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June Webinar Topic: Sensitivity Testing and Setting Margins, Plus a Fully Stochastic PBR Method

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In following the development of principle-based reserve (PBR) requirements from its early days, it seemed that the overall goal was to embed risk analysis in the calculation of reserves. Some referred to this objective as "right-sizing reserves," in the sense that reserves would more accurately reflect the risk profiles of product liabilities and the assets supporting them. PBR would be the logical next step in the evolution of asset adequacy analysis. Different product types could be evaluated based more on risk characteristics and not on the name or category of the product, creating a more level playing field across products based on risk. In such an environment, product development would flourish with new benefits and combinations of benefits. Regulators could more easily keep up with how the reserves of new products should be determined.

Of course, this "win-win" view of the future has not fully developed yet. Complications introduced into the Valuation Manual have reflected regulatory concerns about the subjective nature of the assumption-setting and margin-setting processes. Support for changes to nonforfeiture requirements has generally been less than enthusiastic, perhaps partly because of the uncertainty about the treatment of "in-kind" nonforfeiture benefits in Sections 7702 and 7702A, as well as tax reserve calculations. In any event, the path to today's Valuation Manual has been lengthy and at times difficult. The good news is that the original objective of calculating statutory reserves based on the risk profile of a block of business is still achievable in fulfilling VM-20 reserve requirements. This article summarizes a methodology for identifying and quantifying material risks and calculating PBR margins as presented in a June Society of Actuaries (SOA) webinar and describes a methodology for PBR calculations that are principle-based in the spirit of PBR's original purposes.

SENSITIVITY TESTING AND SETTING MARGINS

Let's start with the subject of the June SOA webinar: sensitivity testing and setting margins. Sensitivity testing has long been a useful tool to identify material assumptions in actuarial models. But if you take the next step and select sensitivity tests at specified probability levels, you could use the sensitivity testing results in additional ways, including setting margins for PBR and calculating target surplus based on the specific risk profile of a block of business.

Under PBR, margins must be established that provide both for moderately adverse deviations from anticipated experience and for the risk that the anticipated experience has been set incorrectly (parameter risk). The greater the degree of sensitivity of the results to variations in a material assumption, the more rigorous the analysis of both the relevant experience underlying the assumption and the margin established in setting the PBR prudent estimate assumption for that risk factor should be. A change in the method for calculating margins must be documented in the PBR actuarial report.

The SOA has sponsored a research project for testing PBR simplified methods. One of the key deliverables from this project is the development of a multi-risk scenario generator. This generator incorporates the economic scenario generator used for VM-20. The generator used for VM-20 is currently hosted by the SOA, but was developed by an American Academy of Actuaries work group. When the multi-risk scenario generator is finished, it will be available from the SOA at no cost. The generator can produce vectors of actual to expected (A/E) ratios, also called actual to tabular (A/T) ratios, for material risk factors based on knowing the following information for each such risk factor:

1. The anticipated experience assumption, normally in the form of a table of decrement rates
2. Experience study data for a one-year period in the form of:
    a. The number of contracts exposed
    b. The number of events (decrements) observed
    c. The A/T ratio between the observed experience and the table from number 1
3. When experience study data are not available, a user-defined distribution for the A/T ratio

With this information, the generator can produce deterministic scenarios for each material risk at a moderately adverse level of the 84th percentile of the distribution or at an extremely adverse level of the 99th percentile. (The 84th percentile of the distribution of the present value of future cash flows is

considered to be approximately the same level of conservatism as CTE 70, the level specified for statutory reserves.) The generator can also produce "fully stochastic" scenarios in which all the material risks vary at the same time. There is one caveat: some assumption types are better handled through dynamic functions than by A/E ratios (such as flexible premiums).

How would you use the generator to apply margins to the material anticipated experience assumptions for a block of business, thus producing the prudent estimate assumptions required by the PBR Valuation Manual? Recall first that margins are only required on material assumptions where variations in those assumptions would have a significant impact on the reserve. Consider the following steps:

1. Using professional actuarial judgment, propose material risks for each product type under consideration and perform initial sensitivity tests to assess the degree of sensitivity. VM-20 provides a starting point of possible material risks to consider: mortality, morbidity, interest, equity returns, expenses, lapses, partial withdrawals, loans and option elections.

