The Actuary's Use of Catastrophe Models in ORSA

by Anders Ericson and Kay Cleary

Introduction

With the regulatory trend towards Own Risk Solvency Assessment (ORSA), companies will have to assess and disclose their own view of risk. For some companies, this will mean establishing more rigorous risk assessment processes.

An insurance company is a risk-bearing entity that, by definition, faces an uncertain financial future and therefore needs to hold capital. A solvency standard transforms and links a risk assessment into a capital requirement. The strength of a firm is a function of both the solvency standard and the quality of the risk assessment to which it is applied. In other words, both the quality of the risk assessment and the solvency standard need to be considered in order to fully understand the strength of a company.

The area of total risk assessment and capital management in insurance can be characterized as an emerging functional area, involving a number of different professions. Actuaries' skills in using limited data and professional judgment position them well to help advance this developing field and become leaders among risk practitioners.

Since catastrophe risk is often a material portion of total risk, an ORSA requirement implies companies need to understand and own the assessment of their catastrophe risk. As the use of catastrophe models has become routine for most companies with material catastrophe loss exposure, an ORSA requirement would require understanding and forming a comprehensive view on model strengths and weaknesses and how they affect the company's catastrophe risk assessment. This goes beyond the current level of catastrophe model expertise of many actuaries.

ORSA regulation requires insurance entities to conduct their own risk assessments. This is a departure from the traditional, more formulaic, approaches commonly required. An ORSA requirement for risk-bearing entities to quantify and disclose their explicit opinion on the risks they underwrite may be necessary to foster a better understanding of risk and help mitigate excessive systemic risk. However, ORSA is not sufficient on its own to prevent systemic risk. There is clearly a risk that firms will adopt approaches similar enough to result in a regulatory system not materially different from the current formulaic approaches. Should this happen, the resulting system would only reflect a change from one systemic model to another. As systemic risk stems from systemic behavior, regulators must be ready to accept a wide range of "models" and company-specific views on risk. Additionally, firms must be ready to hold their own view and, when justified, depart from the norm. Otherwise, an ORSA regulation is unlikely to be truly effective.

In this short essay, we will explore some of the uncertainties related to catastrophe models and how the actuary is well suited to help understand these in the context of an ORSA exercise. Although our discussion is focused on catastrophe models and ORSA, the concepts extend to all actuarial risk models and modeling exercises. Actuaries should understand the model and parameter risks encompassing each risk variable modeled and put all these in context of the overall risk assessment.

Uncertainty in Catastrophe Models

While catastrophe models are based on science and data, judgment also plays a major role in model development. Most actuaries are not and never will become experts in the physical sciences used to develop these models; nor do they need to. For the physical science components of these models, actuaries appropriately will continue to rely on experts in the applicable fields. However, identifying and evaluating uncertainty due to the assumptions, judgments, algorithms, and parameter selection within a catastrophe model is well within the actuary's skill set. The actuary is a good candidate to understand catastrophe model details well enough to be able to determine where additional what-if analyses and stress testing may be appropriate. This kind of evaluation should play a key role in creating and communicating an effective ORSA. As catastrophe modeling software becomes more flexible, such sensitivity and stress testing will become more tractable and should augment current capabilities in overall catastrophe risk assessment.

A typical catastrophe model consists of four sub-models: stochastic event model, hazard model, vulnerability model, and financial model. Each of these sub-models has its own input and output, and analyses proceed through the sub-models in the order listed. A stochastic event set is generated by simulating frequency and location of event occurrences and their physical characteristics. Simulation is used to achieve a full range of potential events. In the hazard component, the damage-causing characteristic (such as peak-gust wind speed for hurricanes) is determined for each stochastic event and exposed geographic area. The vulnerability model uses the hazard model's output to determine each location's damages based on its exposure characteristics (e.g. construction,) and the financial model determines resulting financial losses based on damages and financial contract terms. Each component, as well as the model in its entirety, is subject to process variability, model error (or uncertainty) and parameter error (or uncertainty). Many models produce metrics such as "secondary uncertainty," which cover part of the model's parameter uncertainty. Although secondary uncertainty augments the modeled process variability, many sources of uncertainty are still not fully accounted for. Statistics such as average annual loss (AAL), return period loss (commonly known as PML), and tail conditional expectation (TCE) give valuable information but need to be understood as estimates with associated uncertainty.

