a just-in-time process whenever spreadsheet restructuring is undertaken.

Figure 5
Sample List of Constants With Dependencies

Constant Worksheet	Constant Cell	Constant Value	Dependent Worksheet	Dependent Cell(s) →						
BOLI/COLI	D1	26504	BOLI/COLI	D4						
BOLI/COLI	O1	26504	BOLI/COLI	O33						
Acquired	AB7	spwl	Acquired	AA96	AA97	AA98	AA100			
Acquired	AC7	spwl	Acquired	AA82	AA83	AA84	AA86	AA89		
Acquired	AB8	term	Acquired	AA96	AA97	AA98	AA100			
Acquired	AC8	term	Acquired	AA82	AA83	AA84	AA86	AA89		
Acquired	AB9	term	Acquired	AA96	AA97	AA98	AA100			
Acquired	AC9	term	Acquired	AA82	AA83	AA84	AA86	AA89		
Summary	Z13	31488.33	Acquired	AA13	AA29	AA82	AA83	AA84	AA96	AA97
Summary	AA22	-277000	Acquired	AA29	AA82	AA83	AA84	AA96	AA97	AA98
Summary	AA23	1300000	Acquired	AA29	AA82	AA83	AA84	AA96	AA97	AA98

CONCLUSION

Many actuarial spreadsheets are created using worst practices, resulting in spreadsheets that do not always behave as intended and are difficult to control. However, several techniques allow us to understand the structure and complexity of these spreadsheets and spot areas where mistakes are likely to occur. We can then address the problems so that we have confidence in the results.

Much of what is discussed in this article grew out of having to perform model validation on spreadsheet models. We have implemented all of these techniques in one form or another. Most of them are general enough that they can be applied to almost all spreadsheets. One or two—notably spotting exceptions in spreadsheet link updates—are highly dependent on spreadsheet context. ■

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ENDNOTE

1 Some of the sites that I found to be helpful are listed here. Although there are many other sites, these are the ones I wound up using the most. The Microsoft Developers Network site is indispensable (*https://msdn.microsoft.com/vba/vba-excel*). Stack Overflow has many good worked examples to questions (*https://stackoverflow.com*). Ozgrid is another site with worked responses to questions (*www.ozgrid.com*). Code Project has articles as well as answers to questions (*www.codeproject.com*).

Notes and Observations About the Code

I am not an expert on VBA; however, my Google-fu is strong! This may be even more important than being an expert, since nearly everything you could want, or even imagine, in Excel macros has been done and posted on the internet. The ability to locate specimen macros on the internet is your best bet to becoming proficient in VBA.

Specimen macros not only give insight into techniques that might otherwise take a long time to track down, but they also show good style. After reviewing a number of macros, you learn that good code is succinct and easier to read than poor code.

One of the benefits to using macros is that they are self-documenting in the sense that they fully describe the actions and calculations they perform.

THE FORMULA-LISTING MACRO

The formula-listing macro is the first of these tools that was assembled, and for that reason it has evolved more than the others. The key to the formula listing is getting the range object of all formulas in a worksheet. The code for this is:

```
Set FormulaCells = Range("A1"). _
SpecialCells(xlCellTypeFormulas, 23)
```

Excel contains a number of special ranges. You can get a sense of these by hitting the F5 key while in Excel. This brings up the Go-To dialogue. If you click the button labeled "Special...," you will see all of the special ranges that Excel can easily create for you.

Once this range is created, it is easy to loop through each cell and extract the pertinent information. For example:

.Cells.Count contains the formula count

Use a "For Each" loop through the range as follows:

```
For Each fCell In FormulaCells
```

Then the appropriate attributes can be accessed. For example,

- *fCell.Address* contains the cell address
- *fCell.Formula* contains the cell formula
- *fCell.Value* contains the current value to which the formula evaluates

Because most actuarial spreadsheets contain multiple worksheets, it is important to loop through each of the worksheets. I typically use a *For Each* loop like the following:

```
For Each ws In ActiveWorkbook.Worksheets
  If ws.name <> TabName Then
  ws.Activate
```

The worksheet named TabName is the worksheet I add to contain the formula listing, so I exclude this from the processing.

ALTERNATE SORTING OF RESULTS

The results in the formula listing are not arranged by column. The *natural* order seems to me to be one in which the results start from column A, then proceed column-wise to the right-most column, since this is how spreadsheet logic typically proceeds. But sorting by cell doesn't work since cell AA1000 precedes cell A1.

In order to address this, I have written user-defined functions that allow me to sort results by column. There is no end to the possibilities!

HIDDEN WORKSHEETS AND COLUMNS

One of my serendipitous discoveries was that when using a *For Each* loop through each worksheet, it operates on hidden worksheets as well as visible worksheets. Sometimes in spreadsheet review, it is easy to forget that there may be hidden worksheets. Running the formula listing reminds me of this whenever the formula count tableau shows names of worksheets that I can't see.

Hidden columns are likewise displayed whenever we list any of the special ranges. Although hidden columns are usually more apparent than hidden worksheets, it is still convenient to have listings that do not require un-hiding columns or rows.

ERROR TRAPPING

Because VBA contains only rudimentary error-trapping abilities, the macro may contain some odd "GoTo" statements. For example, in the formula-listing macro, if there are no formulas in a worksheet, an error is generated when attempting to set *FormulaCells*. In this case, error trapping sends the code to the part that lists the number of formulas (zero in this case), but skips the attempt to list the formulas themselves, since there are none.

THE CONSTANTS SEARCH-AND-REPLACE MACRO

The constants search-and-replace macro and the formula-listing macro are very similar, but a few additional details may prove useful when using the constants search-and-replace routine.

First we create a range of constants:

```
Set ConstantCells = Range("A1"). _
SpecialCells(xlCellTypeConstants, 23)
```

Then we allow the user to select some arbitrary range for the search-and-replace operation:

```
Set SearchRange = Application.InputBox( _
"Click Rows or Columns", _
"SEARCH RANGE SELECTION",,,,,, 8)
```

We then reduce our review-and-replace operation to the intersection of the ConstantCells range and the SearchRange range:

```
Set SearchCells = Application. _
Intersect(SearchRange, ConstantCells)
```

The *Intersect* function is one of the most powerful and useful functions when dealing with Excel ranges.

WEAPONS OF MASS IMPLEMENTATION

In certain situations you may want the routines outlined here installed on a number of spreadsheets. Manually copying code from one spreadsheet to another quickly becomes tedious. It also creates another point of potential error. Any tedious manual process is a process that is ripe for automation. You can construct a macro that will perform the implementations. It is a straightforward process to programmatically select a directory and install the VBA code in all (or only some) of the spreadsheets in the directory. If you like buttons for your macros, you can put all of your buttons on a single worksheet and copy it to all of the target spreadsheets. You can then programmatically connect the buttons to the macros.

DEFAULT ACTIONS FOR USER INPUT

When we originally developed this macro, the default action was to enter the threshold value as the new value for cell. One client told us that this resulted in unintentional changes in the spreadsheet. We changed the macro so that updating the spreadsheet with new values required intentional clicking.

Users are the ultimate arbiters of usability!

That's it for macros. And now, as The Dude would say, let's go bowling.

Actuarial Model Component Design

By William Cember and Jeffrey Yoon

As managers of risk, most actuaries are tasked with answering questions about how things will play out in the future:

- How much money do I need to set aside to meet the obligations to my policyholders?
- What should the charges be on a new product to make it profitable yet competitive?
- What will the capital position of my company look like 10 years from now?

In answering these questions, a primary concern is the integrity of the calculations and data used in our analysis. With faulty calculations and poor data, we cannot give reliable guidance to our stakeholders.

Just as important as the *what* in what we do is the *how*. For actuaries, the *how* is our models, and just as we need to make sure those models are programmed correctly to calculate the metric we are interested in now, we also need to make sure they are well designed so they will continue to be reliable in the future.

In this article, we define and discuss the components of actuarial models. We pose key design questions as well as the criteria used to answer them. We also provide you with tools to not only build the *what* but also design the *how*. This will help ensure that even though data is updated and questions change, actuaries are still able to obtain the correct calculation.

ACTUARIAL MODEL COMPONENTS

The three components of an actuarial model—input repository, calculation engine, and output repository—have to work together in harmony. Each has an important role to play in finding answers for our clients.

Calculation Engine

The first thing that comes to mind when most people think of a model is the calculation engine. This component performs the core calculations, turning input data into management metrics. Some example functions performed by actuarial calculations include the following:

- Calculating reserves
- Projecting premiums and claims
- Projecting out assets against liabilities
- Determining required capital

Within the calculation engine, the model developer programs the methodology used to determine and project balances.

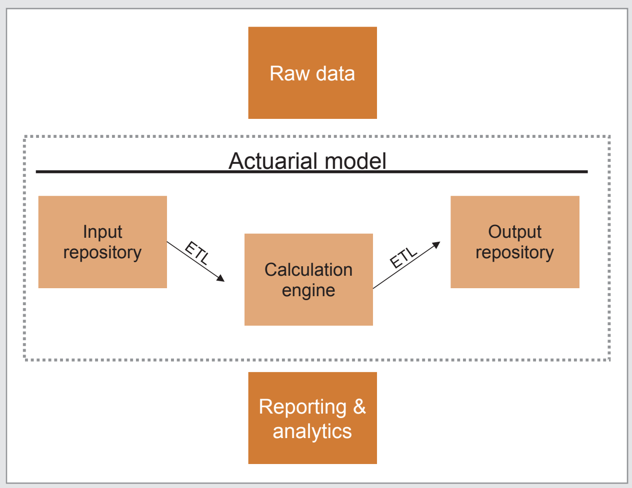
WHAT IS A MODEL?

If you ask 10 actuaries what a model is, you most likely will get 10 different answers. The Federal Reserve's supervisory guidance on model risk management for large financial institutions defines a model this way:

> [T]he term model refers to a quantitative method, system, or approach that applies statistical, economic, financial, or mathematical theories, techniques, and assumptions to process input data into quantitative estimates. A model consists of three components: an information input component, which delivers assumptions and data to the model; a processing component, which transforms inputs into estimates; and a reporting component, which translates the estimates into useful business information.[1]

Per this definition, a model does not only include the calculation engine, which is what is often thought of as the model, but also the end-to-end process (see Figure 1). This includes an input repository, output repository and the associated extract-transform-load (ETL), which passes the data back and forth.

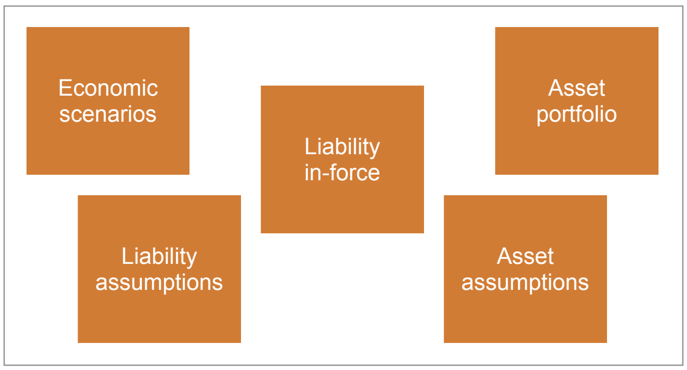
Figure 1
Actuarial Model Components



Input and Output Repositories

The input repository stores the inputs for the broader actuarial model (see Figure 2). Depending on the maturity of the model and type of input, the input repository does not necessarily need to be in a separate location. For example, while many models will have a standardized location for the in-force inventory, assumptions are more often hardcoded in the calculation engine, and therefore, the calculation engine and input repository may be one and the same (although we don't recommend this).