2. Identify relevant company and industry experience for each material risk and perform experience studies. Finding relevant industry experience to supplement relevant company experience for a risk factor can increase the credibility of that experience and reduce the margins required in the reserve calculations for the deterministic reserve and stochastic reserve in VM-20. Note that traditional experience studies may not have identified all significant predictors of experience for a risk factor. Additional significant predictors may include product design elements, distribution channel characteristics, target markets and scenario-dependent in-the-moneyness of benefits. In making the case for the relevance of industry experience to company experience, consideration of all the significant predictors of experience should be included in the analysis. Data aggregators—such as LIMRA, MIB and some reinsurers—are aware of the need to provide relevant industry experience to companies and are working on developing enhanced experience studies that will help companies identify industry experience that would be relevant to their own experience.

3. Set assumptions without margins, or the anticipated experience assumptions.

4. Calculate A/E ratios for the material risks where the relevant historical experience is the numerator and the anticipated experience assumption is the denominator.

5. Develop moderately adverse sensitivity tests (vectors of A/E ratios) for each product type using the multi-risk scenario generator and comparing against historical variations in the A/E ratios. Note that for certain assumptions, such as lapse, you would need to test which direction is adverse.

6. Use the moderately adverse sensitivity tests to confirm the material risks and rank the material risks for each product type.

7. Use the ranking of material risks and the magnitude of those risks to determine blocks of business with similar risk profiles.

8. Calculate the aggregate risk margin, adjusted for covariance, for each group of policies with a similar risk profile.

9. Per VM-20, aggregate the results of the blocks of business into term, universal life with secondary guarantees (ULSG) and other life. This aggregation allows you to offset cash flows and will result in reduced aggregate margins. Calculating material risk amounts and aggregate margins at both

Table 1
Margin and Modeled Reserve Calculations

	2016	2022
Natural Reserve = Central Estimate Reserve	**–4,309,748**	**113,788,808**
84th Percentile Risk Amounts:		
D = Default cost	2,942,409	2,965,812
I = Interest	8,346,500	4,003,348
L = Lapse	846,994	4,788,541
Mf = Mortality fluctuation	5,533,611	5,058,862
Mt = Mortality trend	14,990,356	8,555,984
Sum of 84th Percentile Risk Amounts	32,659,870	25,372,548
Percentile margin (adjusted for covariance)	**18,285,810**	**12,105,780**
Modeled Reserve = Natural Res + Pctile Margin	**13,976,062**	**125,894,588**
Margin if mortality and lapse are dependent	*18,540,354*	*13,964,206*
Percentile Margin = sqrt(D^2 + I^2 + L^2 + Mf^2 + Mt^2) *If Mf and L are dependent, then Percentile Margin = sqrt(D^2 + I^2 + (L+Mf)^2 +Mt^2)*		

the block of business and aggregated levels permits the calculation of the "product hedge" that results from having diversified-risk product liabilities.

10. Attribute the aggregate margin (adjusted for covariance) of the aggregated blocks of business to the anticipated experience assumption for each material risk. There is no elegant mathematical solution to attribute the aggregate margin to individual risks. If you have used the square root formula to calculate the aggregate margin and adjust for covariance (see the numeric example that follows), then one approach would be to allocate the aggregate margin to individual risks in proportion to the squares of the material risk adverse deviations from the anticipated experience reserve (or natural reserve).

NUMERIC EXAMPLE OF AN AGGREGATE MARGIN CALCULATED FOR LEVEL TERM INSURANCE

In developing this example, we start out with six candidates for material risks: default cost, interest, lapses, expenses, mortality fluctuation and mortality trend (improvement). While the first five would be considered for explicit margins applied to the anticipated experience assumptions, the mortality trend assumption would be tested to measure the implicit margin of the regulatory requirement that mortality improvement not be projected beyond the valuation date. This implicit margin could be included in the PBR Actuarial Report described in VM-31 and may constitute important feedback for the National Association of Insurance Commissioners (NAIC) Life Actuarial Task Force (LATF) to consider as part of updating the Valuation Manual over time.

Table 1 contains key values for the calculation of the aggregate margin using the percentile method for a hypothetical block of level term insurance.