Aleatory Variability and Epistemic Uncertainty

Rather than process variability, model uncertainty and parameter uncertainty, seismologists talk about aleatory variability and epistemic uncertainty when discussing total uncertainty associated with earthquake outcomes. This terminology is also useful while discussing total uncertainty associated with catastrophe model output. Aleatory variability is defined as the inherent randomness in a process and epistemic uncertainty is defined as the scientific uncertainty in the model of the process. The process of rolling a die represents aleatory variability since the outcome is always a random number (between one and six). If we do not know the number of sides of the die and the probability of each side, then our option is to build a model based on process observations and informed judgment. This introduces epistemic uncertainty. If, for example, the observations were {2, 2, 3, and 4}, then one might assume that the die has 5 sides with probabilities {Pr(1)= 1/10, Pr(2)= 2/5, Pr(3)= 1/5, Pr(4)= 1/5, Pr(5)= 1/10}. Here the epistemic uncertainty stems from the choice of model (a five-sided die) and its parameters (the probabilities). Even if the correct model is chosen, perhaps based on a *priori* knowledge of the type of die, there would still be epistemic uncertainty resulting from the lack of data with which to estimate the required parameters (the probability of each side). Parameter uncertainty typically represents a portion of the total epistemic uncertainty and makes sense only within the context of the chosen model. In other words, a different choice of model results in a different amount of parameter uncertainty. In theory, the amount of epistemic uncertainty goes to zero as the amount of available data goes to infinity. This means that, with enough data, it would be possible to choose the right model and determine its parameters correctly. More data does not, however, reduce the amount of aleatory variability.

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In some cases it may be difficult to distinguish aleatory variability from epistemic uncertainty. In the case of earthquake occurrence, one may hypothesize that it is a predictable physical process that only requires more scientific knowledge to be modeled precisely. However, scientists generally use stochastic models to supplement physical scientific models where science has not yet evolved enough to explain all observed variability. In this context, these stochastic models represent the aleatory variability of the process. For this reason, scientists regard, for example, the occurrence of earthquakes to have inherent randomness or aleatory variability.

As the total amount of risk is comprised of the total of aleatory variability and epistemic uncertainty, it is important for the actuary to be comfortable that the overall risk assessment accounts for enough epistemic uncertainty to be robust with respect to its intended use. A robust assessment should be stable with respect to the uncertain aspects of a model. The total risk also depends on the distribution of exposure and its data quality.

Although aleatory and epistemic may be new terms to actuaries, the concepts, measurement and evaluation of these types of risk are familiar ground, and the skills needed to review and assess them are well within the profession's domain. Viewing risk this way may be helpful to the actuary in designing analyses to develop a more complete understanding of the total risk. Such analyses could include, for example, stress-testing of model assumptions and scenario-testing exposure data to establish uncertainty ranges.

Conclusion

The challenges of the emerging area of total risk assessment represent an opportunity for actuaries to apply their unique qualifications. The company actuary is in a unique position to evaluate the company-specific exposure characteristics to determine which model and parameter assumptions may need to be evaluated in more depth and/or stress-tested in order to feel comfortable with the overall risk assessment. By using their skills in interpreting catastrophe model output and gaining a deeper understanding of the uncertainties inherent in the models, they will be well-positioned to advance this critical component of the overall insurance company risk assessment. As actuaries' catastrophe model expertise improves, and catastrophe modeling software advances technologically, the feasibility of such evaluation and testing should make them commonplace and help in the ORSA exercise.

Anders Ericson, ACAS, MAAA, is vice president, Model Product Management at RMS Inc. in Newark, Calif. He can be contacted at *anders.ericson@rms.com.*

Kay Cleary, FCAS, FCA, MAAA, is an actuary and director at RMS Inc. in Tallahassee, Fla. She can be contacted at *kay.cleary@rms.com.*