ASSOCIATION ACTUARIELLE INTERNATIONALE
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SECTION SANTÉ DE L'AAI
IAA HEALTH SECTION

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Emerging Risks… Daring Solutions

Stochastic Modeling

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Overview

- General issues of stochastic modeling
- Short term medical insurance risk model
- Example
- Q&A

IAA publication

- Based on the recently published book by the IAA
- Stochastic Modeling: Theory and Reality from an Actuarial Perspective
- Available on the IAA website

General issues

- What factors should be stochastically generated?
- When should I be using stochastic models?
- When should I not use stochastic models?
- Are there alternatives to stochastic models?
- What are the disadvantages of stochastic models?

When should I be using stochastic models?

- Are these required by regulation or professional guidelines?
- Do we need a better understanding of the effects of extreme outcomes?
- Do we need a better understanding of the tail risk or risks in general?
- What is the probability of an event?
- What is the probability of ruin?
- Are certain risk measures needed for reporting?

When should I NOT use stochastic models?

- Can you calculate a probability distribution?
- Can you calibrate the model?
- Can you validate the model?

Are there alternatives to stochastic models?

- Stress testing/Scenario testing
- Static factors/PADs/MADs
- Range testing

What are the disadvantages of stochastic models?

- “Black Box”
- Inappropriate distributions
- Inappropriate parameters
- Improper calibration
- Validation – Beware of false positives
- Model size
- Computer power

Model calibration

- Two general approaches
  - Calibration to historical experience
  - Calibration to current market conditions
- Considerations
  - Does the model track to expected assumptions?
  - Reflect expectations today?
  - Experience period
  - Range of possible outcomes?
  - Extremes

Model calibration

- Calibration to historical experience
  - Can you create a distribution?
  - Expected
  - Correlations
  - Volatility
  - Mean reversion

Model calibration

- Calibration to current market conditions
  - Observed market prices or conditions
  - Closed form formula
  - Market consistent results

Model validation

- How do I validate a model?
  - Cellular checking
  - Reasonableness review
  - Assumption review
  - Formula testing
  - Calibration review
  - Distribution of outcomes

Model peer review

- Documentation review
  - Source of data
  - Experience period
  - Testing
  - Audit/Checking/Peer review

Model calibration

- Reviewed for accuracy?
- Credible data?
- Model and parameter development?
- Correlations?
- Testing
- Validation

Model calibration

- Average
- Outliers – worst case and best case
- Specific scenario
- Type of audience

Model communication

- Source of information
- Development of assumptions
- Development of correlations
- Expected assumptions

Model audit

- Cell checking
- Review of distributions, range of outcomes, extreme cases
- Correlation checking
- New set of scenarios produce similar results

Short term medical insurance risk model

Stochastic risk models for short term medical insurance

- What is stochastic modeling used for in short term medical insurance?
  - Claim level estimation
  - Surplus requirements (Economic capital)
  - Distribution of medical loss ratios
  - Stop loss rating
  - Other

Stochastic risk models for short term medical insurance

- What are major risks to insurance companies selling short-term medical insurance products?
  - Rating parameter adequacy
  - Regulatory issues / Delays
  - Catastrophic events
  - Expense recoupment
  - Other

Stochastic risk models for short term medical insurance

- Is stochastic modeling necessary to establish surplus requirements?
  - No
  - However, it is superior to deterministic models that involve projection of a limited set of likely scenarios
  - Also, it is superior to peer group analysis
    - Where conclusions are drawn from companies with “similar” characteristics
  - Stochastic models allow for simultaneous consideration of multiple risk factors and ranges of possible outcomes

Stochastic risk models for short term medical insurance

- What are some of the considerations in developing a stochastic model?
  - Establish risk level – high likelihood, sufficiency, virtual certainty – corresponding to 90^{th}, 95^{th}, 98^{th} percentiles
  - Determine risks to include in model
  - Develop distributions of outcomes for each risk, based on ranges of potential outcomes
    - Some risks can be easily measured and parameterized
    - Other risks may be more subjective and harder to define
    - Interdependent risks need to be evaluated

Stochastic risk models for short term medical insurance

- How are stochastic models tested to ensure meaningful results?
  - Sufficient number of iterations are run to ensure stability of result
  - Underlying distributions are calibrated to observed data history
  - Model results are validated by comparison to other independent approaches or results