Figure 2
Input Repository



The output repository stores model output before it is used for reporting or analysis. Like the input repository, depending on the type of model output, the output repository and calculation engine may be one and the same. Decisions should be made regarding development of a separate output repository.

As models mature, first-class input and output repositories can serve purposes beyond simply storing data:

- **Approval tracking capabilities.** Before inputs can be used in a model, they must be reviewed and approved. This effort can often be manual but may be prone to error. A first-class input repository includes built-in approval tracking, ensuring the right inputs and automating the process of producing the corresponding documentation.

- **Platform independence.** The input and output repositories can be built so they are independent of the calculation engine. This allows first-class tools to be used as a backend for these repositories, reducing the need for model conversions from one actuarial platform to another.

- **ETL automation.** Automating the data ETL processes between calculation engine and input/output repository increases the ability for actuaries to focus on providing analysis and business insight, rather than performing data work. Results can then be delivered to customers faster, allowing real-time decision making.

- **Metadata.** Beyond approval tracking, the input and output repository can be designed to store rich metadata regarding when and how stored data has changed and who made the changes. This also has second-order consequences, allowing the owner of the repository to quantitatively answer questions such as whether the data are being delivered on time or how long models are taking to run.

KEY DESIGN CRITERIA

Using the following key design criteria, a company, based on its specific characteristics and requirements, can make decisions around the design of its actuarial models.

Accuracy

As actuaries, we always strive for the most accurate models possible. With everything else equal, we believe the more accurate a model, the better. In practice, one often must make a trade-off between accuracy and other characteristics:

- If a certain calculation is improved but the model takes three times as long to run, is it worth it?

- What is the balance between accuracy and maintainability? If it is necessary to code a model in a messy way—which is likely to break down the line—to get a calculation perfect, is it really worth it?

- Can a general solution for many similar products suffice if it is less accurate than a separate solution for each product?

- If the current approximation is replaced by a complicated solution, is the impact material enough and worth the effort?

The answers to these questions depend on the function of the model. For example, valuation models are going to have a lower threshold for errors than pricing or forecasting models. Generally, there is a trade-off between short-term and long-term accuracy. As much as we want to perfect calculations, more complicated models limit us in terms of improvement and increase the chance of future inadvertent model errors.

Controls

Controls regarding models pertain to the process around which changes can be made to the model and how models are run in production. The actuarial model must be controlled to the extent required by the intended model's purpose. Models used for financial reporting or reserving are often subject to specific regulatory requirements, and even models used for other purposes should be subject to a defining set of controls.

At the same time, model control must be balanced against flexibility. In particular, models that are used for multiple purposes will often have users requiring differing levels of control and flexibility.

Flexibility

Flexibility is the degree to which model users can easily achieve the business goal with their model. For example, how difficult is it to run the model with an alternative in-force policy or alternative assumptions? How easily can changes be made to the model in the future?

Different functional purposes have different requirements for flexibility. A model used to project in-force business will often have product features well defined, while a pricing model will often require the ability for the model user to implement innovative product features as these products are being designed.

Testability

Testability is the degree to which models can be tested. For example, does a model show the underlying calculations for each step in a reserve calculation or only the final number? Similarly, how granular are model results—just what's needed for reporting or granular enough to allow the model user to drill down when something goes wrong?

In a perfect world, our models would show every step in every calculation (full transparency) and allow the model user to drill down from aggregate to policy-level results. In practice, as we make a model more testable, it becomes less efficient. One possible practice is to build models in a flexible enough fashion so that model users can make this decision when they run the model or allow different model functions to have different degrees of testability.

Efficiency

Efficiency is the degree to which a model can quickly perform the calculations it needs to perform using the minimum resources (computer and human). When thinking about efficiency, consider the end-to-end process of receiving final reports from model inputs rather than just how long it takes the calculation engine to complete a run. With all else equal, we want our models to be as efficient as possible. In practice, however, there is often a trade-off between efficiency and other characteristics, such as accuracy, maintainability and transparency.

One question to ask when making this trade-off is whether the extra efficiency is useful or not. For example, does it really matter whether a model takes 10 hours or 11 hours to run? Probably not. In both cases, the model runs overnight, and results are ready for the actuary to review the next morning. At the same time, it does matter whether a model takes 10 hours or 100 hours to run.

Transparency

Transparency refers to the degree to which the underlying calculations of the model are viewable by the model user. It is always better to have a more transparent model to allow the

actuary to drill down into calculations as needed, such as when validating the model or trying to understand why the model is producing the results it is producing. In reality, though, there is often a tension between transparency and some of the other characteristics listed here, such as control and efficiency. When designing or building models, one often needs to evaluate how important transparency is for a specific business purpose against other characteristics.

User-Friendliness

User-friendliness is the amount of training and documentation required for a new model user to run or view the model or for a new developer to make changes to the model. We want to minimize the amount of training required to interact with the model. Even if the model is producing correct results, if no one except one "expert" in the company can understand it, is it really serving its purpose?

Standardization

Standardization is the degree to which conceptually similar pieces of the model (or the set of models within a company) are designed in similar ways (such as following a documented convention). Standardization makes models more maintainable and repeatable. It also allows model users and developers to more easily and quickly understand what the model is doing and to change the model if necessary. As obvious as it seems to standardize models, this requires up-front work to determine the model standards and discipline to enforce them down the line. No one single standard will be perfect in 100 percent of the cases.

KEY MODELING DECISIONS

Before any model can be created, decisions need to be made that dictate what kind of model is desired and which characteristics will be of most importance to the practice at hand. The following list outlines the types of decisions that need to be made and what factors to weigh in those decisions.

- **Coupling.** Coupling refers to the degree to which components are dependent on each other. As an example, inputs that are stored directly in the calculation engine are tightly coupled. Tightly coupled architectures are often easier to build but can be harder to maintain and limit the flexibility of the model over time. For example, it is much easier to test the business impact of new assumptions if this can be done by swapping in a new assumption input file for an old one and rerunning, rather than having to go into the calculation engine and manually change internal model tables.
- **Data transformation.** As actuaries, our first instinct is to do everything ourselves, and that often involves using familiar actuarial software. Data transformation done within the calculation engine is often easier to build out by the actuary, providing more flexibility. At the same time, this creates a more tightly coupled architecture, and without careful planning, it can easily lead to a tangled nest of fragile, intertwined data manipulations mixed with calculations. Separating out the data transformation from the calculation engine allows us to use best-in-class tools that are specifically optimized for manipulating data.
- **Modularity.** For a single line of business, should there be a model that projects out both statutory and GAAP reserves or should these be separate models? In the abstract, it's easy to say that our models should be as flexible as possible and we should always be building out the more general solution, but that can be difficult from an engineering perspective. Often there are nuances to various calculations, making it difficult to build a "one size fits all" solution. Similarly, from a process perspective, it's very often the case that separate teams are responsible for various calculations, and building a model that does both calculations requires harmonizing the modeling approach among teams. Often, more modular models are more expandable for new products or methodologies, as already built components can be leveraged.
- **Open vs. closed systems.** Actuarial platforms that are locked down—or are closed systems—allow for the use of a vendor-created solution that has been validated and tested. Conversely, open systems allow a company's actuaries or dedicated developers to code more parts of the calculation to meet company-specific requirements or enrich diagnostic elements; this approach offers more flexibility and transparency at the risk of being less controlled.
- **Reporting vs. analytics.** Ideally, our models would produce perfectly granular output that would allow us to drill down and across the data in every dimension possible on demand. Our models would be forever error-free and run instantaneously. In reality, there is an inherent trade-off between calculation efficiency and output granularity, and we need to be able to strike a happy balance.
- **Enterprise-level standardization.** Just as an individual model can be standardized, the modeling function across a company can be standardized. This can range from harmonizing the actuarial software and model design standards across the company to organizational design of the modeling function. The more standardized solutions will allow "plug and play" and provide compatibility with other systems, promoting a fully automated end-to-end process.

In the preceding pages we defined the actuarial model and discussed the characteristics of a good actuarial model. When we know what makes a good actuarial model, a common set of criteria can be used to make the decisions required to design, build and maintain these models.

We also presented a few of these decisions, but we did not provide the "right answer." The right answer depends on a company's individual needs or a department's specific requirements. The criteria can assist in selecting the right approach for a company or department. ■

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ENDNOTE

1 Attachment to SR Letter 11-7, "Supervisory Guidance on Model Risk Management," Board of Governors of the Federal Reserve System, April 4, 2011, *https://www.federalreserve.gov/supervisionreg/srletters/sr1107a1.pdf*.

Actuarial Modeling Systems: How Open We WANT Them to be vs. How Closed We NEED Them to be

By James Christou, Ravi Bhagat and Alex Zaidlin

The debate over whether closed or open code systems are better positioned to meet actuarial modeling needs has been going on in the insurance industry for decades. Discussions on this topic can become very passionate and involve insurers, consulting companies and vendors. Moreover, the debate can rage within organizations, often dividing functional teams and departments based on their strong opinions. Functional teams tend to focus on their unique business requirements and ultimately choose the type of system that best meets their specific needs. In a real-world setting, typical divisions exist between pricing groups, which desire the ability to customize on the fly, and valuation and projection groups that need to maintain locked-down, controlled environments for financial reporting. Both sides have valid arguments expressed through lively and often contentious debates.

