Actuarial & Finance

The Spectrum of LTC First-Principle Models

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ILTCI

Purpose of Actuarial Models

- Actuarial models help us understand the costs and risks of insurance contracts to help establish:
  - Premium
  - Reserves
  - Required Capital
  - Product Design
  - Strategy
- A model is a first-principles model to the extent the material elements of the underlying policies are directly reflected in the model.
- Whether a specific model framework is first-principles depends upon the complexity of the product.

Is Your Model First Principles?

On a scale of 1-5 where 5 means “absolutely” and 1 means “no way,” how much do you agree with each of the following statements:

Question 1

The mechanics of my model naturally and intuitively reflect how the policies actually work; the model doesn't need convoluted assumptions to reflect basic policy features.

Points: ______

Question 2

Emerging experience directly compares to model assumptions without complicated transformations like claim costs or salvage factors.

Points: ______

Question 3

My model forecasts all of the key items on my financial and operational dashboards in a way that is directly comparable.

Points: _____

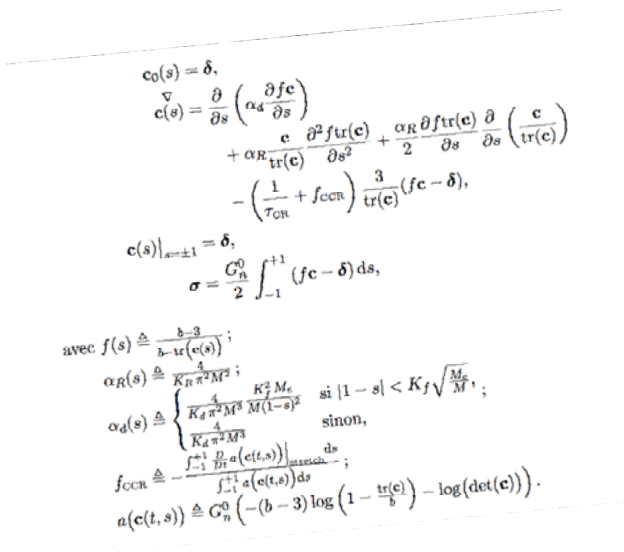
Question 4

Discrepancies between emerging experience and the budget forecast can be easily explained by comparing operational metrics to model assumptions.

Points: ______

Question 5

Sensitivity tests on basic model assumptions (e.g. inflation rates) will be correctly reflected in the results without complicated adjustments to other model assumptions (e.g. utilization factors)



$$\mathbf{c}_0(s) = \boldsymbol{\delta},$$

$$\overset{\nabla}{\mathbf{c}}(s) = \frac{\partial}{\partial s}\left(\alpha_d \frac{\partial f\mathbf{c}}{\partial s}\right) + \alpha_R \frac{\mathbf{c}}{\mathrm{tr}(\mathbf{c})}\frac{\partial^2 f\mathrm{tr}(\mathbf{c})}{\partial s^2} + \frac{\alpha_R}{2}\frac{\partial f\mathrm{tr}(\mathbf{c})}{\partial s}\frac{\partial}{\partial s}\left(\frac{\mathbf{c}}{\mathrm{tr}(\mathbf{c})}\right) - \left(\frac{1}{\tau_{\mathrm{CR}}} + f_{\mathrm{CCR}}\right)\frac{3}{\mathrm{tr}(\mathbf{c})}(f\mathbf{c} - \boldsymbol{\delta}),$$

$$\mathbf{c}(s)\big|_{s=\pm 1} = \boldsymbol{\delta},$$

$$\boldsymbol{\sigma} = \frac{G_n^0}{2}\int_{-1}^{+1}(f\mathbf{c} - \boldsymbol{\delta})\,\mathrm{d}s,$$

avec $f(s) \triangleq \frac{b-3}{b-\mathrm{tr}(\mathbf{c}(s))}$;

$$\alpha_R(s) \triangleq \frac{4}{K_R \pi^2 M^2};$$

$$\alpha_d(s) \triangleq \begin{cases} \frac{4}{K_d \pi^2 M^3}\frac{K_f^2 M_e}{M(1-s)^2} & \text{si } |1-s| < K_f\sqrt{\frac{M_e}{M}}; \\ \frac{4}{K_d \pi^2 M^3} & \text{sinon,} \end{cases}$$

$$f_{\mathrm{CCR}} \triangleq -\frac{\int_{-1}^{+1} \frac{D}{Dt} a(\mathbf{c}(t,s))\big|_{\mathrm{stretch}} \mathrm{d}s}{\int_{-1}^{+1} a(\mathbf{c}(t,s))\mathrm{d}s};$$

$$a(\mathbf{c}(t,s)) \triangleq G_n^0\left(-(b-3)\log\left(1 - \frac{\mathrm{tr}(\mathbf{c})}{b}\right) - \log(\det(\mathbf{c}))\right).$$