Stochastic risk models for short term medical insurance

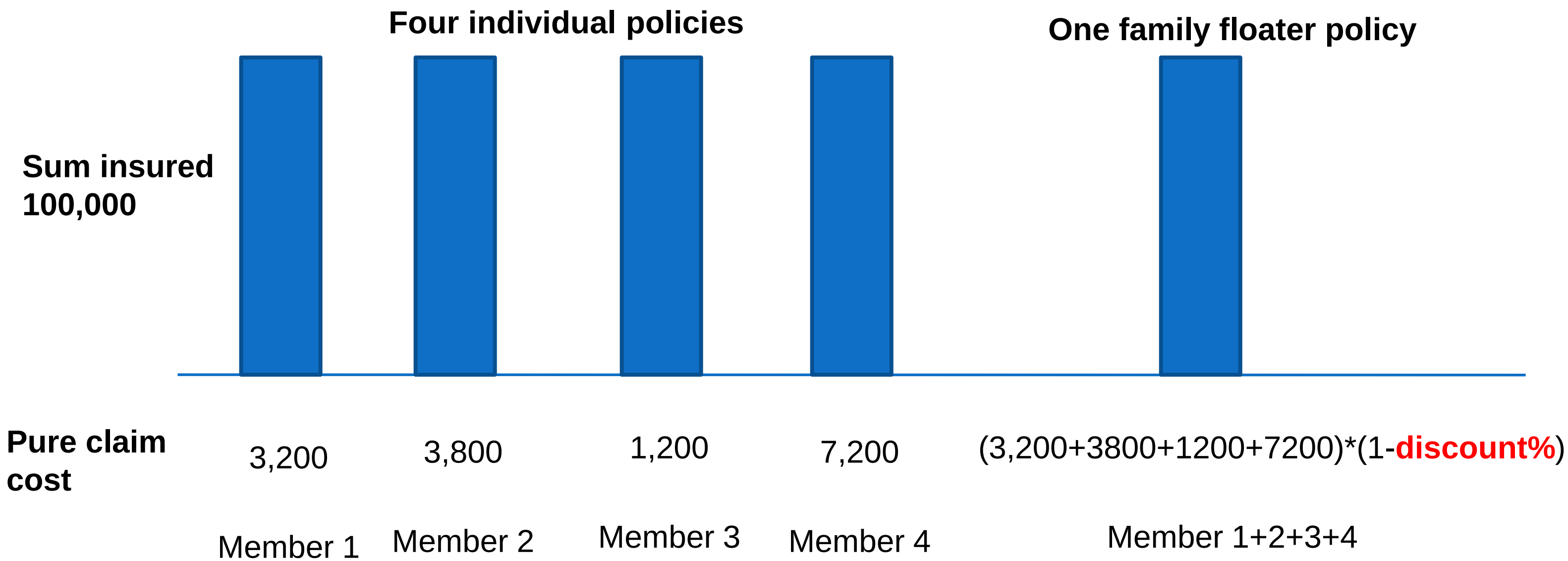
- Examples of stochastic modeling used in short term Indian medical insurance:
  - Pricing
    - Family floater discount calculation
    - Top-up policies,
    - Corporate buffers
  - Stochastic reserving
  - Optimal surplus / Economic capital modeling

Example

Calculating discounts for family floater policies

Family floater discount

- Problem
  - Will the pure claim cost of a Sum insured (SI) 100,000 family floater for a family be different from the sum of four SI 100,000 policies for each of them?
  - What would be the discount on the sum of the pure claim costs to arrive at the family floater pure claim cost?



Family floater discount

- Why discount?
  - The discount is applicable on the sum of the individual pure claims costs for the same age and same sum insured
  - The discount comes due to the fact that there are chances of a scenario where the total payment under a family floater with 100,000 SI will be lower than the total payment for a combination of four individual 100,000 SI policy

Family floater discount

- Solution approach
  - We need the correct pure claim cost for the family floater policy to be able to compare that with the sum of the individual pure claim costs and calculate the discount%.
  - How do we do that?