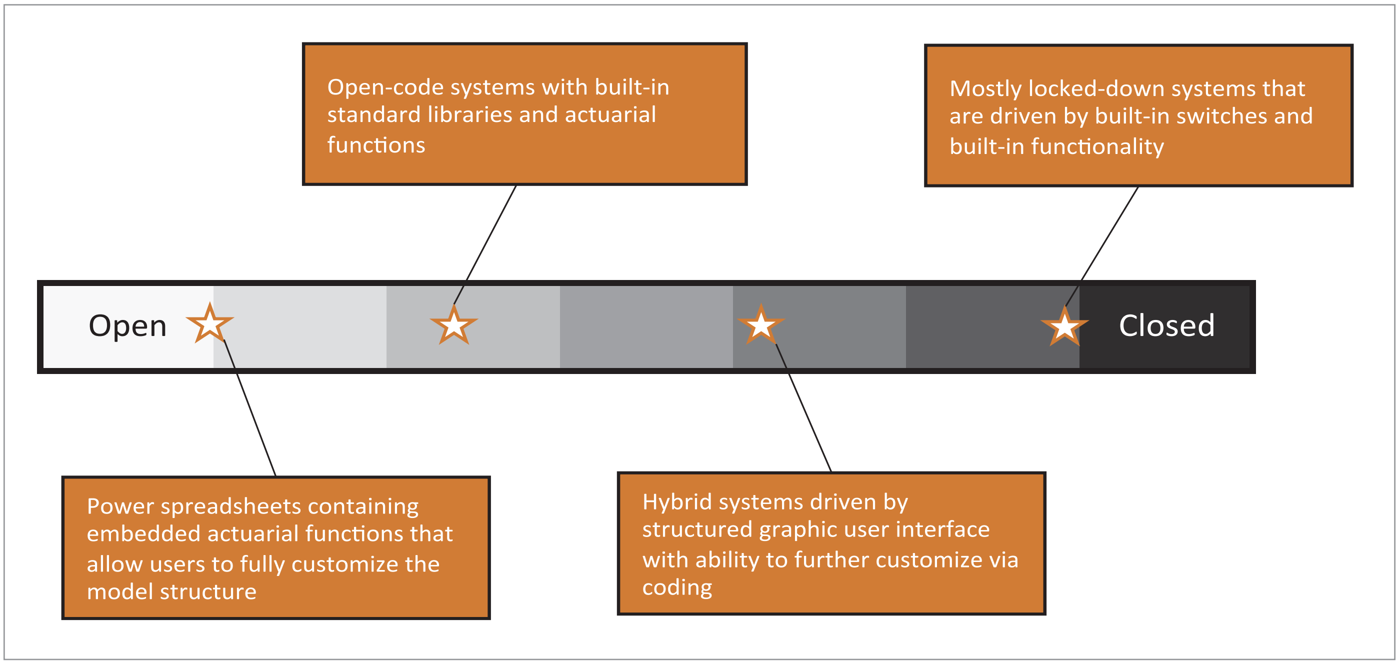
As a result of key stakeholders' competing priorities and varying business requirements, there is no clear front-runner in the systems race. In certain instances, some insurers have drastically changed their operating models in order to force a single-system solution, as they satisfied the priorities of the more vocal group's priorities. However, this is not a common practice in the insurance market and often results in discontent, frustration and lost productivity within the losing group. With unique strengths and weaknesses to each type of system, companies often end up using a combination of systems to satisfy the need of various groups. The way companies use the systems is dictated by the business requirements of each group and can vary drastically. Some companies see actuarial systems as simply an actuarial liability calculator, where data are prepared and transformed externally and the exported cash flows are aggregated and summarized in a database platform. Others prefer an all-in-one solution, utilizing the system functionality to its greatest potential, carrying out data transformation and reporting analytics within the system environment. Additional differences in system use typically include level of automation, model governance practices, modeling environment setup and supporting tools used in conjunction with actuarial systems.

Actuarial system vendors have taken a distinct approach to address competing priorities (and variation in use); some systems are built to satisfy a specific need and/or function, such as valuation, while others are designed to be multipurpose with the ability to support pricing, valuation and projection in a consistent manner. In both approaches, as vendors cater to their clients, differences between open and closed systems are becoming less and less clear.

As the differences between open and closed systems continue to blur, it is helpful to take a minute and understand the evolving universe of systems. Closed systems have become more open to allow the users to customize their models via coding and advanced logic, while open-system vendors have built additional out-of-the-box functionality into the systems' standard libraries. As a result of these actions, the evolution in actuarial systems has created a system openness spectrum rather than two mutually exclusive system types.

On the open end of the spectrum, there are the power spreadsheet systems that provide an Excel-like environment for the user to embed actuarial formulas relevant to their calculations. These systems are fully user-driven and offer maximum flexibility in the way companies choose to build their models. Closer to the middle are the open code systems that allow actuaries significant flexibility in customizing their models and calculations to their needs. These systems typically use coding languages similar to VBA or C++ and rely on the user to code in the logic referencing standard libraries and other out-of-the-box functions. Closer toward the closed end of the spectrum one finds the hybrid systems that provide a structured graphic user interface with some built-in model configuration switches and options, yet allow the user to do a fair bit of coding to map

Figure 1
Actuarial Systems—Openness Spectrum



model components and create complex calculation logic. Finally, on the closed end of the spectrum are the mostly locked-down systems that rely on the built-in functionality and flexibility to meet all the model customization needs of the users. Figure 1 graphically depicts the actuarial system openness spectrum.

As one can expect from a market perspective, there is no widely accepted solution to help traverse issues surrounding competing priorities. Obvious as it may sound, insurance companies are looking for modeling systems that are open where the modelers want them to be open and closed where they need them to be closed. This perpetuates the conflicting priorities that are being faced by companies. Moreover, these needs will vary from company to company, and, therefore, no one-size-fits-all system can exist. When the conflicts occur within a company, this often results in a company operating with two or more systems, each fit for different modeling needs. This satisfies the priorities of each group but may not be economically or practically viable.

With no "silver bullet" solution offered by vendors or demanded from the industry at large in sight, this article discusses various factors that should be considered when evaluating the business requirements and subsequent modeling priorities within your organization. We compare and contrast mostly open and mostly closed systems across multiple business dimensions, highlighting the key advantages and disadvantages of each type of system. We focus on the common areas where conflicting priorities arise within functional groups, including model governance, efficiency and functionality, auditability and transparency, and cost and risk of system maintenance.

GOVERNANCE AND CONTROL ENVIRONMENT

Governance and model controls have become a concern in recent years. Stakeholders, including vendors, insurance companies, regulators and rating agencies, all have strong opinions on this topic. As actuarial models become more complex and highly integrated into production processes, controls over model access, revision and execution have become critical. Both open- and closed-system vendors have taken steps to improve their systems' ability to build in model controls and implement governance policies. Table 1 highlights several items to consider as part of the healthy discussion on choosing a closed or open system.

Table 1
Governance and Control Environment: Open/Closed Systems Comparison by Category

Category	Closed Systems	Open Systems	System Selection Considerations
Model governance	Model governance frameworks are provided by the vendor and are customized by the customer. Advantage: The provided governance frameworks are industry tested and improved over time through customer feedback. Disadvantage: Users are only allowed to customize their model governance framework within the limits offered by the vendor.	Each customer is responsible for setting up their own model governance framework. Advantage: Users can customize the governance framework as needed to reflect their company's specific needs. Disadvantage: Governance framework for the same system can differ significantly across users, making it hard to derive industry-leading practices and potentially requiring multiple refinements over time.	Company risk appetite Existing governance programs in place Resource availability Company-level vs. function-level requirements Ability to create, monitor and enforce governance policies within organization Audit requirements
Control environment	Models would generally allow users to customize calculations, but warn them when illogical operations are performed. Prescribed calculations are controlled and locked in (these include items like prescribed statutory reserves calculations). Advantage: Risk of illogical or not actuarially sound calculations is minimized. Disadvantage: Less transparency into calculations behind locked-in components, and potential over-reliance on the system may increase human-error risk.	Users are able to customize controls over calculations for each model component. Systems often include role-based controls customized for each user. Advantage: Customized controls work well for unique calculations and the customer achieves full transparency into all model calculations. Disadvantage: Customized controls may not be adequate or correctly set up.	Actuarial and IT operating model Company risk appetite Uniqueness of product design and level of customization Existing controls around actuarial processes Audit requirements
System documentation	Robust vendor-provided documentation accompanies the system and gives insight into calculations of actuarial components as well as technical documentation for the system to the extent the customer needs to be aware of its functionality. Advantage: Detailed explanations of system calculations increase customer's ability to understand complex model calculations. Disadvantage: Not all calculations and variable interactions are defined within the system documentation. Items that are extremely obscure or rare may require direct communication with the vendor for supporting documentation.	Robust documentation that details standard libraries, out-of-the-box functionality and methods to customize are typically provided. Advantage: Customer has the ability to gain a complete understanding of standard libraries and out-of-the-box functionality. Disadvantage: Documentation does not provide comprehensive detail on how to perform customization for company's unique needs.	Resource skill and understanding level Actuarial support model (reliance on third parties) Model and product complexity Level of customization required Audit requirements

Clearly both open and closed systems are moving toward allowing the users to implement governance policies and model controls. However, closed systems have taken a more restrictive position over governance processes, while open systems leave much of the setup and implementation work of these processes to the user. In this category, it is key to match system capabilities with the distinct operating model of the company, since it would help resolve the open versus closed system debate.

EFFICIENCY AND FUNCTIONALITY

Actuarial models are challenged to carry out increasingly complex calculations, driven by product features, risk mitigation strategies such as sophisticated hedging techniques and evolving regulation. Despite exponential increases in processing speed, and the scalability of grid and cloud approaches, model run time and expense remain a concern. In a practical sense, virtually infinite computing power is available through a variety of technology solutions, but in reality, multiple concurrent and tiered processes extend production timelines beyond typical management comfort zones. Outside of production and financial reporting function groups, other groups within the organization have calculation requirements that vary dramatically. Table 2 highlights several efficiency and functionality considerations that should be openly discussed in the debate regarding closed and open systems.

Table 2
Efficiency and Functionality: Open/Closed Systems Comparison by Category

Category	Closed Systems	Open Systems	System Selection Considerations
Automation	Closed systems can be seamlessly automated as part of the larger end-to-end production process. The system environments tend to include pre- and post-model elements such as data transformation and structured reporting layers. Advantage: Automation allows for accelerated production timeline, efficient end-to-end process execution and minimization of the risk of human error all the way through the process, from data transformation to structured reporting. Disadvantage: Interaction protocols with outside systems are limited to vendor-provided functionality.	Business process management tools are built in and enable interaction with outside systems and databases. Advantage: Automation allows for accelerated production timeline; interaction protocols are flexible to customers' unique needs. Disadvantage: Interaction protocols with outside systems are limited to vendor-provided functionality.	Existing automated processes in production cycle Pre- and post-model processes The need for manual adjustments pre/post model run Model and process run time Model complexity IT support available
Speed	The vendor has the ability to optimize calculations to increase speed through ongoing testing and customer feedback. Advantage: Since vendor coders are professional programmers, they have deep expertise in code optimization that results in faster model runs. Disadvantage: The customer does not have control over model efficiency outside of what is available through user interface.	Open systems leave it up to the customer to optimize model run time through efficient model processes. Advantage: The customer has control over model efficiency and run time and can gain understanding of efficient modeling techniques through testing. Disadvantage: Actuaries typically do not have sufficient understanding of the technical side of model optimization and are likely not to best optimize model run time.	Model and process run time Computing power available (number of CPU cores and servers) Model and product complexity Speed of model-adjacent processes IT support available

CONTINUED ON PAGE 20

Table 2
Efficiency and Functionality: Open/Closed Systems Comparison by Category, *continued*

