

INSTITUTE OF ACTUARIES OF INDIA

EXAMINATIONS

26th March 2022

Subject CP2B – Actuarial Modelling (Paper B)

Time allowed: 3 Hour 30 Minutes (09.30 – 13.00 Hours)

Total Marks: 100

Exam requirements

Read the background document, which describes the scenarios that have been modelled and documented for this project and the work that remains outstanding.

Read the audit trail, which has been written by your colleague, another actuarial student, for the calculations performed by him. This will assist you in following and understanding the calculations performed in the Excel model provided.

You are not required to add or amend the audit trail.

You should assume that your colleague's calculations have been checked and are correct. Expand the spreadsheet model to produce the following additional calculations. You should ensure that the additional work you undertake on the spreadsheet contains appropriate self-checks and you should not overwrite the existing calculations.

Q. 1) Modelling steps

- i) Extend the cumulative loss ratio distribution of internal data upto 225% and calculate the incremental probabilities. (2)
- ii) Approach-2: Repeat all the calculations completed by your colleague in Approach-1 replacing the exposure curve with the new probability distribution generated using Internal data for the reinsurance arrangement 20% in excess of 100%. Calculate the expected values of loss ratios and compare the same with results from Approach-1. (5)

You may copy Sheet! Approach-1 and modify the same as needed.

- iii) Calculate the reinsurance rates for the XL reinsurance arrangement
20% in excess of 100% and
20% in excess of 120%
using the given exposure curve and that generated one based on internal data. Compare the same in a suitable table. (3)
 - iv) Illustrate the exposure curve generated in Q.1 (i) above in a suitable chart. (5)
- [15]**

- Q. 2) Prepare a summary document capturing the main features and results of the work completed by you and your colleague. You can assume that the summary is being prepared for your manager, a Senior Actuary, who will present the work to the senior management of your company.

Your summary should include the following:

- Purpose of the project, data, methodology and assumptions used by you and your colleague
- Results, including relevant tables and charts
- Commentary on the results
- Key conclusions
- Suggested next steps

Commentary on the results should cover, but not be limited to:

- Comparison of the two exposure curves and reinsurance arrangements.
- Analytical comments on each stage of the results, including any commentary on the different patterns, if any, observed in the result and any unusual features.
- An explanation for the differences between the results under the two modelled approaches.
- Next steps specific to the project with underlying rationale.

The summary should cover the full scope of the project, including the current approach, which was modelled in the spreadsheet provided to you.

You are not required to add or amend the audit trail.

Marks available for the summary:

- | | |
|---|-------------|
| • Purpose data and assumptions | (10) |
| • Methodology | (20) |
| • Data Checks and reasonableness checks | (5) |
| • Results, including charts | (5) |
| • Commentary on results and conclusions | (20) |
| • Next steps | (15) |
| • Drafting | (10) |
| | [85] |