Family floater discount

- Solution approach using stochastic modeling
  1. Simulate the gross claim amount for each member
  2. Calculate the net claim for each member for SI cap of 100,000
  3. ***This gives the pure claim cost for each member for SI 100,000***
  4. In step 1, summing the four gross amounts gives the gross claim amount for the family
  5. Get the net claim for the family by applying the SI cap of 100,000
  6. ***This gives the pure claim cost for each member for SI 100,000***

  7. ***Comparing the pure claim cost in step 8 with the total of step 5 gives the discount% applicable***

Family floater discount

									Discount		
Sum Insured	100,000								3.90%		
										A	B
Mean	3,138.60	2,697.64	7,040.1[illegible]	6,604.30	1,131.1[illegible]	1,081.45	7,631.2[illegible]	5,851.73	18,941.1[illegible]	16,235.12	15,601.65
SD	17,467.36	13,182.54	20,637.50	17,094.17	7,777.62	6,792.26	34,064.72	20,054.33	44,445.03	[illegible]0,556.07	28,130.15
	Adult 1		Adult 2		Kid 1		Parent 1		To[illegible]l		
	Unlimted	Limited	Unlimted	Limited	Unlimted	Limited	Unlimted	Limited	Unlimted Family Cost	Limited Individual Cost	Lim[illegible]d Family C[illegible]t
1	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	78,113	78,113	78,113	78,113	78,113
8	-	-	-	-	-	-	-	-	-	-	-
9	52,601	52,601	-	-	-	-	-	-	52,601	52,601	52,601

Discount = 1 – B/A

Numbers are for illustration purpose only

Family floater discount

- Scenario
  - Sum insured: Rs. 1,00,000
  - Family composition
    - One adult male - 51 years
    - One adult female - 45 years
    - One kid - 11 years
    - Second kid- 17 years
  - Benefits covered
    - Inpatient
    - Daycare
    - Maternity

Family floater discount

Simulations considerations

- What should be simulated? Claim numbers and claim amounts (and get the total claim by multiplying the two) or the total claim from a member directly.
- Which distributions to use for claim number and claim amount simulation? Choice between empirical distribution and parametric distributions.
- Does the chosen distribution reflect the ‘humps’ and the ‘tail’ (extreme values) appropriately?
- How many age-bands should be considered?

Family floater discount

Simulations considerations

- Empirical distribution may be based on
  1. '***claim incidence rate***' (expected number of claims per exposure) and '***claim amount per claim***'
  2. '***claim probability***' and '***total amount of claim per member given a claim***'

Family floater discount

Claim bands		Probabilities
Lower	Upper	Age-band 1
1	10,000	24.03%
10,001	25,000	30.00%
25,001	50,000	37.00%
50,001	100,000	6.00%
100,001	250,000	2.00%
250,001	500,000	0.60%
500,001	1,000,000	0.20%
1,000,001	5,000,000	0.17%
	Total	100.00%

Claim incidence rate **5.13%**

Claim bands		Probabilities			
Lower	Upper	Age-band 1	Age-band 2	Age-band 3	Age-band 4
0	0	95.00%	96.00%	93.00%	87.00%
1	10,000	1.20%	0.70%	0.80%	1.00%
10,001	25,000	1.50%	0.90%	1.00%	1.80%
25,001	50,000	1.85%			
50,001	100,000	0.30%			
100,001	250,000	0.10%			
250,001	500,000	0.03%			
500,001	1,000,000	0.01%			
1,000,001	5,000,000	0.01%			
	Total	100.00%			

Type 1 **Type 2**

- 1) is easily available using the exposure and claim data by age. 2) is possible only when the exposure and claims can be linked by a ‘key’.
- Alternatively, using 1), 2) can be ‘simulated’

Numbers for illustration purposes only

Family floater discount

Simulations considerations

- Which distributions to use for claim number and claim amount simulation?
  - Parametric claim amount distributions such as LogNormal may not reflect the 'actual' distribution behavior for example
    - Tail probabilities
    - Distribution humps at certain claim bands e.g. 100,000 to 300,000 for age bands 50-70 due to major surgeries at this age
  - Empirical distributions can be used so as to simulate from 'near real' scenarios
  - Judgmental smoothing may be required at the tail