Category	Closed Systems	Open Systems	System Selection Considerations
Flexibility and out-of-the-box functionality	Out-of-the-box functionality is available, industry tested and improved over time through customer feedback. Vendors are open to implementing system modifications for missing features. Advantage: Industry-tested out-of-the-box functionality minimizes the risk of errors in calculations and reduces implementation time. Disadvantage: System flexibility is limited within the vendor setup, it is impossible to implement additional functionality without help from the vendor and it may be difficult to leverage built-in functionality for unique product features.	Standard libraries and out-of-the-box functionality are available but need to be customized by the customer. Advantage: Ability to customize calculations increases flexibility and allows for coding of unique model components and product features, while the incremental changes needed for customization and implementation time might be reduced. Disadvantage: System openness increases the risk of calculation error and makes it more difficult to remain consistent across models.	Model complexity Uniqueness of product design and level of customization Resource skill and understanding level Appetite for manual adjustments pre/post model run Vendor flexibility and ability to modify the system
Regulatory readiness	Vendors keep on top of regulatory developments as dedicated resources maintain an ongoing dialogue with the users, implementing new regulatory requirements in a timely manner. Advantage: Users receive new functionality through routine system version upgrades. Logic is industry tested and refined by the vendor, as the vendors have dedicated resources to build new regulations into the systems. Disadvantage: Unique, customer-specific interpretation of regulations would need to be requested as a customized modification that may take some time to implement.	The customer has the flexibility to code new regulatory modules on their own without vendor help. For the more complex regulatory needs, the vendor would update the standard libraries and out-of-the-box functionality. Updates can vary in their timeliness. Advantage: Open system provides additional flexibility in implementing new regulatory requirements into the models, and unique interpretations of regulatory rules can be easily coded by the modeler. Disadvantage: Customized coding of new regulatory requirements may lead to misinterpretation of the regulation or incorrect implementation. The effort needed to incorporate changes can vary significantly based on the update.	Uniqueness of product design and level of customization Resource skill and understanding level Vendor flexibility and ability to modify the system Company interpretation of specific regulatory requirements
Reporting of results	Closed systems have multiple flexible built-in, customizable reports in lieu of the customer having to access calculations to produce output. Some systems include user formula report options, allowing the user to build in custom report variables. Advantage: Minimal customization is required and many template reports are available, industry tested and enhanced over time. Disadvantage: It is difficult to get additional details outside of what the template reports offer.	Standard reports with a high degree of customization are typically available within open systems. Advantage: Open systems allow for flexibility in report building and full transparency into the calculation formulas used. Disadvantage: Coding may be required to extract desired interim and final values.	Existing reporting processes and potential future enhancements Silo or aggregated result reporting The need for manual adjustments pre/post model run Regulatory requirements affecting the company Model and product complexity IT support availability

While open systems allow more flexibility to users to model their product features more accurately, the concept of "industry tested" functionality gives some actuaries peace of mind. With open code systems the user has full control over model efficiency; however, it takes a strong programmer to truly optimize model structure and code execution behind the scenes. Clearly, the trade-offs between the two types of systems are significant and the breakdown of efficiency and functionality provides additional fuel to the fire in the debate.

AUDITABILITY AND TRANSPARENCY

The argument surrounding actuarial systems typically involves a discussion on their ability to justify and reconcile results. Whether it is a leadership or auditor request, model reconciliation and policy-level calculation replication using standard tools like MS Excel are common practice in our field. While some products can be easily reconciled by reviewing the mortality and lapse decrements, others are much more complex and involve advanced calculations. Therefore, model auditability and transparency remain important considerations for actuarial modelers and could potentially become a deciding factor for competing priorities. Table 3 provides a comparative view of audit and transparency advantages and disadvantages for open and closed systems that are often part of an actuarial system discussion.

Table 3
Auditability and Transparency: Open/Closed Systems Comparison by Category

Category	Closed Systems	Open Systems	System Selection Considerations
Auditability and transparency of assumptions and calculations	Closed systems allow the customer to extract high-level summaries of assumptions used and some calculated values used in interim calculations. Advantage: Vendors have proactively increased the transparency of the system by creating extracts of assumptions and interim values. Disadvantage: In some closed systems, these summary-level reports would not be sufficient for detail policy reconciliation exercises if they do not show intermediate calculated values.	Open systems offer full control over calculations and the ability to output interim calculated values. Advantage: By allowing full control of calculations, open systems make it easier to reconcile policy-level results and gain full transparency into step-by-step model calculations. Disadvantage: Coding may be required to extract desired values from the calculation sequence.	Model and product complexity Complexity of calculations Uniqueness of product design and level of customization Resource skill and understanding level Actuarial support model (reliance on third parties) Existing documentation of legacy models and products Model testing protocols and reconciliation thresholds

Although it may seem obvious, companies should consider the underlying need for auditability and the level of transparency offered by the actuarial system. The level of comfort around internal methodologies/calculations and corresponding transparency will vary by company and functional area. While closed-system vendors continue to improve model auditability by building in additional reporting tools that report intermediate policy-level calculations in a detailed manner, open systems remain mostly transparent and are often easier to reconcile.

SYSTEM MAINTENANCE

An often overlooked consideration that is extremely critical to the operating model success of an organization and model sustainability is system maintenance. While building a functional and efficient model is an important and complex process, appropriately maintaining the model and the system it resides in is key for model longevity and risk management. Vendors play a big role in system maintenance—they are the ones who continue to improve their respective systems and add functionality to them. They are often the ones who can train modelers or offer consulting services if a certain skill is missing within an organization. Table 4 provides a few aspects of actuarial system maintenance that should be considered when weighing pros and cons of closed and open systems.

Table 4
System Maintenance: Open/Closed Systems Comparison by Category

Category	Closed Systems	Open Systems	System Selection Considerations
User interface	Closed systems have a logical graphic user interface (GUI) built in. Advantage: The GUI makes it easy to navigate through the model, requiring minimal coding. Disadvantage: The GUI presents a risk of inadvertently changing a switch or value in the model.	Varying level of GUI is available in open systems. Advantage: It is more difficult to inadvertently change code since it has predefined syntax. Disadvantage: Less logical code or formula-based environment can be difficult to get accustomed to and in-house expertise will need to be developed and maintained to successfully manage models.	Resource skill and understanding level Model and product complexity Uniqueness of product design and level of customization Available system documentation
Cost and required skills for model maintenance	Since closed systems are more user-friendly, they are easier and less costly to maintain. Maintenance processes can be automated and performed by actuaries and IT teams without requiring system-specific code knowledge. Advantage: Streamlined model maintenance processes can reduce costs and do not require specialized skills. Disadvantage: It is possible to make accidental changes to existing models; for instance, inadvertently changing a drop-down option choice.	Model maintenance processes would require additional coding but can be partially automated. Advantage: Model updates would be thought through in detail as they would need to be specifically coded into the system. Disadvantage: This mostly manual approach can be time-consuming with potential room for human error.	Model and product complexity Resource skill and understanding level Actuarial support model (reliance on third parties) Vendor support model
Key-person risk	Closed models are more standardized across the industry. Advantage: Closed models are easier to understand due to their being generally standardized across the industry, which makes them easier to maintain and modify. Disadvantage: Although easier to understand, closed models present their own unique set of institutional knowledge risk. Parameters can sometimes be cryptic and workarounds incorporated to accommodate rigid aspects of the system.	Intimate understanding of open-system company models remains in-house, not with a vendor or third party. Advantage: Open code is more widely known and does not require system-specific expertise. Disadvantage: Key-person risk potential is increased with open models since only a small group of modelers intimately understand the model and the history of code development.	Model and product complexity Resource skill and understanding level Actuarial support model (reliance on third parties) Vendor support model Knowledge transfer and training protocols Model and product documentation Department size Employee retention

Table 4
System Maintenance: Open/Closed Systems Comparison by Category, *continued*

Category	Closed Systems	Open Systems	System Selection Considerations
Version upgrades	Closed systems allow for vendor-pushed version upgrade. Advantage: For closed systems, version upgrades are automated processes that easily up-convert the model and all its components to the next version. Disadvantage: Thorough model testing would be required to confirm that no unintended impacts affected the model from version conversion.	Open systems allow for vendor-pushed version upgrades. Advantage: For open systems, version upgrades are streamlined processes that compare vendor and company modifications. Disadvantage: Manual comparison of models and merging of vendor and company modifications are required. Often undertaking a version upgrade could pose an insurmountable task.	IT support available Vendor support model Model and product complexity
Vendor role and dependency	Closed-system vendors are highly market focused, implementing new functionality into their systems as regulations evolve and providing customer support for their platforms. Advantage: Vendor support allows closed-system models to be consistent across the industry since vendors typically focus on leading practices while assisting users. Disadvantage: closed-system users are highly dependent on the vendors for available system flexibility and functionality.	Open-system vendors provide various levels of support with the software agreement that include development, upgrade and maintenance support. Advantage: Vendors maintain their standard libraries and out-of-the-box functionality and are available to answer questions on these. Disadvantages: Users are responsible for model build and customization, which can be costly to support as there is no standardized model build. Vendors need to understand customization before they can provide support.	Vendor support model Model and product complexity Resource skill and understanding level Actuarial support model (reliance on third parties) Knowledge transfer and training protocols

Closed systems make it easier for the modelers to maintain models residing in these systems, as part of the responsibility for system maintenance lies with the vendor. Open systems are often more difficult and costly to maintain and update, due to the varying levels of model customization. Additionally, closed systems make it easier for new modelers to become proficient as a result of structure consistency across models, thereby reducing key-person risk. When trying to select between the two systems, understanding the near-term and long-term maintenance implications is critical.

In the previous comparisons, we outlined explicit advantages and disadvantages to both open and closed systems as well as items to consider when going through system selection. With these in mind, the question that will drive the system selection is, at what cost and at what risk to the organization would the company decide on implementation of a particular system, be it open or closed? Both short-term and long-term costs and risks need to be defined and considered at company and functional group level, as these will vary significantly at both levels. In

Several questions need to be considered when navigating competing priorities in open and closed systems:

1. Which functional group or key constituencies need a seat at the table to determine the considerations that need to be addressed (or their priority)?
2. How do you develop an appropriate business case that communicates the priorities that are most relevant to the organization, the complexity of the problem, practical considerations and the ultimate solution to senior leadership and constituents?
3. Which priorities (or issues) are being defined in hopes of developing point solutions versus defining capabilities that need to be addressed for future considerations and requirements?
4. What costs and potential risks could originate from a particular system implementation, both short and long term?

general, short-term costs would be incurred as a result of system implementation and model environment setup, while long-term costs would originate from ongoing model use and maintenance, ad hoc model updates and model validation exercises. These costs would include time and resources resulting from hiring and training talent with specialized system expertise, hiring external consultants to support system implementation, system licensing and potential vendor support costs. Similarly, short-term risks would result from delays and scope creep in system implementation, while long-term risks would include key-person risk, human-error risks, model-complexity risks, risks related to misinterpretation of results and other similar risks resulting from an inadequately governed and maintained model or modeling system that does not satisfy users' business requirements. These business requirements can generally be grouped into four categories, consistent with our comparison earlier in the article, and would require the system of choice to support the following tasks:

1. **Supporting governance.** Creating a controlled modeling environment and enforcing model governance policies
2. **Maximizing efficiency.** Automating processes to reduce model run time and enabling a company to model all of its products and product features
3. **Enhancing transparency.** Providing the ability to clearly identify and review all model components and calculations through auditability functionality of the system
4. **Minimizing costs.** Allowing for implementation of system and model maintenance routines while avoiding additional costs and risks over the model life cycle

Navigating the competing and occasionally conflicting priorities in the system selection journey will remain a challenging exercise for insurance companies. The evolution of systems is somewhat uncertain, but as the trend would indicate, as closed systems become more open and allow for more flexibility, open systems provide more out-of-the-box, locked-in functionality. Undoubtedly, each company will need to decide on the system that best aligns to its needs. Although alignment may vary between groups, we recommend the selection process be rooted in categories that are ultimately relevant to the actuarial organization. These items are increasingly becoming topics that redefine the actuarial operating model to be less involved with routine technical tasks and more focused on result analysis and problem solving. ■

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Adding Value With Model Validation

By Winston Tuner Hall, Michael Minnes and Veltcho Natchev

When we began building models in the 1990s, it would have been more than strange if an actuary or internal auditor showed up at one of our desks and said, "I would like to validate your model. Please provide me access to the model and all the associated documentation that you have for it."

Things have changed.