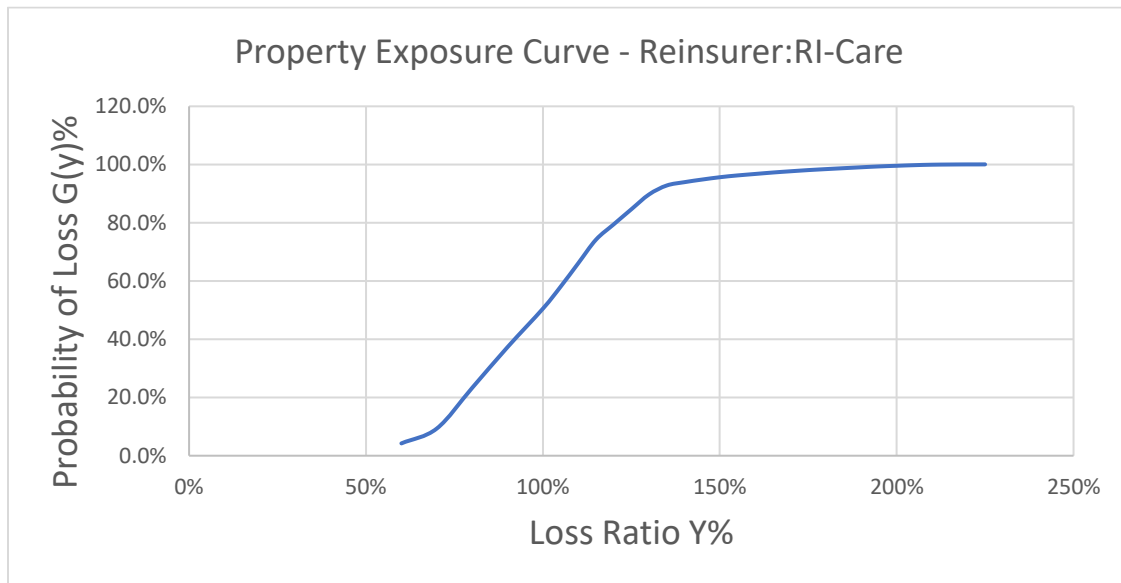
Background

Government of a developing country is looking to protect its rural households against multiple perils through a suitable insurance scheme. The Government, in consultation with a large insurer has developed a benefit-based household Insurance scheme that will pay out in the event of damage to property and contents by fire or natural catastrophes. The cover also includes payment in the event of death by accident to the policy holder, family members and their livestock.

The proposed sum insured is INR 5 lakhs per household, and the scheme is likely to cover about 10 crore beneficiaries within the next financial year. Taking into consideration the large-scale implementation of the scheme, the insurer has designed a benefit-based policy but fears the loss ratio may be higher in the absence of any inspection or survey in the event of a claim.

You work in the product department of the insurance company that is in discussion with the Government in designing this scheme. A colleague of yours was involved in the pricing of the scheme in the past. However, he is on long leave due to personal circumstances and hence, your manager, has asked you to take over the modelling of the pricing of the scheme.

You have been provided with the following exposure curve prepared from last 20 years data of a similar product received from a reinsurer RI-Care.



Exposure curve is essentially a probability distribution of the loss ratio that shows cumulative probability of portfolio hitting a given loss ratio. This distribution is also used for the calculation of the excess of loss (XL) reinsurance rate, for example: the reinsurance rate for excess of loss Y over X is calculated as the difference in probability of losses X+Y and X. This is multiplied by the expected premium income of the insurer to arrive at the reinsurance premium to be charged.

Example: For an insurance policy that has a sum insured of INR 10,000 for which the risk premium is INR 100, the reinsurance risk premium for an excess of loss reinsurance for INR 2,000 in excess of INR 5,000 is calculated from the exposure curve as follows:

XL Premium = INR 100 * (G(0.7) – G(0.5)) Where G(y) is the probability read out from the above exposure curve.

(Where Upper limit is 0.7 (70%), 0.5 (50%) is the attachment point and reinsured band is 20% in terms of loss ratio)

You have been provided with the model and audit trail of the work done by your colleague.

It is expected that the gross premium payable by the policy holder will be 0.2% of the Sum Insured. Assuming 10 crore beneficiaries, the total Expected Premium Income (EPI) is likely to be INR 10,000 crores.

The given model is used to calculate the gross and net loss ratio to the insurer and reinsurer using the property exposure curve provided by the reinsurer: RI-Care with a reinsurance arrangement 20% in excess of 100%.

The model also calculates the expected values of gross and net loss ratios for both the insurer and reinsurer based on the gross loss ratios and their associated probability of occurrence.

You may ignore commission and management expenses of both insurer and reinsurer.

