INSTITUTE OF ACTUARIES OF INDIA

SP8 - General Insurance: Pricing

November 2025 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)

i. Satellite Loss, Damage, or Failure Coverage: Coverage includes total or partial loss, property damage, and system failure at each of these critical stages.
- During transit pre-launch
- At launch
- In-orbit operation

ii. Third-Party/Public Liability: Covers bodily injury and property damage to third parties resulting from satellite launch and in-orbit operations

iii. Launch Delay Costs: Reimbursement for additional expenses arising from the delay of a scheduled launch, including storage, rescheduling, and associated operational costs.

iv. Business Interruption Coverage: Protection against loss of revenue if the satellite fails to perform in accordance with the manufacturer's specifications.

v. Manufacturing & Construction Risks: Covers material damage and other risks during the design, assembly, and testing phases of the satellite

vi. Environmental Liability: Protection against liabilities arising from environmental damage caused by satellite-related activities, including launch debris, fuel leaks, or deorbiting impacts. [5 marks]

ii) Model to price XoL program:
- Use the portfolio of the insurance company though the historical data is likely to be sparse.
- For satellites already in orbit, the current health of the satellite is the best indicator of the risk of a future failure.
- Information on the rate and type of failures and anomalies for satellites and launch vehicles can be obtained from publicly accessible sources as well as from commercially available compilations.
- Underwriters/ Brokers can also provide info on failure rates and specific info relating to the individual risks being placed, including the history of anomalies and the latest diagnostics for satellites.
- As most losses occur during launch, the reliability of the launch vehicle can significantly impact the expected losses.
- For launch failure frequency, use historical performance of each launch vehicle and can adjust the probabilities to give weights to the recent launch statistics.
- If launch vehicle is not specified in contract, then use either an average loss frequency or the loss frequency for the launch vehicle most likely to be used.
- Post-separation and in-orbit failure frequency - based on the historical failure stats for satellites that have achieved successful orbits.
- Selected probabilities of loss by age and satellite based on the historical performance of all satellites following an active life approach, i.e. assuming that exposure takes place over a multiple year time period and that the probability of loss changes over time.
- For satellites still to be launched, we determine the probability of satellite failure during launch and during each year following launch.
- Probability of failure during a given year is the prob that the satellite survives to the beginning of the year times the conditional probability of failure during the year. This

procedure generates a discrete probability distribution of failure for each satellite, depending on its age and launch status

- All launch failures are total losses considered for severity.
- We simulate losses for all satellites exposing the portfolio. Attachment of coverage: given a simulated failure, the model attaches all applicable insurance contracts to the loss.

[11 marks]

Following information is needed for each policy in the portfolio:

- UW year
- Insured satellite
- Coverage offered
- Sum insured

Apply the reinsurance program details including attachment points / limits and their exhaustion and reinstatement premiums.

Run the simulation many times and estimate the expected losses related to the portfolio

iii)

i. Limit the number of reinstatements.
ii. Exclude losses arising from faulty parts or poor design.
iii. Excludes war risk and non-weather cat that could affect launch
   - The reinsurer could insist that the insurer
   - improves required testing before launch and require build of satellites and/or launch plans to be approved by appropriate space agencies
iv. Co-pay or impose higher deductible
v. Purchase retrocession or co-insurer with another re-insurer
vi. Stability Clause [3 marks]

[19 Marks]

Solution 2:

Standard for full credibility is nS=nN×(1+CV^2)

Since it is for 95% two-tailed, $\alpha/2 = 0.025$, $\Phi^{-1}(0.975) = 1.96$

Full credibility standard $n_N = (1.96/0.05)^2 = 1536.64$

nS =1536.64 ×(1+12.25)=1536.64×13.25 =20360.48

Since n is less than ns, Full credibility not met, so we use partial credibility.

Credibility factor z = (n/ns)^ 0.5 = (11500/20360.48)^(0.5) = 0.7515

Credibility Premium=Z·X+(1−Z) ·β = 0.7515*10.25 + (1-0.7515)* 8

= INR 9.69 million

Assumed the observed number of claims is an appropriate estimate of the expected number.

[4 marks]

Solution 3:

The catastrophe loading calculated purely from historical cyclone losses is approximately INR 7.3crores over 10 years, which translates to an average annual loss of about INR 0.73 crores. This is roughly double the catastrophe model's expected loss of INR 0.37 crores.