Model validation is widely viewed as an intrinsic part of a modeling paradigm. Regulators, external auditors and rating agencies all require it and publish guidelines and articles on what model validation means and how it should be performed. However, the only thing that outnumbers published articles on model validation is the various stages of maturity of model validation among companies in the financial services industry.

We are all aware of the advancements in computational power, the ever-increasing complexity of financial products, the evolution of valuation and capital requirements and the high-profile model breakdowns (e.g., lack of a national housing failure stress test) that all worked together to generate this sense of urgency for model validation. This sense of urgency has, of course, found its way into many boardrooms and the directives have been issued: validate all high-risk models in X years and all medium risk models in Y years.

At MassMutual, the development of the strategy and tactics to make this happen is entrusted to us. We are "old-school modelers" who have "seen the light." During our careers as modelers, we were introduced to the model development life cycle, and we were required to document our models and the processes that are supported by them. We have an appreciation for the benefit that a thorough model validation effort can bring to an enterprise, business area and model owner. We also have an appreciation for tact and realize that decrees, ultimatums and an authoritative "just do it" would destroy the type of modeling paradigm a model validation is intended to instill. We see in our work and experiences how model validation efforts have a transformative effect on the culture of an enterprise when it is multipronged, focuses on shared hopes and prioritizes stakeholder buy-in.

In this article, we define what we believe a model validation should entail, the value proposition for stakeholders, the ways in which we gain stakeholder buy-in and how we work with stakeholders to achieve consensus on issues, findings and mitigations. Our objective is a model validation effort resulting in a transformed workforce and organizational culture change from a routine task-oriented, "production" mindset to a "value-add" perspective that is focused on analysis, risk management and continuous improvement.

DEFINITION OF MODEL VALIDATION

The very concept of model validation can have a different meaning to different people, and even modeling experts in various disciplines will have their own interpretations of what a true validation should encompass. Within the life insurance industry, there are multiple definitions of what constitutes a model validation and what objectives it sets to achieve. Some excellent papers on model validation have been published in the past few years:

- "Model Validation for Insurance Enterprise Risk and Capital Models" by M. Stricker, S. Wang and S. Strommen[1]
- "Anatomy of Model Validation Case Study" by M. Guglielmo[2]
- "Did Your Model Tell You All Models are Wrong?" by Systemic Risk of Modelling Working Party at University of Oxford[3]

We used these works to finalize our model validation process. In this paper, however, we want to complement them by discussing how to conduct successful model validations.

We share a holistic view of the goals of model validations as well as the approach to conducting validation efforts. That is, a validation is not just a deep dive into the accuracy of calculations, programming code logic or data inputs, but a comprehensive review of the entire model environment, including all model-related physical components, business processes intrinsic to its ecosystem, model and process documentation, change management process and documentation, model oversight, existing model governance framework and control standards. In addition, our scope of model validation includes the review of the process that was used to develop and implement the model, as well as the artifacts created during its life cycle (e.g., to ensure that it adhered to software development cycle and IT general controls).

The main objectives of a model validation include the testing of a model's conceptual soundness and continued fit for purpose, including identification of potential risks and limitations. These tests must constitute an effective challenge to the existing production model for the benefit of its improvement, risk mitigation and future modeling and validation efforts, and provide comfort and confidence in the model's results to management or recommend changes/enhancements going forward.

Although we advocate a holistic approach to each validation, the efforts should be commensurate with the model's risk. For higher-risk models, especially those with potentially material impact on the organization's financial results or decision-making processes, a validation engagement is an independent deep-dive review and evaluation of the model's environment, design, functionality and compliance with regulatory and business requirements, enabling discovery of actual or potential errors or flaws, as well as identification and quantification of the model's true inherent and residual risks.

Consistent with the three-lines-of-defense (LOD) concept (see Figure 1), we also believe that, where appropriate and feasible, the most effective validation is one that synergizes the efforts and perspectives of the first, second and third LODs and leverages the relative strengths of each of these functions. This is achieved by combining the depth and detail of analysis and recommendations by a model validator who is an independent expert from the second LOD (e.g., an actuary or investment professional who is a member of the risk management organization) with the formalized, disciplined and structured approach to risk mitigation and post-validation follow-up (e.g., remediation based on findings and recommendations) carried out by Internal Audit (a third LOD). Model owners and their peers on the business side (a first LOD) maintain effective controls and implement necessary model and process changes to close out the recommendations and mitigations.

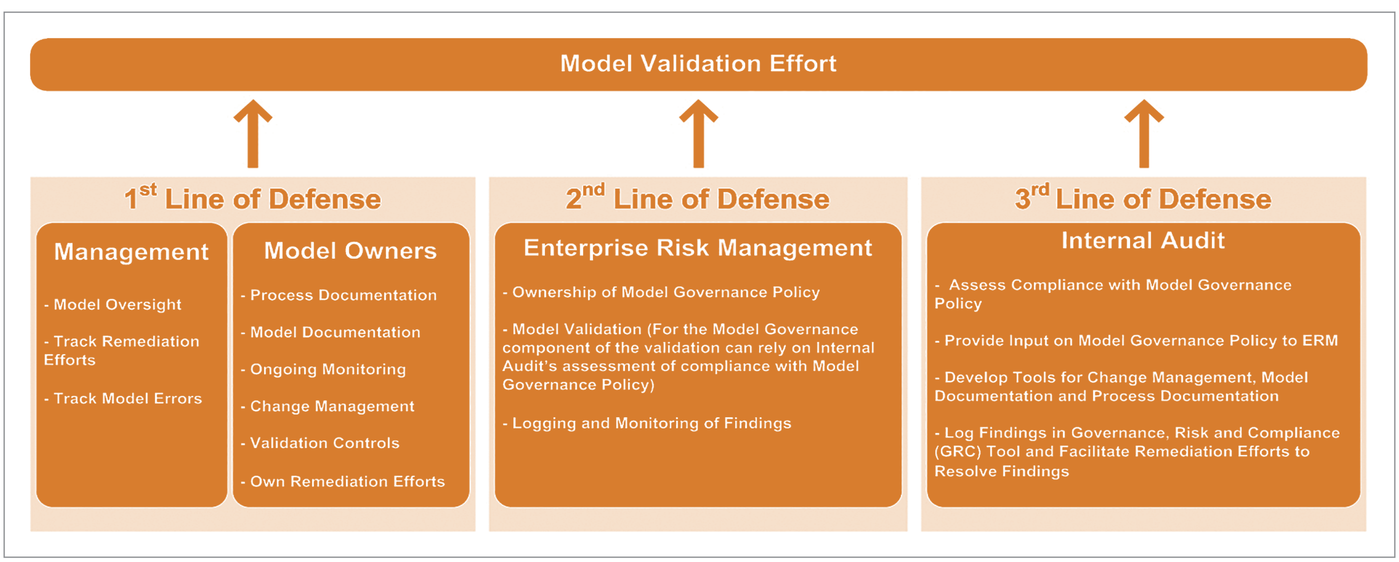
MODEL VALIDATION'S VALUE PROPOSITION

We recognize that model validation is not likely to deliver long-term benefits unless the primary objective for each component is adding stakeholder value. When stakeholders realize value from model validation, they make it a priority. You create value when stakeholders realize benefits that exceed the additional labor and other costs to support the model validation effort. Effecting culture change, mitigating key-person risk and preparing for principle-based reserving (PBR) requirements are benefits that we believe exceed the associated costs and create value for stakeholders.

Effect Culture Change

Our economy is rapidly shifting toward one where automation performs routine, task-oriented work and the workforce must focus on continuous improvement and analysis.[4] You may ask, "How does that affect actuaries?" Automation is already affecting the actuarial profession. Our actuarial workforce has historically focused on production activities like calculating reserves and other financial metrics on a recurring schedule. Actuaries develop models, place them into production and then spend most of their time on routine production tasks like creating in-force files, populating assumptions and aggregating model outputs. A small portion of an actuary's remaining time is available for continuous improvement and analytics. As automation capabilities improve, we expect most production tasks to become automated. Therefore, the actuarial workforce must begin now to shift toward continuous improvement and analysis to prepare for this eventuality. A model validation should initiate this culture change by asking model owners to think about

Figure 1
Three-Lines-of-Defense Concept in Model Validation



their models more analytically and less quantitatively. Do this by challenging model owners to document the model's "fit for purpose," develop ongoing monitoring activities like scenario or stress testing and develop validation controls to demonstrate outputs are generated from approved inputs.

Mitigate Key-Person Risk

As members of second and third lines of defense, we are especially concerned about the preponderance of key-person risk. Key-person risk to us not only includes the risk that business processes may be interrupted due to loss of key personnel but also includes the risk that the control framework for a model is highly dependent on key persons. The former can be mitigated by developing and maintaining adequate model and process documentation. Process documentation mitigates key-person risk when it is complete such that another person with similar access to systems, models and inputs can reproduce the model owner's production results. The latter requires the holistic model validation approach to be fully mitigated. We have validated and audited models that relied on a key person as a compensating control. What does this mean? It means that the model's results were reliable mostly due to the model owner's knowledge and experience with the model. If the model owner was not present, it was likely that the results would not be reliable. Mitigation of this risk can be accomplished when model validation verifies that the model is fit for purpose, confirms presence of controls that evidence accuracy of results, verifies that documentation exists enabling a modeler to use or replicate the model and attests that there is ongoing performance monitoring to establish quality of results.

Mitigating key-person risk should have value to the model owner too. It can be challenging to get the model owner to realize the value in model documentation, process documentation and establishing controls. A model owner that has been the primary or even sole control over a model may see model validation and its requirements as diminishing their value. It is important to have success stories to share with such a model owner. The intent of model validation is not to diminish their perceived value but to unleash their true value. A successful model validation should result in releasing such a model owner from production and shifting to tasks where his or her knowledge and experience can add more value, such as identifying trends in data, optimizing model performance, modernizing the platform and developing projects to support major initiatives (e.g., regulatory development, economic modeling).

Prepare for PBR

PBR is not just about technical changes to the valuation process. PBR requires model owners to describe all material decisions made in complying with the requirements, disclose experience study and assumption governance, and provide descriptions of approaches used to validate models. It is also likely to expect

regulators to request that models be submitted for validation. A model and the model owner will be prepared for this if they have already been through a holistic model validation and the model owner has addressed the issues and findings. Waiting until the first PBR actuarial report needs to be written will require immense struggle and effort to produce all the required documentation and evidence. If a validation effort has not been undertaken, then for some lines of business it may not be possible to comply in a timely fashion.

Balance Costs

Value is created when benefits exceed costs. Costs vary depending on whether the model is in production or in development. We have found that, when development teams involve Internal Audit and Model Validation teams early in the process, the costs can be significantly lower. Internal Audit creates and maintains templates for model documentation, process documentation and change management (project plan, testing strategy, technical documentation and change memorandum). All of the templates comply with the corporation's model governance policy. Audit will advise the development team on how to incorporate the templates into their modeling process and consult on the overall control framework. Model Validation fills a similar advisory role but also focuses on the components of the validation that do not directly involve model governance requirements. There are marginal additional costs to have a development team member document the development process, populate model documentation and interact with Internal Audit and Model Validation.

