Institute of Actuaries of India

Subject SP8 – General Insurance: Pricing

December 2022 Examination

INDICATIVE SOLUTION

Introduction

The indicative solution has been written by the Examiners with the aim of helping candidates. The solutions given are only indicative. It is realized that there could be other points as valid answers and examiner have given credit for any alternative approach or interpretation which they consider to be reasonable

Solution 1:

i) A Catastrophe models typically consisting of a five interlinked modules:

- Event module
  - A database of stochastic events (the event set)
  - with each event defined by its physical parameters, location and annual probability / frequency of occurrence.
- Hazard module:
  - This module determines the hazard of each event at each location.
  - The hazard is the consequence of the event that causes damage.
  - E.g. in the case of a hurricane, wind speed is the primary cause; for an earthquake it is ground shaking.
- Inventory (or exposure) module:
  - A detailed exposure database of the insured systems and structures.
  - As well as location this will include further details such as age, occupancy and construction.
- Vulnerability module:
  - Vulnerability can be defined as the degree of loss to a particular system or structure
  - resulting from exposure to a given hazard (often expressed as a percentage of sum insured).
- Financial analysis module
  - Uses a database of policy conditions (limits, excess, sub-limits, coverage terms)

  …to translate the total ground-up loss into an insured loss.

[1/2 mark per point, **Max 6]**

ii) Traditional rating approaches such as burning cost and frequency / severity work well for a high frequency, low severity risks.
They are far less appropriate for a low frequency, high severity risk.
…this is because the observed losses may not reflect the true underlying risks,
…as the period over which losses have been observed may be much shorter than the return period of the losses under consideration.
In some cases, certain event scenarios under consideration may never have occurred previously. [1/2 mark per point, **Max 2]**

[8 Marks]

Solution 2:

Claim frequency and severity are assumed to be independent. [1]

$\Phi(y) =$ 1.95/2 = 0.975, giving $y = 1.960$ [0.5]
$n_N = (1.960\text{^}2)/ (0.05\text{^}2) = 1536.64$ [0.5]

For $X \sim Gamma(1.68,5)$ we have μ_x=1.68/5 and $\sigma^2_x = 1.68/25$ [1]

$n_S = n_N + n_X = n_N (1+CV^2_x)$
= 1536.64(1+((1.68/25) / ((1.68/5) ^2)))
= 2451.31 [1]

Since the expected number of claims is unknown, we assume that the observed number of claims is an adequate approximation of the expected number of claims.

Using the square root rule:

Z = (400/2451.31)^0.5 = 0.404 [1]

[5 Marks]

Solution 3:

Solar Power plant:

i) Coverages & Perils:

- Fire
- Explosion
- War / terrorism
- Natural Catastrophes e.g. STFI (Storm, Tempest, Flood, Inundation), Wave/Tsunami damage, if based in sea, Earthquake / Volcano, Subsidence etc. (any 2)
- Manufacturer / Product warranty on solar cells
- Solar energy shortfall / performance warranty
- Breakdown/failure of machinery
- Third party Liability (property damage / death or bodily injury)
- Employers' liability for people employed at the site
- Theft (e.g. copper wiring)
- Malicious damage / vandalism
- Accidental damage
- Damage to parts in transit
- Loss of profits/consequential loss
- Construction risks [1/2 mark per point, **Max 6]**

ii) Data sources:

- Reinsurer data / Broker data
- Competitor / market rates for similar power plants
- Industry/scientific studies/statistics
- Pricing data for similar products available overseas [1/2 mark per point, **Max 2]**

iii) The external data could be:

- Sparse or missing values
  …The data available in respect of exposure and claims for ascertaining the price mostly contains mostly zeroes or blanks for most data items.
- Not granular
  …The data available is largely aggregated and granular detailed analysis for different rating is not possible.
- not developed, as the cover is new and fast-evolving
  …The ultimate claims experience is not available as the underlying insurance coverage for the risks continues
- out of date
  …The exposure and claims data are not consistent with respect to time
- poor quality
  …The details corresponding to exposure and claims do not corroborate
- not representative of the type of solar power plants in specifically, but of all power plants overall
- Heterogeneity driven by (any 4):
  - Different geographies
  - Different levels of cover (deductibles, excess, etc)
  - Different terms and conditions
  - Errors in data
  - Inconsistent format/coding of data
  - Different processes by different insurers