- India is known to be vulnerable to cyclones, as evidenced by 3 loss years within the last decade (2018, 2019, and 2021). However, the total exposure size and its changes over time are not fully detailed, making it challenging to precisely assess the severity and frequency of cyclone impacts on the portfolio.
- According to the catastrophe model, losses of INR 6 crores to INR 12 crores have a very low annual probability (ranging from 0.1% to 0.5%), but the 2019 loss of INR 6.8 crores fits within this tail region, indicating the model's tail estimates are broadly consistent with historical extreme events.
- Investigating the 2019 loss to understand whether the loss is normally expected every 10 years If not, the loss should be adjusted with the higher return period attached to it.
- The small losses in 2018 fall within the more frequent loss brackets modeled.
- The 2021 loss is much smaller and falls outside the range of the catastrophe model results. If the catastrophe model does not generate small events, we should model such losses as part of attritional claims .
- The recent absence of cyclone losses in the last few years (2022–2025) could reflect changes in risk exposure, improved mitigation measures, or simply natural variability in cyclone occurrence. It would be prudent to investigate whether portfolio composition has shifted towards earlier engineering phases, where risk is typically lower.
- It is important to review the quality of the historical loss data—whether losses are gross or net of reinsurance recoveries.
- It is to consider any changes in underwriting or risk terms have occurred that might affect the loss profile.
- Finally, the clustering of losses in certain years might be linked to broader climatic phenomena, such as El Niño events, and should be considered in future risk assessments.
- Overall, while the historical data is limited, it does not provide sufficient evidence to discount the catastrophe model. The model remains a valuable tool, but its outputs should be regularly validated and supplemented with expert judgment and additional data where possible.
- It is also worth to analyse the losses based on pincode. This will also lead to analyse the diversification impact. **[8 Marks]**

Solution 4:

i)

- What the company does?
- Number of employees
- Revenue/turnover/average profits
- Volume of data the company holds

- Complexity of data/systems architecture
- Sensitivity of data captured/held
- Dependence of the revenue on IT Location of servers e.g. cloud or particular host
- Data and IT security controls in place eg: firewalls in place or anti-virus software in place or staff training and related security measures
- History of incidents or near-misses
- Who the company shares data with or receives data from and the third parties' data/IT security standards
- Business continuity plan in case of IT event / backup of servers etc
- Level of regulatory fines for breaches
- Level of cover chosen, e.g. Sum Insured / Reputational damage / Legal costs / Excess and limits / other example
- Trends in incidence and severity of cyber attacks [7 marks]

ii)

- Lack of historical events to estimate likelihood and severity of losses
- Many events go undetected
- Uncertainty about frequency/severity of catastrophe events, e.g. a worldwide ransomware attack affecting many insured
- Uncertainty related to possibility of past events being detected years later (depending on when the retroactive date is
- Large variety of ways in which security could be breached
- Large variety of ways in which the business may be impacted
- Ways in which security can be breached is evolving / increasing skill, resource and number of those launching attacks
- As are the methods by which businesses can protect themselves, it is difficult to quantify the benefit that certain protection measures give
- Evolving regulatory requirements and uncertainty around potential fines for breaches
- Uncertainty around the level of moral hazard or anti-selection, and how to allow for this in pricing [5 marks]

[12 Marks]

Solution 5:

i) Response variable: Binary (1 = churned, 0 = not churned)

Appropriate distribution: Binomial- Because the outcome is binary, this aligns with the binomial distribution in the GLM framework.

Link function: Logit (logistic) link [1 mark]

ii) In a GLM, the link function connects the mean of the response variable (μ) to the linear predictor (Xβ):

$$g(\mu) = X\beta$$

- Biased Coefficient Estimates: The model incorrectly describes how predictors influence the outcome.
- Violation of Link-Mean Relationship: GLMs assume a specific functional form between the mean of the response and predictors. If the link is wrong, the model can't capture that relationship. You underestimate or overestimate effects systematically.
- Incorrect Predictions: Even if the coefficients are numerically stable, the model may produce poor predictions, especially on new/unseen data.
- Misleading Inference: Hypothesis tests, p-values, and confidence intervals become unreliable. predictor might appear statistically significant when it's not, or vice versa.
- Poor Model Fit: Model deviance and residuals will suggest lack of fit.
- Numerical Instability or Convergence Issues: In some cases, if the link is too incompatible with the data, model fitting algorithms (like IRLS) may fail to converge.

[3 marks]

iii) Reasons are:

1. Capturing Nonlinear Relationships

- GLMs are linear in predictors.
- GAMs model complex, nonlinear effects without requiring you to specify the exact form.
- Example: The effect of age on health risk may increase sharply after 60 — GAM can model this flexibly.

2. Better Fit & Predictive Accuracy

- Because GAMs can capture subtle nonlinear patterns, they often provide better model fit and improved prediction.

3. Interpretability

- GAMs maintain interpretability because each predictor's effect is modeled separately as a smooth function.
- This is easier to interpret than "black-box" nonlinear models like neural nets.

4. Handling Mixed Data Types

- Like GLMs, GAMs can handle different types of response variables (binomial, Poisson, Gaussian, etc.) because they are an extension of GLMs.