For models in production, the costs can be significant. For instance, Internal Audit recently began a consultation with a pricing model owner who is working on becoming compliant with the model governance policy. The amount of documentation and number of new controls to be implemented will require most of the model owner's time for two to three months. Some of the additional effort is required because some of the documentation will require locating and researching the original development effort. Documentation is best addressed during development when the information is fresh and the developer is present. Additional effort is required because some of the new controls (e.g., input and output validation) necessitate extracting and transforming model inputs and outputs. Less effort is demanded if specifications for controls are provided during development. A good analogy is wiring a house for high-speed internet. It is much more cost-efficient and requires less labor when the house is wired while it is being built compared to retrofitting an existing building.

Whether in development or in production, the costs are mostly short term, while the benefits are significant and long term. For instance, the pricing model owner can delegate much of the routine production work to actuaries in the student program, which will allow the model owner to address some enhancements and other projects. In addition, if a model is written in an older coding language exposing the area to key-person risk then model documentation will reduce the risk to nominal levels.

OBTAINING STAKEHOLDER SUPPORT AND BUY-IN

Our experience suggests that, in order to perform a successful model validation, the validator is encouraged to obtain support for these efforts and buy-in from all key model stakeholders for the potential value and benefits they can deliver as early in the engagement as possible. This support will increase information sharing by establishing a collaborative atmosphere for interactions between model ownership, business area management and the validator; improve effectiveness of communication across these parties throughout the process; and reduce natural resistance or opposition to the validator's conclusions and recommendations.

Ensure There is Appropriate "Tone at the Top" Regarding Validations

Clear and strong support for the idea of deep-dive validations and commitment to these efforts should be evident all the way up and down the chain of command, including senior leadership and business area management, as well as communicated widely throughout the organization. It is important that all model stakeholders are aware that the company has made a significant investment in the program with time and resources dedicated to conducting model validations. This is achieved by a series of meetings with the stakeholders during which these issues are discussed, as well as assuring stakeholders that the validators understand the extra burden imposed on model owners. Also, the potential risk management benefits from validations should be clearly outlined to illustrate the value that can be delivered to the business areas. This ensures the cooperation by the stakeholders with the validation efforts.

Generate Shared Hopes With All Model Stakeholders About the Process

This can be achieved by developing, communicating and adhering to a consistent set of standards for validation planning, execution and results reporting.

While validation efforts, including resources and time allocation, may vary across engagements (e.g., based on each model's materiality, complexity or availability of documentation), there should be a single scale (e.g., criteria and methodology for score carding) used to evaluate and rate the models across the organization. For example, when assessing a model's fit for purpose or conceptual soundness, apply the same weights for these categories for all models. This will create a consistent mechanism to track post-validation (residual) model risk throughout the company and will also focus management's attention on business areas with elevated risk levels, having the confidence that they have undergone a uniform risk assessment.

> A model validation's objective is *not* to look for a "gotcha" opportunity … but to ultimately provide comfort to stakeholders and identify improvement opportunities.

Build Validator's Credibility With Model Stakeholders

This is especially important with model ownership. Demonstrate their expertise in the model's domain up front, which will contribute to building a stronger credibility for the entire program in the organization. During the initial meetings validators should describe their prior experience with the type of product and/or business process that the model supports, as well as provide professional credentials (and may even share a résumé) during the discussion. However, it is also very important for validators to be honest about any gaps in their experience or theoretical knowledge so that stakeholders can provide appropriate explanations.

Thus, during the discovery phase of the validation, frequent feedback should be solicited from model owners by asking as many questions as necessary to fully understand the model, assumptions and processes—it is better to be repetitious than misunderstand something. Ideally, in the case of hiring new talent for independent model validations, representatives of the model-owning business areas should be involved in the initial interviewing process. This can help garner maximum trust and commitment from these areas by building the sentiment of shared trust of the validator and responsibility for the success of their efforts.

Introduce/Reinforce and Continue Driving Value of "Lines of Defense" Concept

Introducing, reinforcing and continuing to drive the value of the lines of defense concept will help institute or change and promote a culture of risk awareness and responsibility through the ranks of model-owning areas. When meeting with model stakeholders prior to beginning the validation efforts, take the time to explain the reasons for validation, its value and its direct potential benefits to stakeholders in terms of "what's in it for them," in addition to how the company itself will benefit from the project.

Since any model validation is intended as a challenge to the status quo, be prepared for some level of resistance from model ownership or business area management, at least initially. To mitigate resistance, it is useful to describe validation deliverables in terms of comfort they can ultimately provide to model owners by either confirming the model's fit for purpose or recommending changes needed to achieve it. Also demonstrate how the validators can be a valuable partner. For example, every group has projects on the back burner because of lack of resources. However, if the Model Validation team shows support for some of these projects, management may be willing to find resources, especially projects that do not add value to the company if performed by actuaries. One typical example of such process is in-force file creation. Often this is done by actuaries working with data provided by IT. Creation and control of such files are better done by IT, freeing time for actuaries to do more analysis of the results during the reporting period.

Whenever Possible, Avoid Disruption of Business

Communicate up front the desire to avoid disruption in the daily work lives of stakeholders who will be involved in validation efforts (remember that they have deliverables of their own). Often there are system conversions taking place in the business areas, or new models being developed and implemented, which may coincide with the timing of a planned validation. For example, the new VM-20 (addressing PBR methodology) that went into effect in January 2017 for life products will probably impact actuarial reserving areas over the next three years as they update their models to comply with the new regulation. When appropriate, the validator should get involved in the testing of the new model, thus helping the owner as well as delivering on the validation objectives. When timing or resource conflicts arise, the validator is encouraged to revise the timeline if necessary. Any efforts to box the stakeholders into an unachievable deadline should be avoided, as they have their own deliverables and unexpected fire drills. Therefore, validators should ensure considerate and judicious use of the model owner's, users' and other stakeholders' time through maximum possible reliance on own experience, knowledge and efforts.

Create a Collaborative Environment

Create a collaborative environment for the entire engagement among all parties at the very outset. A model validation's objective is *not* to look for a "gotcha" opportunity (e.g., making it a validator's goal to find flaws, errors or deficiencies), but to ultimately provide comfort to stakeholders and identify improvement opportunities. The validator can have several initiation meetings with the model owner to discuss various topics such as modeled risks, compliance with regulations or adopted industry practices embedded in the model, as well as any issues with the model itself. However, these should be intended to provide clarity and direction for the validation, rather than be used to immediately identify and point out potential problems. This approach will help build an atmosphere of trust and set the tone for the entire engagement.

Avoid duplication of efforts with other corporate entities that may be conducting parallel efforts in the same business area and even touching the same model. This will reduce the burden on the model owners and area management and eliminate the need for them to answer the same questions multiple times. In addition, model validators can potentially rely on the information (including documentation) obtained by other units reviewing the model and its environment. For example, findings and recommendations generated by Internal Audit can be referenced and/or incorporated into the validation report. It is essential, therefore, for the validator to be fully aware of all the activities taking place in the model area during the validation project, including internal and external audits, and to agree on the scope of work for each party prior to kicking off the validation activities. It is also important to communicate the scope of each function's involvement to the model stakeholders and assuage any anxiety they may have about possible undue burdens.

If an escalation is needed due to an impasse, such as a disagreement between the validator and model ownership over a finding or recommendation for mitigation, remediation or improvement, make sure that you follow the proper hierarchy of escalation. This mechanism should be agreed on and put in place up front by all stakeholders during the planning stage of the validation engagement, which will help avoid future conflicts. At the same time, a mechanism for "risk acceptance" by model owners and business area management should also be established early in the process. That is, if there is a finding or recommendation for changes that, after escalation and review by management, results in an unresolvable disagreement between their and the validator's opinion, owners and management agree to accept the risk and live with consequences of not instituting proposed changes. This should be done through a predefined process, with sign-offs by all appropriate risk-accepting parties.

ACHIEVING CONSENSUS: ISSUES, MITIGATIONS AND FINDINGS

We believe that to ensure a beneficial impact and tangible results from a model validation, it is important for the validator to achieve consensus, where possible and appropriate, on findings and potential recommended mitigations with model stakeholders. This will help with the entire follow-up process, including verification that remediations have been implemented in a timely manner and in accordance with the recommended approach. To help with a smooth transition to the post-validation period and its successful outcome, several steps should be taken throughout the validation project:

- Build model trust, confidence and comfort through statements of confirmation (e.g., model validity, appropriateness, strong points) and/or actionable and implementable recommendations for mitigation or improvement. It does not make sense to recommend changes that, a priori, cannot be realized due to company policies, technical limitations or other factors. For example, recommending a full-blown regression testing for AG43 CTE(70) calculations is generally not feasible because of the number of scenarios involved. However, the validator can help the owner to pick several (between 3 and 10) scenarios on which regression testing can be performed.
- Maintain stakeholders' goodwill by driving and managing project deliverables and communication through appropriate channels (e.g., do not point out any discovered errors or inefficiencies to management before presenting findings to the model owner). The validator should discuss all findings with the model owner, because sometimes the validator may be wrong about an error and sometimes the error is in the model because of system limitations. For example, the annuitization benefit stream may be excluded from the BAR calculations. This should be OK for CFT or C3P1 models because of immateriality; however, it would be wrong in AG43 models.
- Deliver full transparency of all validation efforts through frequent communication throughout the validation engagement. There should be no surprises in the final report. Ensure consistent communication of objectives to all stakeholders and avoid conflicts due to misunderstandings. Ensure that the final objective is independent, fair and documented in an unbiased model validation report.
- Build reliance on the validator's opinion by only presenting actionable (i.e., realistic and implementable) recommendations. Variable annuity hedging is a very complicated process. AG43 models often simplify the hedging in order to save time. In such cases, the modeler should discuss appropriate changes to the hedging that will improve the model's results without making the cost of running it prohibitive.
- Provide a fully documented and shareable record of all steps taken to validate the model. It should include a comprehensive final model validation report containing feasible, practical and actionable recommendations in line with industry best practices.
- Ensure stakeholders' involvement with proposing recommendations for remediation, enhancements, process improvements and implementation of best practices. Soliciting opinions on mitigation and process improvements will empower stakeholders and help with buy-in.
- Be prepared for dealing with a "we have always done it this way" attitude. Recommendations should focus on improvement rather than disruption of existing processes; recommendations should be framed as mutual benefits for all stakeholders, business processes and the organization as a whole. Be skeptical of responses such as "it is company policy." The policy may have existed at the time of model development but may have changed over time and without being reflected in the model's functionality. Often during conversions full assumptions testing is not done; it was seen as unnecessary since the results "matched our expectations" or "we validated them visually." The validator should stress the need for thorough testing and, if needed, help the model owner to set up such process.

Use model validation to help transform your company's culture from a routine task-oriented one to a value-add and analytical one.

It may be prudent to establish a mechanism whereby Internal Audit takes an active part in managing post-validation deliverables, as they often have the infrastructure and tools to track and guide post-audit actions. Model governance should play the main role, however, in tracking major themes emerging from validations and providing communication among business areas if common threads (e.g., trends) are observed or new ones are emerging. This may help streamline mitigation efforts and achieve consistency (e.g., identify common assumptions that can be single-sourced by multiple areas, if feasible, or frequently repeating failures, errors or issues, which may be an indication of a larger systemic problem).

Put together detailed post-validation risk mitigation, remediation and improvement plans and obtain full sign-offs from all stakeholders; implementation of mitigations and recommendations should be carefully managed, with clearly identified deliverables, timelines, follow-ups and communication. Validation should also be followed up with education and socialization of learnings throughout relevant business areas and establish framework for future validation efforts.

