DISCUSSION BY JAMES E. GANT

1. INTRODUCTION

Mr. Meyers has laid out a framework within the context of his previous contribution, the Competitive Market Equilibrium risk load formula, that reasonably accounts for the increase in the variance of expected losses due to the effects of geographic concentration of an insurer's portfolio. The key idea that the author expresses may seem apparent to most actuaries, but the author's use of statistical notation to establish his point is impressive. In Mr. Meyers' words,

> "The marginal capital needed to support an insurance contract increases with the concentration of exposure."

The author has also addressed the timely need of how to calculate a risk load for catastrophic lines of insurance covering both earthquake and hurricane losses, including a brief summary of computer simulation models that have been offered as a solution to critical issues in pricing for these catastrophic lines. The use of geographic information systems within the overall framework of the risk load calculation is also proposed.

2. THE MAIN SOURCE OF RISK

Mr. Meyers uses the output of a computer simulation model, and then develops a risk load formula that has as its main source of risk for catastrophe lines the geographic concentration of an insurer's portfolio. The author has made a strong argument for the fact that catastrophic risk loads are large in comparison to normal risk loads, given concentrations of writings lying on a well-frequented storm track for hurricanes. One could make a similar argument regarding a risky portfolio in close proximity to an active earthquake fault historically causing massive damage to lives and property. This does not prove that geographic concentrations are the main source of risk, however, and actuaries should consider other possible sources of risk connected with catastrophe lines.

Specifically, the types of risk that should be considered when pricing catastrophe coverage include, but may not be limited to, the following:

1. The uncertainty of earthquake and hurricane prediction: In this regard, the Northridge earthquake occurred along a previously unknown fault. Were the geographic concentrations in the Northridge area a main source of risk before the event, or only after the event occurred? Or should all geographic concentrations, regardless of whether the prevailing wisdom of where any "safe harbors" are located, be considered at risk? On the subject of the hurricane peril, Clark [2] has addressed the impact global warming may have on both the frequency and severity of future hurricanes. Should insurers include a provision in the rates for an increase in severity in these storms due to global warming?

2. The time-dependence question: Are earthquake or hurricane events independent in time? This question may be raised in different ways. One way is to ask whether an area that has been struck by an earthquake or a hurricane is either less likely or more likely to be struck again in the relatively near future. Another way is to question whether cycles of earthquake or hurricane activity can be expected to occur, and the question may be raised regarding either the frequency or the severity of a series of events that are in some way causally connected.

3. The demand for insurance: Mr. Meyers' Competitive Market Equilibrium risk load formula assumes that the market can work effectively to reach an equilibrium be-

tween the demand and the supply of insurance. The occurrence of events such as Hurricane Andrew or the Northridge earthquake create disequilibrium. The demand for insurance increases as homeowners recognize the need to reduce the risk of a major loss. At the same time, the supply of insurance decreases as insurers recognize the need to reduce the risk presented by geographic concentrations of their portfolios.

4. Social pressures to offer coverage for catastrophes at an affordable price: The ability of insurers to control geographic concentrations through price increases or withdrawing from the market may be limited by political forces. Alternative funding mechanisms may be created that may or may not reduce the ultimate amount of risk borne by insurers.

5. The computer simulation models and sources of error: In calculating risk loads for most lines of insurance, some actuarial methods generally measure process risk and ignore parameter risk, or use approximations to normal or log-normal distributions that reduce parameter risk to an acceptable level.[1] These assumptions are not valid for catastrophe risks such as earthquakes or hurricanes when computer simulation models are used.

Some of the above sources of risk may be interconnected. The interest in computer simulation models and the perceived need to abandon historical methods of pricing for catastrophe risks may be symptoms of disequilibrium in the insurance market. All dimensions of risk need to be considered carefully before using computer simulation models in pricing.

[1] However, as Heckman [4] points out, "parameter uncertainty is the prime determinant of the risk load in a consistent and market-viable scheme." See also Feldblum [3] and Philbrick [5].

The author's choice is to treat the output of the computer simulation model as a series of events that are time-independent, identically distributed random variables so that the overall frequency is binomial-distributed. These are reasonable assumptions given a scarcity of raw, unprocessed data. However, the computer simulation models do not rely on the scarcity of data, but upon an abundance of scientific, engineering, geophysical, and meteorological knowledge applied to a historical record of sparse data.[2] The models also rely on an insurer's database for coverage-related data. The accuracy of the model's output is directly related to the accuracy and level of detail that an insurer can provide about its portfolio.

3. COMPUTER SIMULATION MODELS AND PARAMETER ERRORS

Actuarial familiarity with computer simulation modeling of catastrophes is needed to assess both the ability of the models to accurately forecast potential losses and the sensitivity of the models to parameter error. Actuaries should insist on treating the output from computer simulation models the same way we treat all data:

- How credible or reliable is the data?
- How variable are the results?
- How sensitive is the output to parameter selection?
- How much confidence is there that the expected annual loss produced as an output by the model equals the true value of the future annual losses?

[2] See Risk Management Solutions, Inc. [6]. RMS treats the output of their model, IRAS, as coming from a binomial distribution to calculate mean values and 90th percentile values. The study also details the complex inputs used in the model.