Family floater discount

- Calibration
  - Initial estimates obtained from ‘claims database’
  - Each claim mapped to benefit type using ICD
  - Mean and Standard Deviation calculated using historical data to be used for ***LogNormal***
  - We have used ***Poisson*** for claim number and ***LogNormal*** for claim amount simulation

Initial Estimates from Data

	Adult 1 - Male	Adult 2 - Female	Kid 1	Parent 1
Inpatient				
Frequency	4.96%	4.59%	3.15%	8.23%
Cost - Mean	60,956	53,069	28,476	78,476
Cost - SD	54,860	47,762	25,629	70,629
Daycare	Adult 1 - Male	Adult 2 - Female	Kid 1	Parent 1
Frequency	0.96%	0.92%	1.20%	2.20%
Cost - Mean	30,693	30,327	14,325	45,325
Cost - SD	26,089	25,778	12,176	38,526
Maternity	Adult 1 - Male	Adult 2 - Female	Kid 1	Parent 1
Frequency		15.00%		
Cost - Mean		31,244		
Cost - SD		18,746		

Model Parameters

	Adult 1 - Male	Adult 2 - Female	Kid 1	Parent 1
Frequency Based on Poisson				
Inpatient	4.96%	4.59%	3.15%	8.23%
DayCare	0.96%	0.92%	1.20%	2.20%
Cost Based on Lognormal	Adult 1 - Male	Adult 2 - Female	Kid 1	Parent 1
Inpatient - Mean	10.72	10.58	9.96	10.97
Inpatient - SD	0.77	0.77	0.77	0.77
DayCare - Mean	10.06	10.05	9.30	10.45
DayCare - SD	0.74	0.74	0.74	0.74
Maternity - Mean		10.20		
Maternity - SD		0.55		

Family floater discount

Simulation steps

- Claim numbers
  - Generate a random number from a uniform distribution, U(0,1)
  - Compare it with the cumulative probabilities of the calibrated Poisson distribution to generate the corresponding Poisson variate.
  - Repeat the process for each family member
- Claim amounts
  - Generate from Lognormal using any of the standard methods e.g. transformation of a Uniform random variate or using the Excel spreadsheet function.

Family floater discount

- Results from one simulation
  - Claim incidence

Benefits	Frequency Simulation			
	Adult Male	Adult Female	Kid	Parent
Inaptient	1	-	-	-
Day Care	-	-	-	1
Maternity		-		
Total	1	-	-	1

  - Severity per Claim

Benefits	Cost Simulation											
	Adult Male			Adult Female			Kid			Parent		
	Claim 1	Claim 2	Total Severity	Claim 1	Claim 2	Total Severity	Claim 1	Claim 2	Total Severity	Claim 1	Claim 2	Total Severity
Inaptient	25,777.6	-	25,777.6	-	-	-	-	-	-	-	-	-
Day Care	-	-	-	-	-	-	-	-	-	19,985.5	-	19,985.5
Maternity				-		-						
Total	25,777.6	-	25,777.6	-	-	-	-	-	-	19,985.5	-	19,985.5

  - Severity per member (all claims)

	Adult Male	Adult Female	Kid	Parent
Total Severity	25,777.6	-	-	19,985.5

Family floater discount

- Results from 10,000 simulations
  - Unlimited severity per member

Simulations					
Sr. No	Adult Male	Adult Female	Kid	Parent	Total
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-
7	-	-	-	78,113	78,113
8	-	-	-	-	-
9	52,601	-	-	-	52,601
10	-	-	-	-	-
11	-	-	-	-	-
12	-	-	-	-	-
13	-	-	-	-	-
14	-	-	-	-	-
15	-	-	-	177,083	177,083
16	-	-	43,437	-	43,437
17	-	44,128	-	46,741	90,870
18	-	-	-	-	-
19	-	-	-	-	-
20	-	20,645	-	227,382	248,027
21	-	-	-	-	-
22	-	-	-	-	-
23	-	88,856	-	-	88,856
24	-	-	-	-	-
25	-	-	-	-	-
26	-	-	-	36,222	36,222
27	-	-	-	-	-
28	-	113,942	-	-	113,942

Family floater discount

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4	-	-	-	-	-	-	-	-	-	-	-
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Q&A

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