WHAT SHOULD YOU DO?

Is there a sense of urgency around model validation at your company? Consider the value that can be added by undertaking a holistic model validation approach led by people who have an appreciation for how it can add value and are familiar with the development life cycle and model governance. Leverage your current workforce and utilize a multipronged effort among first, second and third lines of defense. Do not dampen long-term benefits by using the authority you have most likely been given to tell validators and model owners to "just do it." Instead, establish shared hopes to drive results.

Most of all consider how the number of routine jobs in our economy is decreasing and use model validation to help transform your company's culture from a routine task-oriented one to a value-add and analytical one.

At MassMutual, we embraced the holistic approach to model validation, and the first, second and third LODs work collaboratively. The second LOD (risk management) and the third LOD (audit) work in unison to assess compliance with model governance policy and assist model owners in getting into compliance. The first LOD (model owners) realizes that the components required by a model validation can best be addressed during the development phase and seeks out our involvement in model conversions and development projects. Model validation is no longer being viewed as "overhead" but as something that adds value. ■

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Long-Term Care Modeling, Part 2: First-Principles Modeling

By Linda Chow, Jeremy Levitt, Yuan Yuan and Laura Donnelly

In the first installment of our three-part series (published in the December 2016 issue of *The Modeling Platform*), we provided an overview of long-term care (LTC) modeling and compared a claims cost approach with a first-principles approach. In this installment, we dive deeper into first-principles modeling for LTC. First-principles modeling is both more sophisticated and more challenging than a claims cost approach. There should be careful planning around model architecture and design, implementation, testing, validation and model maintenance from both a technical and an operational perspective.

MOTIVATION FOR FIRST-PRINCIPLES MODELS

The decision to convert to a first-principles model will depend on the merits of the advantages relative to the disadvantages, set out in Table 1.

BUSINESS SITUATIONS THAT MOTIVATE FIRST-PRINCIPLES MODELING

A good actuarial model is likely to improve management's understanding of their business, lead to better decision making and ultimately boost the financial health of the organization. This is because an actuarial model is a fundamental tool enabling senior management to monitor the financial status of the business and to gain insights not easily obtainable otherwise. The following business situations illustrate the value of a robust LTC first-principles model.

- **Management attempts to improve their understanding of LTC experience drivers to ensure that a closed block of business continues to break even.** A closed block of business that generates losses is undesirable. This could be addressed by improving the actuarial reporting and modeling capabilities using a first-principles model. Since the current claims cost framework utilizes existing industry claims cost tables, a company's experience drivers may not be accurately reflected within the source of earnings analysis. Implementing a first-principles structure tailored to the company's claims incurred, emergence and recovery pattern enables greater granularity and higher accuracy.

- **Companies look to enhance their enterprise risk management and control effectiveness.** A claims cost approach involves a high level of manual adjustments and regular calculations of tables that are used in the models. To reduce key-person risk and increase effectiveness of input controls,

Table 1
Deciding Whether to Convert to a First-Principles Model

Advantages	Disadvantages
More granular approach (tracking status of policyholders) facilitates better understanding of the financial drivers of results and appreciation of in-force movement	Greater complexity and computing power are required to implement and support a first-principles model
More direct sensitivity testing, for example, negates the need to go through regeneration of claims cost tables	First-principles model is more difficult and time-consuming to audit or maintain due to higher complexity
Greater consistency, streamlining of assumptions and more efficient implementation of assumption changes reduce issues associated with more traditional approaches, e.g., manually estimating claims cost	Challenges emerge in conversion to first-principles approach, such as recalculation of in-force reserves that were ascertained on a claims cost basis and the redesign of assumption tables
Users are able to calculate paid claims and decrement simultaneously, without pre-generation of payment pattern inputs	Greater focus on, and understanding of, assumptions are required for model operators (relative to claims cost table-based model)
Drivers of discrepancies in excess of materiality thresholds can be easier to identify	First-principles model requires more granular experience studies to be performed for accurate component assumption setting, which may not be available

first-principles modeling automates the data and assumption loading procedure and lowers the requirement for additional actuarial support, boosting efficiency.

- **Companies wish to improve pricing model capabilities.** Companies may benefit from adopting a first-principles approach to their pricing modeling framework to increase sophistication and modeling accuracy. For example, a stochastic first-principles pricing model allows for the generation of a full distribution of scenarios, such as the 95th percentile. This broadens the risk management capabilities of the company. Financial results can be measured with greater detail and accuracy on new and in-force business blocks, facilitating better business decision making.
- **Companies engaging in merger or acquisition activities.** There has been increasing activity in the market for selling closed LTC blocks of business. For a potential merger or acquisition, a first-principles model could be adopted by both sides of the transaction to ensure a fair and appropriate price range. On the sell side, companies may use a first-principles model to prepare for experience analyses, actuarial financial projections and the appraisal model development. On the buy side, in instances when the potential buyer believes the seller's model is not desirable or practical, a robust first-principles model may be helpful.
- **Companies wish to synchronize modeling approaches and increase modeling robustness.** Companies that have already converted to a first-principles modeling approach on their in-force block of business or pricing practice may now wish to synchronize their new-business modeling approach for consistency. In addition, companies may benefit from adopting a first-principles approach in order to have a more robust financial reporting capability. In particular, a first-principles approach lends itself to analyzing financial results by segment. This enhances management's ability to understand the drivers of results and increases consistency with existing models (e.g., consistency of in-force models with cash-flow projection models that have already been converted to first principles).

FIRST-PRINCIPLES MODELING LEADING PRACTICES: KEY CONSIDERATIONS

In setting up a first-principles model, an actuary should keep in mind the primary technical perspectives. They include, but are not limited to, the following leading modeling practices related to model architecture, conversion methodology and assumption development.

Financial Model Architecture

A company must consider numerous factors when selecting modeling software. Among them are type of system, single vs.

multiple modeling platforms, level of granularity, reinsurance model, and handling of riders, miscellaneous benefits and manual adjustments.

Type of System

This refers to whether a modeling software is designed to be an open system or a closed system. An open system allows for user customizations, which calls for tighter model governance and controls. A closed system has a defined system code that cannot be easily modified by users and, therefore, requires less formal governance. For example, in pricing new products, most actuaries would prefer an open system, as it offers customization flexibility to capture new product features, while a closed system may be preferable for a stable closed block.

Single vs. Multiple Modeling Platforms

Depending on the actuarial organization structure and the age of product, a company may find it has multiple modeling platforms to meet its business needs of each actuarial functional area. Alternatively, they may use, or strive to consolidate to, a single modeling platform that supports various business units, including valuation, forecasting, year-end testing and rate increases.

Level of Granularity

The level of granularity supported by the model can range from seriatim level to group level. This will largely be driven by how the assumptions vary and are applied in each model, how the experience analysis model must be set up to support the financial model, the input data table structure and the desired segmentation of financial analysis.

Reinsurance Model Consideration

Depending on the complexity and the type of the reinsurance treaties, companies may model their reinsurance in either separate models or the same model. A one-model approach is usually more appropriate for coinsurance types of treaties, while a separate-model approach would be more applicable if separated premiums and assumption structures are negotiated under the reinsurance treaties.

Handling of Riders, Miscellaneous Benefits and Manual Adjustments

Historically, in modeling riders and miscellaneous benefits under a claims cost model, most companies have used simplified approaches, including (1) applying factors to the base claims cost assumption or (2) making topside adjustments. The decision to use a simplified approach is primarily due to companies' concerns about the complexity in modeling riders or benefits that produce only a small financial impact. The improvement of computational power and the robust calculation capability under a first-principles model has definitely improved companies' abilities to model many of the riders and benefits. Companies should carefully contemplate future sales expectations, financial impacts, product portfolio and marketing focus among other factors when deciding what should or should not be modeled.

In addition, the current modeling environment may require a variety of manual interventions and adjustments to determine the reported results. The modeling software chosen should be sufficiently flexible to incorporate these manual adjustments as automatic features, thereby reducing the amount of manual work required in the modeling process. This is an important consideration, as eliminating or reducing manual adjustments increases efficiency, lessens reliance on resources, speeds processing and increases accuracy.

Conversion Methodology

Once a decision is made on the system architecture, another key decision is which model conversion/implementation approach to employ.

Conversion of Different Accounting Bases and Order

Different accounting bases and order, such as best estimate, statutory/tax, and U.S. generally accepted accounting principles (GAAP), are used in LTC financial models to support a wide array of business and financial analysis activities. A company may set up separate models to support different business applications to accommodate a variety of actuarial concepts and assumption structures. In choosing the order of conversions for the various models, consideration should be given to which business activities would benefit the most from the conversion.

For example, LTC companies with first-principles models have chosen to convert the cash-flow projection model before converting their reserving models. A first-principles cash-flow projection model provides management with the benefits of robust reporting and analysis capability (e.g., better understanding of the emerging claims incidence by care location, recovery and disabled death pattern). However, most of these companies believe the benefits of a first-principles approach are somewhat diminished when it comes to reserving, as reserving assumptions and methodologies are either locked in or prescribed. If the pre-converted reserving models are set up correctly, the post-converted models should produce exactly the same results. As alluded to in the business cases earlier in this article, if the existing reserving models are set up on a group basis that does not provide much flexibility to analyze financial results by segment, a conversion to a first-principles reserving approach would be a natural step following the conversion of the cash-flow model.

Implementation Steps

Many carriers have used a multistep "walk" approach during the conversion process. A "walk" approach enables carriers to discover errors from existing models, explain differences and understand movements. Here are a few different "walk" examples:

- **Example 1.** Company 1's pre-converted models were on a total lives claims cost basis. The approach that Company 1 has used was to first convert from a total lives claims cost model to a total lives interim first-principles model, then from a total lives interim first-principles model to a healthy lives first-principles model (two "walk" steps). The total lives interim first-principles model would enable the modeler to (1) verify that the claim assumptions are being decomposed correctly and accurately, as the only change made is the decomposing of the claims cost into its components (incidence, termination and utilization); and (2) to detect any issues that may exist in the claims cost mechanics of either the pre-converted model or the post-converted model. If both models and assumptions are handled appropriately, the results from both models should match very closely, as there are virtually no changes made besides decomposing the claims cost assumption.
- **Example 2.** Similar to Company 1, Company 2's existing models also use total lives claims cost. Company 2 first "walked" its total lives claims cost models to healthy lives claims cost and then performed another "walk" from healthy lives claims cost model to the final first-principles model. This interim step enabled the company to derive a set of interim healthy claims costs that later could be used to verify the converted healthy first-principles model claims costs. It also enables Company 2 to appreciate the impact of converting from total lives to healthy lives in isolation of the claims cost decomposition impact.

Either approach mentioned here increases the companies' abilities to identify errors and analyze results, which will result in much more reliable models. This benefit usually exceeds the cost of the additional effort.

Assumption Development

Key assumptions for the long-term care business include mortality rates, lapse rates and morbidity (e.g., incidence rates, underwriting selection factors, termination rates, utilization factors and morbidity improvements). The common assumption bases include best estimate, statutory and GAAP.

Best Estimate Assumptions

Conversion of the best estimate assumption has a multidimensional impact: (1) the use of implied assumptions vs. derived assumptions; (2) consideration of the morbidity assumptions; and (3) preservation of mortality.

