Article from:

Long-Term Care News

June 2013 – Issue 34

Credibility Theory and Long-Term Care Insurance

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A classic problem in group insurance begins with the benefit manager's question: "Why is my group's premium so high when our experience is so good?" Ms. Jones is the benefits manager for a group of 50 employees. Mr. Black, the insurance broker, quoted a rate from the rating manual that was twice what the inflation-adjusted experience over the last five years showed. The rating manual looked at age, family composition and occupational class. Yet there were unique aspects to Ms. Jones' group that fundamentally made them a better risk.

Mr. Black considers the group and realizes that this is not just a run of good luck, so he goes to the actuary to see if something can be done.

This trip into one of the lesser-understood realms of actuarial science was given a theoretical structure in the early part of the 1900s when a workers' compensation actuary wrestled with this problem and developed a way of dealing with these tensions. **Limited fluctuation credibility theory was born.** This theory found a way to blend the experience of the group with the overall experience of the general insured population.

In our case, the experience of Ms. Jones' group was assigned an amount of credibility, Z, and a blended rate was determined. The blended rate is [group experience x Z] + [manual rate x (1-Z)], a simple proportional weighting. With this formula in hand, and knowing the manual rate and the group experience, what we need to know is the value of Z, a value between 0 and 1, inclusive.

Limited fluctuation credibility uses an elegant and appealing approach. Assuming the actual claim count is n and asking how many claims would make the group "fully credible," call this N, it works its magic: Z = sqrt(n/N). So far, so good. But where does N come from?

N is defined by a confidence interval calculation that needs two parameters. The first would be the width of the interval, say ± 3 percent, and then the confidence that the result is within this interval, say, 98 percent.

At this point, I will refer the reader to a good source for the details of finding N. *An Introduction to Credibility Theory,* fourth edition, by Thomas Herzog is a solid starting place.

While easy to apply, limited fluctuation credibility is not without its theoretical challenges. In a letter to *Contingencies,* March/April 2004, Herzog notes several concerns. How are the parameters chosen? How comfortable are we with the accuracy for the "manual rate" with which we are blending actual experience? Should we ever give data 100 percent credibility or just let full credibility be approached asymptotically?

It's not clear as to how one should obtain the two parameters of the limited fluctuation model. They appear to be subjectively determined and, in fact, in practice that is what this author has personally observed. In fact, in some cases the full credibility amount was simply stated without appeal to the parameters. Moreover, unlike the Bayesian credibility approach, the limited fluctuation approach allows the analyst to hide all of the model's assumptions. But for all these issues, limited fluctuation credibility gives a better answer than if we did not use any credibility approach.

CREDIBILITY AND THE LONG-TERM CARE ACTUARY

Before reviewing some alternatives to limited fluctuation credibility, it would be useful to ask in what way a long-term care (LTC) actuary might be interested in using credibility theory. The most common usage of which this author is aware would be in rate filings with various states. State regulators typically ask for experience in their state as well as nationwide.

Suppose there are 10,000 policies with 700 claims in state X, giving a loss ratio (LR) of 82.3 percent. The nationwide LR is 89.9 percent. If due to the natural volatility of the data it is decided that "being within 5 percent of the actual loss ratio 90 percent of the time" is a good measure, then full credibility is found with 1,082 claims (see Herzog book or multiple other sources). Thus Z = sqrt(700/1,082) = .804, and state X would blend its state-specific loss ratio with the national loss ratio using LR(blended) = .804 * 82.3% + .196 * 89.9% = 83.8%.

A concern with the approach just demonstrated involves the theoretical underpinnings. Standard credibility theory is developed for claim count or amount during a specific period. When loss ratios are considered, the time period is expanded and a new variable is introduced—policy decrements. This complicates a less-than-perfect method. The actuary should use caution in applying credibility theory to lifetime loss ratios and verify that theoretically what is being done is appropriate.

A few states have their own full credibility definitions, but the one-size-fits-all nature of their formula may make the state actuaries interested in a different approach to the problem if the filing actuary would offer it. Of course, it never is that easy.

The state not being fully credible poses a concern glossed over above. With what will the filing actuary blend the experience? Above, the choice was nationwide data. An alternative is to blend with other LTC forms within that state. Using nationwide data might seem the most appropriate choice since there is a similar basis for the experience. The use of other forms within a state may cause blending of experience that is different in some fundamental way. This inter-form variation is likely not a big issue for most LTC forms, but it could be. As well, it could be that the total pool of experience among all forms in a state is still "less credible" than nationwide experience on the one form.

Another potential application would be for group LTC pricing, much as discussed above. This application would be uncommon as the LTC experience development is glacial compared with most other group coverages.

Credibility adjustments to pricing parameters could be considered. This becomes a bit more complex. Count-oriented parameters might work here, such things as mortality, voluntary lapse and claim incidence, but it would seem that severity is a tough item to go after. One of the first questions to pursue with pricing parameters is the standard table with which to blend experience. Is this the pricing assumptions? Or the industry experience, such as an actuary can determine? Should we even be doing this if we see trends moving in one direction while the process of credibility blending pulls us away from where experience is trending toward? An alternative approach might be to determine a confidence interval for decrements based on pricing assumptions. If the experience develops outside the confidence interval, make a change; otherwise, not.