Further development

Your manager feels that the relying solely on the exposure curve provided by the reinsurer RI-Care is not ideal for product pricing. Hence, he has asked the actuarial team to fit a distribution to the loss ratio from your company's own data. Your colleague could collect about 5,000 data points over the last 10 years. The underwriting year wise premiums and claims are provided to you under "Data-Internal" tab of the model. The premiums are adjusted for change in premium rates over the years and the claims are adjusted for inflation. Your colleague has calculated the loss ratio for each data point in the portfolio. Based on the claims experience, the maximum loss ratio is found to be 225%. The probability of loss, G is found to follow a Lognormal distribution with parameters:

Mean of $\text{Ln}(x) = -0.296881$ and

Standard deviation of $\text{Ln}(x) = 0.3504859$ where x is the loss ratio in %

Your manager wants you to use the exposure curve developed using internal data and compare the reinsurance rates and expected gross and net loss ratios with those calculated using the exposure curve provided by reinsurer RI-Care and produce a summary report of the project to be presented to the senior management of the company.

Your summary report should cover all elements of the work done by your colleague and the additional modelling work done by you including the following elements.

1. The exposure curve calculated using the internal data.
2. Comparison of expected loss ratios based on the exposure curve from reinsurer RI-Care and that based on the internal data, for reinsurance arrangement 20% in excess of 100%
3. Comparison of XL reinsurance rates for 20% in excess of 100% and 20% in excess of 120% in a tabular format.
4. Your views on which of the exposure curves will be suitable for the insurer.
5. In addition, your summary should include the purpose of the project, methodology, assumptions, results, commentary on results, key conclusions, and next steps.

You are not expected to include the additional modelling you undertake in the audit trail, but the approach and results of all elements of the scenario (both those completed by your colleague and by you) should be included in the summary.

Audit Trail

Background

The project models the loss ratios for a large scale pre-underwritten benefit insurance product that protects rural households from multiple perils. In addition to the property and contents, the insurance also provides a benefit in the case of an accident to the policyholder, family members and their livestock.

The enclosed spreadsheet is used to calculate the gross and net loss ratio to the insurer and reinsurer using the property exposure curve provided by the reinsurer: RI-Care with a reinsurance arrangement 20% in excess of 100%. The model calculates the net loss ratios

under different levels of gross loss ratios. The expected value of loss ratios is calculated for both the insurer and reinsurer based on the probability of occurrence of the loss.

Objective

To compare an excess of loss reinsurance protection and calculate the expected loss ratios for the insurer and reinsurer using the exposure curve provided by a reinsurer and internal data.

Data

The Property Exposure curve provided by reinsurer RI-Care is provided in Sheet! Data-RI-Care. The exposure curve lists the probability of different loss ratios up to the maximum of 225%.

The gross loss ratio, probability of occurrence and the cumulative probability is given in column A:C along with the graphical illustration.

In addition, the internal data is provided in Sheet! Data-Internal. There are 4,995 data points available that include the individual premiums from policies written from 2010 to 2019 along with the claims. The premiums are adjusted for change in premium rates over the years and the claims are adjusted for inflation. Loss number, underwriting year, premium and claims are given in columns A:D. Individual loss ratios are calculated in column E and natural log (LN) of the same is calculated in column F. The mean and standard deviation of the loss ratios in % and the natural log of the same is tabulated in cells H1:J3. Excel formulas AVERAGE and STDEV is used to calculate the Mean and SD respectively.

A Log-Normal distribution fitted using the Mean and SD above is given in cells L2:M15 for different gross loss ratios up to 140%. The Excel formula LOGNORM.DIST with associated parameters is used to calculate the cumulative probability of the loss ratio.

In addition, the sum insured per beneficiary, the premium charged, expected number of beneficiaries and total Expected Premium Income (EPI) is given in Sheet! Parameters cells B3:C9

Assumptions

The given exposure curve represents the likely expected future claim performance

The data used for preparation of exposure curve is already de-trended

No other inflation adjustments are needed

Premium for Catastrophe loss if any is already included

No other reinsurance arrangement is there other than the proposed XL

Claims already include the claims management expenses

The reinsurer has not entered into any retrocession arrangement

The excess of loss premium is paid in advance

Worksheet: Approach-1

This worksheet shows the working of Expected loss ratio with XL reinsurance of 20% in excess of 100% under different Gross loss scenarios and its associated probabilities using the exposure curve provided by reinsurer RI-Care.