For example, the current state of earthquake prediction relies in part on a simple formula to compute return periods, that in turn represent the frequency with which a given event of a given magnitude will occur at a location along an active fault.[3] The equation assumes a log-linear relationship between two parameters, the earthquake magnitude, and the return period. Tables 1 and 2 show sample values for the initial parameters, α and β, and the corresponding relationship between predicted magnitudes and return periods. The exact values of α and β are unknown, and their estimates do not have any high degree of precision. Adjusting the parameters by as little as 5% may

TABLE 1

EARTHQUAKE FORMULA

Earthquake formula using loglinear relationship of magnitude and the reciprocal of the return period:

$$N(m) = \alpha + \beta \times M$$

$$\text{100-year return period: } (\log(.01) = \alpha + \beta \times M)$$

The parameters α and β are determined by examining the historical data and geologic characteristics of the fault. Estimates are typically given as a range of values corresponding to the 100-year event, M_0. Table 1 shows the predicted magnitudes of the 100-year event for a mythical fault having the following estimated range for α and β:

M_0		α	
β	5.550	5.843	6.126
−1.5428	6.6	6.8	7.0
−1.6200	6.3	6.4	6.6
−1.6966	6.0	6.2	6.3

Computer simulation models will choose a single point estimate for α and β for each known historical fault. For example, α might be selected to equal 6.126 and beta selected to equal −1.6966. The model would predict that the fault would generate a 6.3 magnitude event with probability 1%.

[3] See Bolt [1] for a generic version of this formula.

TABLE 2

VARIATION IN RETURN

Table 2 shows the variation in the return periods and probabilities given:

1. Selections of α and β from Table 1.
2. Possible error of plus or minus 5% in either direction.
3. A magnitude 7.1 event.
4. $\log p = \alpha + \beta \times 7.1$.
5. Return period = $1/p$.

Return periods and associated probabilities of a 7.1 magnitude quake:

$R(7.1)$		α			Average % across rows	Resulting Relative error
β		5.820	6.126	6.432		
-1.6118	return	277	204	150		
	frequency	0.36%	0.49%	0.67%	0.51%	82.57%
-1.6966	return	506	372	274		
	frequency	0.20%	0.27%	0.36%	0.28%	
-1.7814	return	924	680	501		
	frequency	0.11%	0.15%	0.20%	0.15%	45.29%
Avg. % down columns		0.22%	0.30%	0.41%		
Relative error		26.40%		35.89%		

The model would assume a probability of 0.27% that a magnitude 7.1 earthquake would occur along the mythical fault. However, if both α and β were 5% above or below their "true" values, the probability might be as high as 0.67% or as low as 0.11%. In the former case, the assumed probability would be less than half the true frequency. In the latter case, the assumed probability would be more than double the true frequency.

magnify the error in the resulting return periods by over 100%. This is a case of extreme sensitivity to initial parameter selection that the actuary should consider in the selection of a risk load.

Hurricane prediction is also fraught with uncertainty. One component of the disaster potential that is difficult for the computer simulation models to manage is the storm surge and how high it could rise, since the role of the tidal forces must also be fit into the equations. Return periods are likewise not known with precision, and the chief problem confronting the computer simulation models is whether the historical data upon which the model's parameter selections have been based have been drawn from a long enough period of time to represent a random sequence of all potential hurricane events.

The author's suggested approach is to develop a risk load using the output from computer simulation models. This implies that the risk load is dependent only on the variance of the expected annual loss. But the catastrophic risk threatens not only the stability of individual insurers and the insurance industry, but also their survival. Some portion of the risk load must account for the contingency of underestimating the "Great Earthquake" or "Great Hurricane." One possible solution is to use the models to compute a worst case scenario event that uses less conservative frequency and severity assumptions than are used to generate the expected annual loss.

4. APPROPRIATE USES OF COMPUTER SIMULATION MODELS

The focus on using computer simulation models to calculate appropriate risk loads for catastrophic lines may shift attention from other possible uses of such models in pricing. Among these uses are the following:

1. Territory relativities for earthquake premiums. Computer simulation models can be used to determine the relative potential for loss between territories. Care should be taken to ensure against bias in measurement. Should the individual insurer's portfolio be used or should a simulated book of business representative of the demographics of the state be used instead? Are the mean damage ratio assumptions and construction type assumptions used in the simulations unbiased with respect to territory

(e.g., has the model accounted for possible correlation of size of dwelling and territory)?

2. Variance of expected annual losses. Should a simplifying assumption as to the underlying distribution of the model's output be used? Or should the variance of the actual simulation runs or stochastic model be used?

3. Scenario analysis. The model can test the effects of changing deductibles, limits, or other coverage features. Conversely, actuaries can test the reasonableness of the model's output by changing these and other inputs pertaining to the inventory database.

4. Ex ante tests. How well does the model do in predicting actual losses given the event that occurred and its location?

5. Evaluating reinsurance program costs. Models could be used to demonstrate how exposed an individual insurer is in a catastrophe-prone area. Claims of careful underwriting can be analyzed. The adequacy of limits of coverage can also be analyzed. Risk loads might be based on the individual insurer's portfolio spread.

6. Portfolio management. The costs of writing business in catastrophe-prone areas may be better understood.

5. CONCLUSION

Mr. Meyers has bravely proposed a way of calculating risk loads for catastrophe lines that treats the task as a tractable problem; he deserves special commendation for a distinguished effort. The Competitive Market Equilibrium risk load approach is a promising one that recognizes the importance of including parameter risk in the risk load. However, the author omitted consideration of all the risk factors involved in writing catastrophe lines of insurance.

It is important for actuaries to consider all the sources of risk in the calculation of a risk load for catastrophe lines. This is true whether or not computer simulation models are used. When computer simulation models are used for calculating risk loads, the impact of geographic concentrations of exposure certainly needs to be included. Some measure of the parameter variance within the model needs to be included as well. Other sources of parameter risk exist that may be part of the underlying assumptions of the model or that may lie outside the focus of current computer simulation models. Without accounting for these other sources of risk, the associated risk loads will be less than adequate.

REFERENCES

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