The Use of Implied Assumptions vs. Derived Assumptions. In converting best estimate assumptions, many companies have considered the choice of implied assumptions vs. derived assumptions. To avoid an abrupt change to the projection results, some companies have elected to first calculate a set of morbidity assumptions by decomposing their existing claims costs into incidence rates, termination rates and utilization factors. If all existing claims cost generators are error-free, the converted claims cost using the "implied" assumptions should match the pre-converted claims cost. However, many legacy models historically use total lives claims cost, and while decomposing claims cost may seem as easy as a pure mathematical exercise, actuaries should carefully contemplate the conceptual implications of such calculations. For example, do the relative sizes of the post-converted claims cost components make sense? Are they really an appropriate representation of the healthy lives basis claims cost? For example, a company may have previously used a set of J factors (ratios of non-claimant exposure to total exposure) to help bridge the gap between total exposure and total lives claims cost. These J factors may have varied by policy characteristic. The implied healthy lives claims cost would, therefore, vary by benefit period (product of total lives claims cost and J factors). A technical check may not show any issues with this approach, but conceptually, is the converted claims cost appropriate?

For companies with frequently updated experience studies and well-maintained and robust assumptions, it may be intuitive to simply use a set of derived assumptions (e.g., incidence rates, termination rates and utilizations) based on the latest experience study. With this approach, companies should still make sure that the pre-converted and the post-converted claims cost match at the conversion date and into the future.

Regardless of which approach a company uses, the experience analysis framework should be structured consistently so that post-converted models can be validated periodically.

Consideration of the Morbidity Assumptions. As stated earlier, first-principles morbidity assumptions include incidence, terminations (which can be further decomposed into recoveries and disabled deaths) and utilizations. Key morbidity assumption conversion considerations include (1) ensuring no erroneous subsidies/shifts among incidence, termination and utilizations during the decomposition; (2) confirming factors and adjustments, if any, are being interpreted properly and converted accurately (for example, how should the adjustments be qualified? Should they be decomposed to have implication on incidence rates, termination rates and utilizations?); (3) verifying the original termination assumptions are preserved after being decomposed into recoveries and disabled deaths; and (4) accounting for any morbidity improvements and if they should be reconsidered separately for incidence and terminations.

Preservation of Mortality. Historically, most models use total lives mortality. This is mostly due to system and data limitations in the LTC industry.

A first-principles model is able to keep track of and, therefore, require separate mortality assumptions for healthy lives vs. disabled lives. Depending on data credibility and granularity of the experience analysis model, companies could use various approaches to develop their mortality assumptions. For example, (1) maintain existing total life assumptions, develop a set of disabled life mortality assumptions and calculate a set of implied healthy lives mortality; or (2) separately develop the mortality assumptions for healthy lives and total lives.

During the conversion, it's important that the actuary makes sure the number of total deaths is preserved (e.g., the sum of healthy deaths and disabled deaths should equal the total deaths implied by the original total lives mortality assumptions). This is referred to as preservation of mortality. Table 2 illustrates how the preservation of mortality could be violated. Model validation and assumption calibration are common approaches to correct for any violations discovered during model validation.

Table 2
Example of How Preservation of Mortality Could be Violated

Year	Assumptions	Results
x	Total life mortality rate = 0.01 Incidence rate = 0.01 Disabled life mortality rate = 0.15 10,000 lives	Total deaths = 10 (1,000 × 0.01) Disabled lives = 10 (1,000 × 0.01) Disabled deaths = 1.5 (10 × 0.15) Expect 8.5 active deaths (10 total deaths − 1.5 disabled deaths) Mortality rate for active lives = 8.5/990 = 0.008596
y	Total life mortality rate = 0.04 Incidence rate = 0.12 Disabled life mortality rate = 0.15 700 active lives 150 disabled lives	Total deaths = 34 [(700 + 150) × 0.04] New disabled lives = 84 (700 × 0.12) Disabled deaths = (150 + 84) × 0.15 = 35.1 Expect −1.1 active deaths (34 total deaths − 35.1 disabled deaths) Observe that expected active deaths is negative, which is not plausible Preservation of mortality does not hold

Statutory Assumptions

In converting National Assocation of Insurance Commissioners (NAIC) reserves to a first-principles approach, major challenges to companies include the following:

1. Interpretation of the minimum reserve requirement. For financial reporting purposes, companies are required to hold reserves at or above the minimum statutory reserve levels, regardless of the approach used. However, there have been different interpretations in terms of whether the minimum reserve requirement should be applied in aggregate or at an individual policy level.
2. Interpretation of the model regulation and deciding the treatment on their NAIC valuation mortality, lapse and morbidity assumptions for the healthy lives and disabled lives.
3. Ensuring that the pre-converted projected reserves and the post-converted projected reserves match at time zero and going forward.

The statutory reserve basis cannot be changed after a policy is issued unless regulatory approval is obtained. When the regulation was written, a first-principles reserving model did not exist. Therefore, the regulation remains silent in terms of the separation of the mortality rates into healthy mortality and disabled mortality.

The following list provides some sample approaches that companies have considered in handling the NAIC model regulation during the conversion:

- **Example 1.** Treat the prescribed mortality table as the healthy life mortality table. Since the regulation remains silent about disabled mortality, a set of disabled life mortality table rates developed from the company's own experience is used.
- **Example 2.** Treat the prescribed mortality table as the total mortality table, separately develop a disabled life mortality table and calculate a set of implied healthy mortality rates.
- **Example 3.** Ensure that the total prescribed policy termination does not change before and after the conversion. Develop a separate disabled life mortality table solely for the purpose of separating claim termination rates into disabled deaths and recoveries.

The regulation also doesn't address the decomposition of the claims cost tables. The statutory reserving basis is not supposed to change post policy issuance. The reserving model regulation doesn't prescribe any standard morbidity tables. For many companies' older policies, the NAIC morbidity reserving assumptions are based on their original pricing claims costs. Some of these pricing assumptions were created when the policies were first issued (e.g., more than two decades ago). It, therefore, would be difficult for companies to track down the claims cost components. The separation of these claims costs into the different components would, therefore, become arbitrary.

Companies have considered these two approaches:

- Use morbidity assumptions from similar policy forms for which the morbidity components are identifiable and calibrate to the converted claims cost in order to match the reserves, net premiums and/or claims cost.
- Develop a set of average-length stay of proxy and apply it to the original claims cost to back into other components of the claims cost assumptions (e.g., incidence rates).

Regardless of which approach is used to handle the issues outlined here, the post-converted reserves should match the pre-converted reserves as of the conversion date and into the future, unless errors were discovered and corrections must be made to the pre-converted model. Any reserve comparison divergence into the future should be based on reason.

Finally, it's important for management to ensure that the regulator's approval is obtained for any key methodology and assumption changes.

GAAP Assumptions

The handling of the GAAP reserve conversions is similar to the handling of the NAIC reserve conversions in that the GAAP assumptions shall be "locked in" per GAAP accounting requirements under ASC 944-60 (formerly FAS 60). During a conversion process, the "locked in" concept is challenged because claims costs are decomposed, and mortality and lapses often need to be redefined on a healthy lives basis as opposed to total lives basis. The general approaches that companies have taken are to ensure that the claims costs calculated by the first-principles model match those from the pre-converted model and that the projected reserves match reasonably well as of the converted date and into the future. Any changes to the reserves due to error discovered during the conversion should be fully disclosed.

If the Financial Accounting Standards Board's (FASB) proposed Accounting Standards Update is approved, companies will be required to update their assumptions annually. If planned carefully between model conversion and assumption analysis, the concept of "locked in" would become a moot point in this situation.

Assumption Governance and Maintenance of Assumptions

Regardless of the assumption basis, it is important to consider the governance structure in place for assumptions on a first-principles LTC model. A comprehensive governance framework would typically entail multiple levels of committee review and approval, taking into account differences in the various assumptions used in a first-principles LTC model. In addition, a centralized assumptions review and governance committee may be required in order to promote consistency of assumptions used for the LTC model and those for other business lines. High-functioning assumption governance committees typically have adequate stakeholder representation to prevent the assumption-setting process from being disproportionately impacted by a particular group. The assumption-setting process, review, approval and final basis should be adequately documented, regardless of the complexity of the business and associated modeling framework. Details of assumption governance and control will be further discussed in the third installment of this article series.

VALIDATION AND TESTING

Generally speaking, model conversion is usually a significant effort involving many functional areas, such as data warehousing, actuarial assumption setting, experience studies and actuarial modeling. After the conversion, it is crucial to ensure that there is still close integration of all components and that there is compliance with company-wide governance policies. This can be accomplished through model validation procedures and testing.

As discussed in the first part of the series, a model validation process should at minimum include model verification, model fitting and user acceptance testing. A test plan helps guide the model developer, tester and end user to track the status of model validation. These concepts generally apply to a first-principles modeling approach but with specific caveats in such a complex situation.

During the model verification step, a modeling expert would ask if validation criteria were set with sufficient granularity and in a way that captures the company's goals. The questions to ask include (but are not limited to) the following: Is the design of the model aligned with the company's objectives and goals? Did the modeling team ensure that the models are producing reasonably close results for premiums, claims and expenses? Were significant components of the models compared, and were differences attributed to the key changes made?

Similarly, when evaluating model fit, there are many questions to ask and considerations to be made. Users should check if the initial data align reasonably with historical data and if there is a smooth transition between experience and projected data. The model's limitations should be documented, and model experts should understand their impacts on results. As experience emerges, users should confirm if backtesting indicates a reasonable fit of the model to the data.

Finally, the model users should evaluate the converted model's robustness and performance relative to expectations. They will want to confirm that the model still performs as expected when certain assumptions are stressed and that data inputs are accurately captured within the model. The users should understand any modifications that must be made to model outputs. Additionally, the model's run time, efficiency and processing should be reasonable from the viewpoint of the model users.

There are many considerations in validating a converted model. While it is generally the last step during a conversion project, it is arguably the most essential to ensure that an effective model is put into production. When specifically applying these steps to LTC models, there are certain comparison items between the pre-converted model and the post-converted model that should be considered:

1. Pre-converted claims cost and post-converted claims cost (should match at the conversion date)
2. The projected cash flows
3. The projected lives by cohort (e.g., healthy and disabled versus total, disabled lives by care location, number of recoveries and disabled deaths versus number of terminations)
4. The average reserve factors
5. The pre-converted net premium and post-converted net premium
6. The projected reserves at the conversion date and into the future

The details of each of these will be discussed in our next article.

CONCLUSION

First-principles modeling of LTC products is a complicated task, requiring careful planning and foresight. We have highlighted important aspects to consider with respect to a first-principles LTC model, including model architecture, conversion methodologies and assumption-setting processes. These considerations impact the potential model uses, spanning a wide spectrum from valuation such as GAAP and statutory reserving to actuarial and financial projections, including cash-flow testing and asset liability modeling. Model validation will also play a crucial role in the conversion process by ensuring robustness and goodness of fit. Owing to the potentially significant impact of the choice between first-principles and claims cost models, the decision regarding whether to convert should not be taken lightly. ■

The views expressed are those of the authors and do not necessarily reflect the views of any member firm of the global EY organization.

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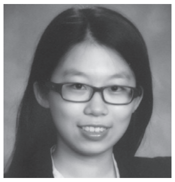

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