If one can get by these issues, the Financial Reporting and Product Development sections, along with the Committee on Life Insurance Research, commissioned a research project in 2009. The resulting paper, titled Credibility Theory Practices, can be found on the SOA website at *http://www.soa.org/research/research-projects/life-insurance/research-credibility-theory-pract.aspx.* In this paper and accompanying spreadsheets the authors provide a reasonably detailed theoretical workup of both the limited fluctuation method and the greatest accuracy method along with a discussion and significant example of how to apply these methods to actual-to-expected ratios for mortality experience. For a step-by-step treatment, this is a highly recommended source.

GREATEST ACCURACY CREDIBILITY

To get the idea of greatest accuracy credibility, a standard example supposes a marksman is shooting at one of four targets, the targets being positioned at the four corners of a square. If the square is "large" rather than "small," it will be easier to tell at which target the marksman is aiming. This concept is at the heart of greatest accuracy credibility.

In this case, Z = n/(n+k) where n is the exposure and k is determined in some manner. Note that Z never reaches 100 percent. Greatest accuracy credibility is certainly more difficult than limited fluctuation but it avoids many of the theoretical challenges. There are no parameters to pick. It simply looks at means and variances within the population based on expectations.

BAYESIAN CREDIBILITY

The Bayesian world starts with Bayes' formula that all statistics students learn. It philosophically addresses the concept of how much we know outside the data presented specifically in a case. So a prior understanding of how the data works is brought into the problem, e.g., a rating manual. A non-Bayesian (a "frequentist") feels this pollutes the data. The Bayesian feels she knows something relevant but frequentist techniques don't allow her to use it. The

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Perhaps one of the good disciplines coming from Bayesian thinking is that the world asks to be specified probabilistically. That's a good habit for any actuary to cultivate.

Bayesian knows that not all her knowledge is being tapped. And if the data is thin, any knowledge may be useful.

From a credibility perspective, the general knowledge of the rating manual is updated with the actual experience.

This may take the classic Bayesian form of the prior distribution being updated by the observed data to give a posterior distribution. Loss Models, by Panjer, et al., describes this process and gives some examples. A standard Bayesian example starts with a prior distribution which is a beta, B(a,b). The prior mean is a/(a+b). If we observe r claims in n trials, then the posterior distribution is B(a+r,b+n-r) with the posterior mean of (a+r)/(a+b+n). This is an appealing outcome. The beta distribution is nice for Bayesians, and while it isn't the only distribution with this "conjugate" property, there aren't many.

Bayesian strengths include its nice mathematical theory with all the assumptions clear. It gives reasonable results in extreme examples. But the guidance in how to make the assumptions is weaker. There is much subjectivity. But a Bayesian would say that is appropriate if you don't have much else to go on. For example, what is the probability that a nuclear war breaks out this year? There are (thankfully) few data points for this question, so bringing some subjective reasoning to bear on the problem may be the only hope of developing any answer. And that answer is constantly updatable as new information and understanding is obtained.

One of the challenges of the Bayesian approach is finding the prior. It is helpful if it fits the form of one of the conjugate distributions, but it well may not. What is to be done? A table of prior beliefs is needed, and an application of Bayes' formula gives an answer. These prior beliefs can come from the actuarial muse (aka actuarial judgment) or they can come from techniques such as the Markov Chain Monte Carlo (MCMC) simulation. MCMC uses a tree with probabilities as to which branch is taken and then does many random simulations. The result is a prior distribution derived from some set of assumptions which are to be updated by observations. Note that there are potentially many subjective assumptions used in developing this prior.

Perhaps one of the good disciplines coming from Bayesian thinking is that the world asks to be specified probabilistically. That's a good habit for any actuary to cultivate. Instead of giving point estimates, a range of possible outcomes is given with probabilities assigned. There may be some appeal to the actuarial muse once again.

CONCLUDING THOUGHTS

Credibility should not be applied blindly. Start with a good understanding of the theoretical structure. This isn't easy to do but should be pursued to avoid unfortunate applications.

It is worth emphasizing that one must ask what makes a table the standard table. Why is one confident that it is the appropriate item with which to blend a particular set of experience? Related to this, just because data is judged to be credible doesn't make it relevant. For example, data may be fundamentally different from the standard table being used. The world is changing and past relevant data may no longer be so. Is data predictive of the future?

Credibility may be a bit like graduation of data. Actuaries learn now to smooth data in various ways. The mathematical methods from the exams give reasonable results. A professor explained one of his graduation techniques. On a piece of paper he would graph the data points, sit on the sill in one of the big windows at the company, stare at the data for a few moments, and draw a line through it. After all, whatever the results of a more mathematic presentation may be, it still has to line up with intuition. ■