- Different definitions of data (paid, o/s, etc)\
- Different loading for expenses, profits, etc [1/2 mark per point, **Max 5]**

iv)

- Policy / cover details:
  - term required (1 year, 5 years, etc)
  - deductible or excess required
  - limits of cover required (if any)
  - Sum Insured
  - types of cover
  - exclusions, if any.

- Risk Details
  - Risk location details
  - located on land or sea
  - Size of plant - Area covered, Plant capacity te.
  - Value of plant
    i. Number of solar panels
    ii. Number of batteries/cells
    iii. Type of solar panels/cells
    iv. Value of each solar panel
    v. Value of each battery/cell
  - Age of solar panels/cells
  - Expected Life of solar panels / cells
    i. There is a gradual reduction in solar panel capacity over years
    ii. Required for OEM warranty
  - Plans for upgrading plant / adding capacity
  - Safety features within solar panels / cells / circuiting
  - Security of the site
  - Quality of management of ABC company
  - Number of employees
  - Last year's premium
  - Turnover/profit
  - Ease of access for repairs

- Historical losses:
  - Claim history with previous insurer (if any) / experience rating
  - History of losses (unclaimed)
  - Cause + type of each loss (claimed and/or unclaimed)
  - Exposure details to match
  - Dates of each loss
  - Amount of each loss and time taken to settle [1/2 mark for each point, **Max 12]**

[25 Marks]

Solution 4:

i) Liability insurance

- provides indemnity where the insured, owing to some form of tort (private or civil wrong, such as negligence), is legally liable to pay compensation to a third party.
- Coverage for property damage
- …bodily injury

- …personal and advertising injury
- Cover can be on a claims-made or losses-occurring basis.
- Coverage also be provided for fault liability
- May cover related legal expenses.
- Indemnity to individuals from personal losses if they are sued as a result of serving as a director or an officer [1/2 mark for each point, **Max 3]**

ii)

- **Employers' liability**

- The construction process is likely to involve hazardous materials or working conditions.
- EL cover indemnifies the company against legal liability to compensate an…
- …employee or his or her estate…
- …for bodily injury, disease or death and loss of, or damage to, employees' property…
- …owing to negligence of the employer, or fellow employees, in the course of employment.
- It may also be a legal requirement.

- **Directors' and officers' liability**

- The company is likely to purchase D&O insurance on behalf of its Directors
- …to indemnify them against legal liability ..
- …to compensate third parties owing to…
- …any wrongful act…
- …e.g. allowing false financial statements to be published…
- …allowing the company to continue operating when it should have been declared insolvent
- any act resulting in the insured being declared unfit for his or her role.

- **Motor third-party liability**

- The company will own various motor vehicles, e.g. for transporting materials
- MTPL covers the driver's legal liability to pay compensation to a third party
- …for personal injury
- …or damage to their property
- The cover may be mandated by law.
- Marine or aviation liability cover might also be required for a large company if it owns these types of vessels.

- **Public liability**

- The company will want to be indemnified against legal liability to pay compensation to a third party
- …such as visitors to the site and owners of neighbouring properties
- ….other than those liabilities covered by other liability insurance.
- May be a compulsory cover in some territories

- **Environmental liability**

- The company should indemnify itself against the legal liability to compensate third parties as a result of unintentional pollution for which they are deemed responsible.
- .)This would also cover the costs of cleaning up the pollution and may also cover any regulatory fines.