The 84th percentile risk amounts are each calculated by taking the scenario reserve for the particular risk (such as default cost) and subtracting the natural reserve. So, the 84th percentile risk amounts represent a set of differences from the natural reserve. Note that the natural reserve equals the present value of benefits plus the present value of expenses minus the present value of premiums without margins. In the PBR Simplified Methods project, we use the term "central estimate reserve" as a standard of comparison for a reserve without margins. In a PBR context, we could also call the natural reserve the "anticipated experience reserve," as it is based on the anticipated experience assumptions.

The modeled reserve equals the natural reserve plus the percentile margin, an aggregate margin calculated using the percentile method. Note that the natural reserve is negative in 2016 and positive in 2022. When calculating natural reserves for a newer block of policies, get used to negative values. The addition of the percentile margin may or may not make the modeled reserve greater than zero.

You may have noticed that only five material risks are listed in Table 1. The original list for sensitivity testing included expenses, but it turned out the expense risk was not material in this case, so I have not included it in the margin calculation.

Like the Life RBC formula, the percentile margin is calculated using a square root formula. In applying this formula, we must give attention to the independence or dependence of the material risks. The percentile margin calculated above (and shown in the formula) assumed that all five material risks were independent. In some cases, lapses and mortality fluctuation may be dependent, since when people lapse, they usually are not expecting to make a claim soon. On average, then, lapses represent healthier lives, leaving a remaining in-force population that tends to be less healthy overall.

The italicized values and formula show the aggregate margin if lapses and mortality fluctuation are considered dependent rather than independent risks. For 2016, the difference in this margin is not large, but the difference grows considerably in the 2022 calculations ($13,964,206 versus $12,105,780).

If all the material risks were dependent, the aggregate margin would simply be the sum of the values for the five material risks. While this may not be the case for the moderately adverse 84th percentile scenarios, risks tend to become more dependent in extreme scenarios, such as those at the 99th percentile.

In comparing the 2016 results with those for 2022 in Table 1, note how the lapse risk grows over time, while several other risks gradually decrease. In this example, the ranking and relative magnitudes of the risks change between 2016 and 2022.

IDENTIFYING GROUPS OF POLICIES WITH SIMILAR RISK PROFILES

The VM-20 significance of identifying groups of policies with similar risk profiles is related to the following potential PBR tasks:

1. Both the stochastic exclusion test and deterministic exclusion test are performed for groups of policies with similar risk profiles.

2. The option to make an actuarial certification regarding interest rate risk and asset return volatility is done for groups of policies with similar risk profiles.

3. Groups of policies with similar risk profiles are used to develop model segments to calculate net asset earned rates for deterministic reserve calculations.

More generally, it makes sense to organize modeling for PBR and risk analysis purposes into these groups. As noted earlier, the value of product hedging can be quantified when the modeling is done using these groupings.

Criteria for determining "similar risk profiles" may include the following: (1) the products in the group have the same or similar material risks, including both ranking and relative magnitudes of risk; (2) the margins on the material risks for different products within the group go in the same direction; and (3) the same or similar investment strategies are used for the different products in the group.

ADDITIONAL THOUGHTS

When I first started following the development of PBR, I was working for a small life insurance company. With that perspective, I realized that the PBR modeled reserves (deterministic reserve and stochastic reserve) would reflect the size of the company through the credibility of the company's mortality experience and the development of margins. In a hypothetical situation of two companies with identical products and experience, the larger company could hold lower PBR reserves than the smaller company. This has not historically been the case with formulaic CRVM reserves and with asset adequacy analysis requirements being unclear about the use of margins. I remember speaking to the LATF at an NAIC meeting about the possibility, under PBR, that a larger company could acquire a smaller company using as currency (in part) the extra reserves that the smaller company was holding due to its smaller size and that the larger company could release upon acquisition. Therefore, smaller companies have an economic incentive to identify relevant industry experience to supplement relevant company experience in setting assumptions and margins and developing dynamic functions to use in modeling. Using the multi-risk scenario generator, the company can build the business case for acquiring that relevant industry experience by quantifying the difference in the reserves at different levels of credibility.

The task of identifying the probability distribution in the multi-risk scenario generator has been simplified by incorporating a methodology developed by Dr. Brian Hartman. Using this methodology in the multi-risk scenario generator, the user need only specify either a binary distribution for risks that have a binary (0,1) outcome such as mortality, lapse or default cost, or a user-defined function for non-binary risks such as mortality improvement. This methodology provides for both types of risk required by the Valuation Manual—process risk and parameter risk. Recall that some non-binary risks, such as flexible premiums, may be modeled more effectively using a dynamic function that would adjust the material assumption based on the conditions projected in each scenario.