5. Partial Linear Models

- GAMs allow you to model some predictors linearly and others nonlinearly.

[4 marks]
[8 Marks]

Solution 6: All working in crores

RI Loss ratio = Claims Incurred with IBNR/ Premium earned

= 30% *(14 + 4) *1.10 /30% * 27

= 5.94/ 8.10 = 73.33%

Profit commission payable is 10%

Profit commission =10% * (Ceded EP- RI share in Claims)

= 10% * (8.10- 5.94) = 10% * 2.16 = Rs. 0.216

Amt payable to Reinsurer = Ceded WP- RI share in Claims – Ceding commission- Profit commission payable

= 9.00- 5.94- 1.08- 0.216

= 1.764 crores **[5 Marks]**

Solution 7:

i)

- It seems inconsistent to add an expense ratio based on one year to a loss ratio averaged over 5 years to get the combined ratio.
- Consistency of definitions, e.g. is treatment of RI consistent, definition across all the metrics.
- Loss ratio is on an underwriting year basis and expense ratio is on calendar year.
- Some contracts may be multi-year such as construction projects, so 2024 may not be representative
- Proportion of Premium:
    - The proportion of premium is based on the latest underwriting year. We do not have information about the increasing or decreasing trend in the volume.
    - The current underwriting year may not be a full year so seasonality could distort the proportions.
    - Property book is multi-year so 2024 may not be representative
    - This might include some large one-off deals example Crop, PA scheme that are unlikely to be repeated.
- Loss Ratios:
    - The loss ratios are based on the historical 5-years. This may be a short period of time if the classes have volatile results. This is especially true for classes which have the potential for large losses. The loss ratios may not have been adjusted for IBNR. Long tailed classes like Motor TP may not have developed fully in 5 years.
    - We can't see the trends in the loss ratios as we only have averages over time.
    - It's unclear if the loss ratios are just simple averages over the last 5 years or if they have been adjusted to allow for e.g.: Changes in policy terms and conditions / coverage or unusual experience or Rate changes / claims inflation
    - There may be differences in prudence of case estimates between classes
    - Lacks information on inflation/trends/business goals/other external influences.
- Expense Ratios

- The expense ratios are based on the latest financial year. The ratios are probably calculated based on FY expenses divided by FY written premium in the financial year.
- With a planned increase in business volume, fixed expenses will reduce as a proportion of premium.
- Ensure that expense ratios include cost of reinsurance cover / commission and other operational expenses like policy administration, CHE.
- There could be one-off expenses e.g. the cost of hiring a consultant to improve the profitability for a line of business.
- Would be better to get a split of fixed and variable costs to reflect new volumes appropriately.
- Planned changes in expenses should be allowed for e.g. hiring of specialist energy claims team. [8 marks]

ii)

- Investment returns on each line of business.
- Capital allocation for each line of business i.e. capital-intensive lines of business should have a lower combined ratio.
- Correlation/ Diversification across the classes.
- Risk appetite and whether altering between base period and future projection point Premium changes must be compared with current reinsurance program, subsequently allowing for future changes in reinsurance structure.
- Loss ratios split by attritional, large and CAT losses.
- If appropriate, more granular splits, e.g. by channel and/or product and/or territory and/or peril.
- The current position in the insurance cycle and Planned rate changes
- Insurer's reputation and broker relations for specific lines of business
- Market share for each line of business might indicate areas with growth potential Price sensitivity/elasticity by rating segment persistency
- Target lines with lower market loss ratios
- Understand why own performance is different from market Policy terms and conditions changes Distribution changes and possible impact on expenses.
- New deals/products in the pipeline Budget for advertising / marketing

[5 marks]

[13 Marks]

Solution 8:

- More detail required for Retail health generally / data requirements more granular
  - Age and gender- Critical for retail health. Average or distribution data used to assess overall risk in group health.
  - Medical History: Retail Health: Requires detailed individual medical disclosures (past illnesses, treatments, etc.). Group Health: Typically does not require individual medical histories; uses group-level risk assumptions.