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- **Professional indemnity**

- The company may employ surveyors and architects and will want to indemnify itself against legal liability…

- ….for losses resulting from incorrect advice, an error in plans (or other suitable example).
- It may also want to buy insurance against faulty or unsatisfactory workmanship in the construction. [1/2 mark for each point, **Max 10]**

iii) Rating:

- The sum insured increases as the bridge/tunnel nears completion – tending to the rebuild value.
- The risk to each peril covered varies differently over the duration of the build….
- … e.g., for storm, losses would be relatively low at the start of the project
- … whilst for theft of raw materials, the risk will rise and fall at different stages (or other suitable examples).
- Inflation over the length of the contract is likely to affect the cost of claims.
- Seasonality or economic cycles may affect the intensity of risk over the period.
- The sum insured may also change following revised plans from the civil engineers…
- … or alterations to the bridge/tunnel may be required to meet changing buildings regulations.
- If a flat exposure measure is used over the whole period, we would apply a percentage load to it that varies over time according to the risk profile.
- Or use an exposure measure that varies over the term of the contract.
- This would allow a deposit premium to be determined.
- Over the duration of the contract, the assumptions could be updated and an adjustment premium derived.
- It may be useful to split the premium by the different types of cover, to allow for the variation in different types of risk more accurately [1/2 mark for each point, **Max 5]**

iv) External factors leading to uncertainty (process uncertainty):

- Climate change (frequency of floods)
- Legislation change (compulsory cover/limits, etc)
- Court awards
- Political changes
- Delay in project (due to land acquisition) (impacting inflation estimates for instance)
- Inherent uncertainty (mountain collapsing for instance)
- Economic conditions (inflation, etc)
- Differences in third-party behaviour (environmental activists / lawyers for instance)

[1/2 mark for each point, **Max 4]**

v) Reasons for monitoring

- Assessing actual performance vs expected (/goals)
- Managing risk /re-pricing (adjustments/endorsements)
- Gaining market intelligence (writing other similar businesses)
- Satisfying regulators (capital requirements)
- Reporting requirements (shareholders, etc)
- Reinsurance quotations/requirements
- Reserving
- Part of actuarial control cycle [1/2 mark for each point, **Max 4]**

[26 Marks]

Solution 5:

i)

Revised risk premium = The probability that a claim is above 5000 $\times$ (the average claim size given that the claim is above 5000 minus the 5000 excess) $\times$ original claim frequency. [1]

Now, the total number of claims below 5000 represents 10% of the total claims amounts.

So, if there is a claim:
0.10 = (Prob that the claim is less than 5000 * Avg. amt. of those less than 5000)/ (Avg. amount of all claims)

Assume that the average claim size of those less than 5000 is 4000. [1]

Therefore, if there is a claim, the probability that it is less than 5000 is 62.50%

The probability that a claim is less than 5000 × Average claim for those less than 5000 *plus* probability a claim is more than 5000 × Average of those above 5000 = 25000.

So:

25000 = 0.6250 × 4000 + (1 – 0.6250) × Average amt of those above 5000 [1]

So, the average of those above 5000 is 60000.

The revised risk premium is (1 – 0.6250) × (60000-5000) × 0.2 = 4125 [1]

This calculation assumes that the introduction of an excess will have no impact on the types of policyholder and the claims experience. [1]

[Max 5]

ii)

Collect and project data

- Collect historical data say latest 5-years
- The data pertaining to claim numbers, claim amounts and exposure.
- …data should be adjusted for IBNR, partially settled claims and reopened claims.
- The data should be projected from the date of claim to the current date.

The projection should allow for factors such as changes in:

- … policy conditions and coverage
- …underwriting
- …target market
- …possibly very large claims and seasonality
- …suitable inflation index

Decide upon an excess

- A suitable excess should be chosen
- …which should reflect the excess that is expected to be charged.
- However we might vary or sensitivity test this later.

Consider future inflation and trends

- Using expected future claims inflation
- …data needs to be a projected to the midpoint of the period of exposure.
- …allowing for any trends in claims frequency
- This is because claims will continue to inflate in the future, but the excess will be a fixed amount.