To address regulator concerns about subjectivity in the assumption-setting process, the SOA's PBR Simplified Methods project includes the development of methods to demonstrate the objectivity of assumption setting. While these assumption objectivity methods are not required by the Valuation Manual, voluntarily providing the results of these methods would assure regulators, auditors and other reviewers

that professional objectivity was used in setting the assumptions underlying the reserve calculations.

In comparing modeled reserves with current statutory reserves, you should keep in mind that the modeled reserve will reflect the profitability of the product. For testing purposes, we built models for par whole life and level term. I was surprised to see that the par whole life modeled reserve (natural reserve plus percentile margin) was much lower than both the statutory reserve and the cash surrender value. We were modeling a very profitable par whole life product.

In contrast, our level term model produced modeled reserves that were lower than statutory reserves in the early durations but higher in the later durations. This term product projected losses after the shock lapse at the end of the level premium period.

The use of aggregate margins versus individual margins, both adjusted for covariance, may be more about terminology than substance. VM-20 requires the actuary to produce individual risk margins for the material risks but allows for a covariance adjustment. The method proposed in this article is based on developing an aggregate margin first, including the covariance adjustment, then attributing this margin to individual material risks. This attribution step should be done after the groups of policies with similar risks have been aggregated to the three VM-20 product groups of term, ULSG, and all other life products. The attribution to individual risks would then be done only once and would have no bearing on measuring the product hedge, which can be done using the aggregate margins.

The multi-risk scenario generator can be used for other purposes than calculating margins. Of course, it can be used to calculate PBR reserves using simplified methods (as in the SOA research project). This article has already mentioned quantifying the economic benefits of obtaining relevant industry data and has alluded to developing target surplus. For developing target surplus, you would use the 99th percentile deterministic reserve scenarios and calculate a larger margin to add to the natural reserve in a similar manner as shown in the earlier numeric example. For this calculation, you may want to consider the extreme situation when all the material risks are dependent. For target surplus, it would again make sense to calculate this larger percentile margin for groups of policies with similar risk profiles and for all the groups of policies combined. These values could then help you allocate total target surplus to specific products for pricing and profit analysis.

You could also use the multi-risk scenario generator to perform asset adequacy analysis. While the ideal of "one model for all purposes" may not be achievable, using the multi-risk scenario generator to develop a consistent analytical structure for analyzing all your company's long-tailed reserves, pre-PBR and post-PBR, would produce risk information that could feed seamlessly into your company's risk management reporting structure.

PBR CALCULATIONS USING FULLY STOCHASTIC SCENARIOS

No margins are required in PBR for (1) prescribed assumptions, (2) assumptions that are not considered material and (3) assumptions that are stochastically modeled. If a group of policies with similar risk profiles passed the deterministic exclusion test, you could generate fully stochastic scenarios (in which all material risks vary at the same time) for material risks that fit well with the generator and develop dynamic functions for the other material assumptions that reflect the conditions represented by each scenario. Using this approach, no additional margins would be required other than the CTE 70 calculation itself plus the implicit margins embodied in the prescribed assumptions, such as asset default rates and the restriction regarding projecting mortality improvement beyond the valuation date.

Developing and calibrating the dynamic functions with relevant industry data would be part of the value in acquiring that data. A proposed SOA project focuses on validating predictive models, such as these dynamic functions. That project would likely increase the acceptability of using calibrated dynamic functions in PBR calculations to regulators, auditors and others.

Following this method, a company could choose to run any number of fully stochastic scenarios and add the CTE estimator error adjustment to the CTE 70 reserve based on the number of scenarios. The CTE 70 reserve plus the error adjustment would be the PBR reserve. The sum of the CTE 70 reserve plus the CTE estimator error adjustment appears to decrease with larger numbers of scenarios, which would create an incentive for a company to run a larger number of scenarios for year-end calculations. This method is likely to be the basis of comparison for the simplified methods tested in the SOA PBR Simplified Methods research project. If emerging PBR requirements for annuities, long-term care, and long-term disability have the same exemptions for margins as VM-20, you could use this fully stochastic approach for calculating PBR reserves for these additional product types in the future. ■

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