Points: ______

Is Your Model First Principles?

Sum of all points: _____

Total	
20-25	Congratulations! You are benefiting from a true first-principles model
15-19	Your model has many first-principle characteristics, but probably has room for improvement
5-14	Your model design could be dramatically improved to reflect the way your business works

Spectrum of First-Principle Models

Simple ↑ … ↓ Complex

Product Features

- First-diagnosis dread disease style
- Simple indemnity policy
- Policies *without* restoration of benefits
- Benefit changes with site of care
- Pool-of-money benefits
- ROP Benefit
- Shared Care
- Combo Products

First Principle Model Structure

Claim Cost

Deterministic Incidence/Termination

Monte Carlo Simulation

Two Distinct Reasons to Use Simulation

1. Monte Carlo simulation is the true first-principle way to handle path-dependent contingencies and benefits (e.g. shared care, ROP, pool-of-money, multi-state, combo). It is simpler to capture these policy features using simulation.

2. Simulation facilitates modeling risk. Helps to evaluate riskiness of product designs, measure process risk, calculate projection intervals, determine CTEs, etc.

Example

<u>The following policy was recently hit with a 50% rate increase</u>

- 50-year old policyholder
- Pool-of-money benefits corresponding to 5-year BP
- 5% compound inflation
- Currently at benefit of $150 per day
- Two options offered to reduce premium & benefits:

Option 1	Option 2
• Reduce daily benefit (and lifetime max) by 33% • Reduce premium by 33%	• Reduce lifetime max by 40% without reducing daily benefit (i.e. reduce BP to 3 years) • Reduce premium by 20%

- Were these reductions priced correctly?

Example (cont.)

Option 1	Option 2
• Reduce daily benefit (and lifetime max) by 33% • Reduce premium by 33%	• Reduce lifetime max by 40% without reducing daily benefit (i.e. reduce BP to 3 years) • Reduce premium by 20%

- Option 1 implies it was priced with utilization rate of 100%, both before and after reduction in benefit. Is that a good assumption?
  - Cost of semi-private nursing home room in Kansas in 2016: $173
  - Actual inflation rate since purchasing policy: 3%
  - Cost of care in 35 years (inflated at 3%): $488
  - Daily max at 5% in 35 years, with and without benefit reduction: $551, $826
- First principle model would forecast inflation directly and would automatically capture benefit utilization based on comparing future cost of care to future daily limit. Effects of attained age, inflated daily benefit, and economic scenario automatically captured.
- Conclusion: Option 1 seems inconsistently inexpensive compared to accepting full rate increase and Option 2.

A Unum Perspective

- Early experience with Monte Carlo stochastic DI model
- What went well and what didn't
- Considerations for LTC modeling
- Final thoughts

A Unum Perspective

Early experience with Monte Carlo stochastic DI model

- Developed in-house circa 2000
- Complex framework of all policy and claim states
- Used for all types of projection purposes
- Used for booking reserves as well as reserve analysis
- Movements with limited data were combined with other movements
- Framework revisions involved complex programming projects
- Additional programming was created to help with runtime issues
- Management interested in point-estimates:
  - ✓ What is the reserve and the reserve margin?
  - ✓ What did the reserve assume for recoveries, deaths, etc?