Fit distributions for frequency and amount

- Distributions should be fitted for both the claim frequency
- and grounds-up claim amount
- For claim frequency, a Poisson model might be used.
- For claim amount, a distribution that best fits the data will be used – this might be a gamma or a log-normal distribution.
- Combine the claim frequency and claim amount distributions to obtain the insurer's expected payout using simulation.

- For each simulated claim, the excess is applied to determine the expected claims payout net of excess.
- The ratio of the two expected claims payout gives the required reduction in risk premium.

[1/2 mark each, **Max 7]**

iii)

- The reduction, in practice, would apply to the office premium not the risk premium. Therefore, the allowance for expenses should also be considered.
- Has to be considered how policyholders' behaviour might change as a result of introducing the excess.
- E.g. the policyholders might inflate claims if an excess is applied.
- …or the policyholder may not bother claiming for amounts just above the excess.
- The risk profile of the customers might be different for those with the excess
- e.g.. Insured with good claims history might opt for excess
- Consider the price sensitivity of the market and also competition [1 mark each point, **Max 5]**

[17 Marks]

Solution 6:

UW Year	Ult. Losses (Cr.)	EP (Cr.)	Premium Rate Change	Rate Change Adj. Factor	Inflation Adjustment	Inflated Claims	On Level EP	LR
2016	90	85				110.69	112.57	98.33%
2017	80	75	5%	132.44%	122.99%	95.52	94.60	100.98%
2018	75	80	10%	126.13%	119.41%	86.95	91.73	94.78%
2019	95	100	-5%	114.66%	115.93%	106.92	120.70	88.59%
2020	105	110	-5%	120.70%	112.55%	114.74	139.76	82.10%
2021	100	90	10%	127.05%	109.27%	106.09	103.95	102.06%
2022	110	105	5%	115.50%	106.09%	113.30	115.50	98.10%
2023				110.00%	103.00%		Weight LR	94.27%
							Simple Avg. LR	94.99%

The weighted average loss ratio is 94.27% and the average loss ratio is 94.99%.

[2 marks for Rate change adj. factor,
2 mark for Inflation adjustment,
2 mark for on-level EP,
2 mark for the LR,
Total 8 Marks]

Solution 7:

i)

$$X = \begin{bmatrix} 1 & 1 & 2 & 15 & 225 \\ 1 & 1 & 2 & 12 & 144 \\ 1 & 0 & 0 & 7 & 49 \\ 1 & 0 & 1 & 9 & 81 \end{bmatrix}$$

$$X = \begin{bmatrix} 1 & 1 & 1 & 0 & 15 & 225 \\ 1 & 1 & 1 & 0 & 12 & 144 \\ 1 & 0 & 0 & 1 & 7 & 49 \\ 1 & 0 & 0 & 0 & 9 & 81 \end{bmatrix}$$

[1.5 marks for each correct matrix, Maximum 3]

(Columns need not be in the same order as above across matrices for the categorical factors. If weight of cattle is split into two binary factors, then a matrix with 6 columns)

where (for X on the left)
column 1 = the base level parameter/covariate (intercept was also accepted) [½]
column 2 = Any surgical operation happened in past (0 = No, 1 = Yes) [½]
column 3 = Weight of cattle (0 = small, 1 = medium, 2 = large) [½]
column 4 = Age of Cattle [½]
column 5 = (Age of Cattle) ^2 [1 mark]
[Max 6]

ii) Under the null hypothesis that the two models are not statistically different
$(D1 - D2) / \Phi \sim X^2_{df1-df2}$ [1]

In the example
D1 = 44.3423
D2 = 41.0237

$Df_1 - Df_2 = 2$ [1]

Therefore, the test statistic is

(44.3423-41.0237)/0.31 = 10.71 [1]

Compare with $X^2(10\%) = 4.61$ [1]

As 10.71 > 4.61, we reject the null hypothesis and conclude that the factor weight of cattle is statistically significant. [2]
[Max 5]
[11 Marks]

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