Table -1: XL arrangement – Cells A4:C9 show the XL reinsurance arrangement for 20% in excess of 100%

Attachment point = 100% in cell C5.

Upper Limit = 120% in cell C6.

Reinsured band (A) in cell C7.

Cell C8: RI rate from Exposure curve (B) = 29% which is read out from sheet! Data-RI-Care i.e. Sheet! 'Data-RI-Care'!C11-'Data-RI-Care'!C7.

RI Rate (Min of A & B) is calculated in cell C9 as MIN(C7, C8). The minimum of the above two is used to ensure that the premium rate is not more than the reinsured band.

Rows 11 and 12 show the gross loss ratio and its associated probability read out from the Exposure curve. Excel VLOOKUP function is used to read the probability corresponding to the loss ratio as follows

In cell B12, For the loss ratio 60% in cell B11, the following formula is applied

=VLOOKUP(B\$11,'Data-RI-Care'!\$A\$3:\$B\$32,2,FALSE) and so on.

Rows 14 to 21 show the calculation for the direct insurer.

Row 15 shows the Expected Premium Income (EPI) of INR 10,000 crores for each of the Gross loss scenarios 60% to 225% projected in columns B to AE. This is set equal to Sheet: Parameters! \$C\$9.

Row 16 shows the XL premium payable which is the EPI multiplied by the RI rate calculated in cell C9. For cell B16 the formula is \$C\$9*B15 and so on.

Row 17 is Net Written Premium (NWP) which is calculated as difference of Expected premium income and XL premium payable. For cell B17 the formula used is B15-B16 and so on.

Row 18 shows the Gross claim which is EPI * Gross Loss Ratio. For cell B18 the formula used is B11*B15 and so on.

Row 19 shows the XL recovery. If the Gross loss ratio exceeds the attachment point, reinsurance recovery is triggered till the upper limit. The resultant loss ratio is multiplied by the EPI. For Cell B19 two nested IF statements are used as shown below

IF(B11>\$C\$5, IF (B11<=\$C\$6, B11-\$C\$5, \$C\$6-\$C\$5),0) *B15

C5 is the attachment point, C6 is the upper limit, B11 is the Gross loss ratio and B15 is Expected Premium Income.

Row 20 is Net claim amount that is calculated as difference of Gross Claim and XL recovery. For cell B20 the formula used is B18-B19 and so on.

Net Loss Ratio is calculated in Row 21 as the ratio of Net claim to Net Written Premium. For Cell B21, the formula is B20/B17.

Rows 23 to 26 show the calculation for the reinsurer.

Row 24 shows the reinsurance premium receivable which is same as the XL premium in Row 16.

Row 25 shows the reinsurance claim payable which is same as XL recovery shown in Row 19.

Row 26 shows the Gross loss ratio for reinsurer which is XL Claims payable / XL premium receivable. For cell B26, the formula is B25/B24.

Table -2: Expected values – Cells A28:C31 show the expected loss ratios

The expected loss ratio is calculated as the sum product of the loss ratios and the associated probabilities. The Excel formula SUMPRODUCT is used here

For Gross Loss ratio (insurer) the formula in cell C29 is written as =SUMPRODUCT(B11:AE11,B12:AE12) where B11:AE11 is the Gross loss ratio and B12:AE12 is the probability.

For Net Loss ratio (insurer) the formula in cell C30 is written as =SUMPRODUCT(B21:AE21,B12:AE12) where B21:AE21 is the Net loss ratio of insurer and B12:AE12 is the probability.

For Gross Loss ratio (reinsurer) the formula in cell C31 is written as =SUMPRODUCT(B26:AE26,B12:AE12) where B26:AE26 is the Gross loss ratio of reinsurer and B12:AE12 is the probability.