A Unum Perspective

What went well and what didn't

- Positive
  - Insight into distribution of outcomes
  - Understanding of tail risk
  - Valuable to ERM analysis and capital needs

- Not so Positive
  - Need assumption for each transition
  - Source system data limitations
  - Slow runtime, led to complex logic to enhance, led to hidden bugs
  - Complex knowledge in the heads of a few (limited transparency)
  - Focus was on mean not distribution
  - Impact of assumption changes were muddied by variations in random walks
  - Valuation system needed to be consistent, yet deterministic
  - Transparency is key – what did we expect vs what actually happened

Considerations for LTC Modeling

- Extensive discussion and review to consider DI-type model for LTC
- Final decision to go with deterministic model was based on:
  - Complexity vs transparency
  - Short term expectations needed to analyze financial results
  - LTC contracts do not have Shared Coverage
  - Desire for one integrated system for all projection needs: Valuation, RAS/CFT, Pricing, and Planning
  - Generally, the needed result was a point-estimate or a set of cash flows
- Some simplifications were needed such as Original care location and Original diagnosis
- Capital modeling would ideally use a stochastic model

Considerations for LTC Modeling (continued)

- Focused on consistent treatment of assumptions with the way they were developed
- Development of assumptions was as complex and involved as development of the projection model
- The value of the result relies on the value of the assumptions
- LTC experience is still quite young and immature
- A 50-year projection results in a compounding of the unknown
- Simple indemnity benefit, no new business, no shared coverage
- Desire to have one model with consistency, transparency, and (relatively) quick response time

A Unum Perspective

Final Thoughts – what do you need from your model?

- Pricing and ERM – need a range of possible outcomes
- Planning and Valuation – need a point estimate, transparency and consistency
- Audit – need a reproducible formula
- Management Discussions – need transparency and clarity
- Analysis – need quick response time; flexibility for sensitivities; and consistency across all aspects of the projection

What Else You Might Learn

- Expose Hidden Assumptions
  - The Monte Carlo Method wants Transition Probabilities
  - Sometimes differ from familiar assumptions
- What Does Model Variance Tell You?
  - It might not be what you think

Exposing Hidden Assumptions

- Easy Example – Claim Termination
  - Models are often built with Termination and Disabled Mortality
  - Transition Probabilities are Recovery and Disabled Mortality
  - Easy to Re-factor
    - All exposures are "Lives on Claim"
  - Have you actually looked at your Recovery assumptions?
    - Reasonable levels?
    - Reasonable patterns?

Exposing Hidden Assumptions

- More Complex Example – Mortality
  - Models are often built with Aggregate and Disabled Mortality
    - "Conservation Of Deaths" Methodology
  - Transition Probabilities are Healthy and Disabled Mortality
  - More Difficult to Re-factor
    - Constantly shifting mix of Healthy and Disabled Lives
  - Might NOT look like previously expected
    - Especially toward the long end of the table
  - Once exposed, can lead to better coordination of Healthy and Disabled Mortality assumptions
  - A significant issue for Combo products

Explaining Variance

- Running a Monte Carlo Model means getting results with a variance
- Many ways to communicate this
  - Standard Deviations
  - Confidence Intervals
  - CTE
  - Histograms or other Distributional Charts
- But what is the variance telling you?

Explaining Variance

- Two Distinct Approaches To Model Structure

- Model Your Block
  - Number of Simulations proportional to expected volume of each cell
  - Scale Total Model to a known time period, such as a year’s issues
  - Each run simulates a period of issues run to ultimate terminations

- Model Each pricing Cell
  - Number of Simulations constant for each cell
  - Results for each cell are determined, then weighted into a total and subtotal model result

Explaining Variance

- Model Your Block
  - Simulating a block of issued policies
  - Picture of what normal period by period variance looks like
  - Captures risks and risk offsets in the product at the overall level
    - Both inside a cell and among cells
  - Variance is the estimated uncertainty of the business
    - Variance is as or more important result than the Average
    - Requires multiple runs of the model to determine
    - Running more iterations improves estimate of Variance
  - Very useful for managing a block, ***even one that isn't too complex***
  - Individual cell results can have wildly varying results
    - Especially cells that have limited weight

Explaining Variance

- Model Each Pricing Cell
  - Simulating a cell-based pricing model
    - Theoretically perfect but due to complexity unattainable model
  - Variance in results tells you how closely you are approaching the "perfect model"
  - Want a closer approximation? Run more iterations
    - Accuracy will improve proportional to square root of total number of simulations
  - Good for rate setting and developing other cell-level factors
    - Even on high variance cells, you can just run more targeted iterations to narrow in on result
  - Doesn't actually say much, if anything, about overall product riskiness