  - Lifestyle & Occupation: Retail Health: Underwritten per individual—factors like smoking, alcohol use, and high-risk jobs affect premiums. Group Health: Broad occupation category of the employer considered; no individual lifestyle assessment.
  - Geographic Location: Retail Health: Pricing varies by city or region due to local medical cost differences. Group Health: Based on the group's main office or average location; less granular.
- Claims History: Retail Health: Individual no past claims may lead to lower premiums or increase in Sum Insured. Group Health: Group's past claims experience (loss ratio, frequency, amount) is crucial in pricing.
- Retail lines is likely to carry out credit checks on the policyholder. Group Health is likely to carry out checks on the company requesting cover, such as financial performance.
- More information is required to be captured to enable cross selling / marketing activity. This is unlikely in group business especially if it comes through brokers.
- Experience rating are used for Group health business. Change in exposure is required.
- Group Size: Retail Health: Not applicable. Group Health: Larger groups get better pricing due to diversification and credibility.
- Enrollment and Membership data are required for Group health for addition and deletion of members.
- Network Hospital Utilisation: Retail Health :Individual hospital preferences (tier, city) influence costs. Group Health: Group-wise usage patterns (preferred hospitals, cities) influence TPA and network pricing negotiations. **[10 marks]**

Solution 9:

i)

Advantages:

- Potential Causal Link to Risk: Drivers who sleep less are more likely to be fatigued and hence at greater risk of being involved in accidents. Including sleep duration may help in explaining some of the variation in claim frequency.
- Improved Risk Segmentation: the variable may enhance model segmentation and improve pricing adequacy
- Lifestyle Indicator: Sleep duration might indirectly reflect other factors like occupation (e.g., shift workers), stress levels, or health — which can be correlated with driving habits.

Disadvantages:

- An hour of sleep is well defined and objective, however it would be difficult to obtain and verify. Obtaining data: hours slept per night is not often recorded by individuals, let alone reported.
- Verifying data: You would have to rely on self-reporting which would be subject to unintentional mis measurement or would encourage moral hazard and people would lie about it. Once they report it, it would be very difficult to verify.

- It's an ambiguous measure- hours in bed? Hours with eyes closed? Deep sleep? What if insured gets up to drink water?
- Asking for sleep data may be seen as intrusive, raising customer trust and privacy concerns.
- Model Stability: Sleep patterns can change frequently and are hard to track consistently.
- Sleep duration may correlate with other variables (e.g., occupation, age), making it redundant in the presence of better-measured proxies.
- The marginal gain in model accuracy or segmentation may not justify the additional complexity or data collection effort. [5 marks]

ii)

- Vehicle year is easy to determine as compared to hours driven. It would require expensive telematics to determine
- Hours driven may or may not be proportional to expected loss. Some areas may be having more traffic congestion than others. Hence, more number of hours driven does not necessarily translate to higher expected loss
- The current exposure base in vehicle years. Changing to different exposure base may alter the premium rates significantly
- Changing the exposure base can be very expensive and time consuming. We need to restate the entire historical data for any analysis and trending.
- There may not be any data captured for this variable and so, may not be possible to restate the historical data. There may not be any industry benchmarks available for this exposure base
- Hours driven may not be appropriate as this can be manipulated by drivers if self-reported. [3 mark]

iii) Adjacency based smoothing to be used. It will handle urban and rural differences more appropriately localized risk [2 marks]

iv) Employing too low a level of smoothing will capture too much noise (i.e. over fit) causing distortions and reducing the predictiveness of the model.

Employing too high a level of smoothing will blur the experience so that some of the true underlying residual variation is lost.

Over or under smoothing will lead to inaccurate pricing and anti-selection. [2 marks]

v)

- To constrain selected rating factors – due to regulatory or marketing considerations, we may have to constrain certain rating factors to take on pre-specified values. E.g., discount provided on personal motor insurance for different levels of No Claim Discount. We must fix the values of certain rating factors in advance, and allow the remaining rating factors to optimally conform to these constraints.

- Offset can be used in sequential modeling – this can be applied while building a credit scoring model on top of an existing rating plan. This is achieved by fitting the first model, offsetting all the values (ie fixing the parameters at the values obtained in fitting the first model), and then fitting a second model to explain the remaining patterns in the data.
- To compare a final model to a new "hold-out" sample of data - to do this, first divide the data into modelling and test sets. A division like ¾ and ¼ may be appropriate. Then fit the model on the main dataset, and then fully offset it. Offsetting fixes the parameters so that they can be reloaded and scored against the test set. [2 marks]

[14 Marks]

Solution 10: Assumptions:

1. Losses occur at mid point of each year
2. Claims are developed. There are no IBNR provisions. Year 2024-25 is developed.
3. 10% inflation will be observed in future as well.

Loss Year	Incurred claims	Inflation factor	Inflated amt	Recovery Max (min(Inflated amt- deductible, limit),0)	Marks
2020-21	750,000	1.1^5 =1.61	1,207,500	207,500	1
2022-23	1,700,000	1.1^3= 1.33	2,261,000	500,000	1
2023-24	800,000	1.1^2= 1.21	968,000	-	0.5
Total				707,500	0.5

Expected recovery In 1 year = 707500/ 5 = 1,41,500

Premium = Burn cost/ (1- Expense Loading) = 141,500/ 0.75 = 188,667

Rate on Line= Premium/ Limit = 37.73% **[7 Marks]**

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