Institute of Actuaries of India

Subject SP7 – General Insurance Reserving and Capital Modeling

July 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:

Tender / Term sheet as applicable for State – Season combination

- Scheme ('weather index based' to identify policies issued under this scheme and distinguish them from other yield-based policies, if any)
- Insurance Unit, Tehsil, District, State (to identify granularity at which claims need to be calculated based on index parameters as captured by associated weather station)
- Crop name, Season (Kharif / Rabi) - (to understand triggers impacting claim pay out for a particular crop in particular season and State / District)
- Phase number, Phase Start Date, Phase End Date (as per Term sheet specified by State Govt and to check that actual index data is available over full policy term)
- Maximum Pay-out under Phase (to apply cap on calculated values in line with term sheet)
- Applicable Triggers by index (e.g., Rainfall, Temperature, Humidity, wind, combination of multiple indices),
- Short name for Trigger and Phase no (Continuous Rainfall / higher monthly rainfall / draught / min Temp etc. to understand impact of each trigger to cross check with reported level of claims)
- Trigger level / condition (to code trigger conditions in actual daily weather index data) (Max 3 Marks)

Claim Calculation at Insurance Unit (Tehsil/ District/State) by Crop Name (for specified season) and summation across all specified crops by State

- Against each insured unit identify applicable Weather station and insured land by Crop name
- Actual weather data at required granularity for each insurance unit to calculate total pay-out for each crop (per hectare, say reference landholding unit) by applying triggers and caps as specified in tender document
- landholding at Insurance Unit against each insured Crop Name (as per policy details Vs enrolment details as per State Govt portal) to ensure premium reconciliation based on quoted premium rate is matching with enrolment data as per State Govt Portal
- multiplication of per hectare calculated claim amount and insured hectares will give total pay-out for each crop at each insured unit
- Sum across all insured units to calculate total pay-out for each crop
- Sum across all crops to calculate total expected claims for each insured unit
- To be compared against booked claims (as per policy booking – by insured unit or by crop name etc.) (Max 3 Marks)

Reinsurance details

- Proportional Reinsurance arrangement – Treaty capacity, any limit by insured unit / district, state etc., min / max retention per district / State , if any
- Non proportional reinsurance arrangement – Min /max LR (and applicability e.g. only Kharif /Kharif + Rabi for a particular State or across States etc.), any limit if different for a particular reinsurer
- Exclusions by treaty if any e.g. not covering weather data purchase expenses
- Weather Data purchase Expenses (assuming these expenses are booked as claims expenses) covering specified State during specified season (Max 1 Mark)

Reference policy numbers and claims booked against these policies

based on criteria like State, Season, Scheme and Crop name

- Filter out booked policies (premium) and
- booked claims against these policies (Max 1 Mark)

[8 Marks]

Solution 2:

i) Govt can take multiple initiatives to help reduce Motor Road Accidents.
Sample initiatives are listed below

Education

Govt can run Awareness campaigns, publicity through newspapers / TV channels / Radio / Other social media
Can introduce Road Safety related information in school curriculum,
Can create certification courses

Engineering – Roads
Based on actual accident information, Govt can identify accident prone spots (black spot) and by allocating funds do necessary corrections
Govt can make Road Safety as primary clause in design work while awarding tenders for road projects
Govt can introduce regular road safety audits and corrections to avoid accidents

Engineering – Vehicles
Govt can introduce / modify safety standards in respect of vehicle crash test, airbags to protect passengers, anti-breaking system (ABS), quality of tyres, speed limiting devices to cap max speed or alert driver

Enforcement
Govt can encourage safe driving by punishing the offenders with heavy penalties (e.g., for not wearing helmets, seat belts, drunk driving, not having license), use of technology like speed cameras to identify vehicles breaching speed limits, vehicle scrapping policy / fitness certification based on maintenance standards

Emergency care
Govt can encourage / reward people who help accident victims so that victims get immediate medical help, can provide free medical treatment to victims during golden-hour, can increase availability of ambulances and hospitals to save lives

[Max 5]

ii) impact of Govt initiatives

Premium - To increase with reduction in % of uninsured vehicles, assuming no change in tariff premiums, but over a longer period, premiums may reduce due to lower claims frequency but inflationary trend and reduced investment income would act in opposite way (extent of claim frequency reduction and % reduction in uninsured vehicles will determine overall premium reduction or increase)

Investment income - Expected to reduce with faster settlements. Overall investment book might increase in case of higher GWP and lower claims frequency scenario till tariff premiums get adjusted to newer claism experience

Motor Claim Frequency - expected to reduce with better road and vehcile engineering (and higher base of insured vehicles)

Death - injury mix - quick medical assistance and improved safety features in vehicles may cause proportion of deaths to reduce and injuries to increase. This may reduce overall severity if savings in deaths turn out to be more than additional outgo in case of injuries)

Claims Reporting delay - Expected to reduce with faster claims reporting in long term and hence lower absolute IBNR (IBNER quantum to depend upon case reserving standard of individual insurer) in long term

Reserving uncertainty - expected to reduce due to faster claims reporting (but higher uncertainty in short term as difficult to quantify impact with non-availability of any benchmark)

[Max 5]
[10 Marks]

Solution 3:

i) Financial LR would equal Accident Year LR if release from prior years had been 0 across prior years.
Hence in this case, if any Accident year is providing release over next FYs, then AY will be reserved with MAD initially (1 Mark)

Assumptions

insurer has written business uniformly over all FYs such that

- risk is uniformly spread
- over policy duration of 1 year.
- Hence Earned premium has grown by 10% annually over last 8 years (FY 3 to FY 10) in line with business growth
- AY fully develops in 3 years and hence no further impact assumed
- There is no non proportional reinsurance (hence NIL RI cost and NIL RI recovery)
- No additional impact from industry pools
- No reinsurance accepted business (2 Marks)

Let EP for a particular AY(i) is 100 – where 'i' is between 3 to 10
Let AY LR at the end of year 0 is A%
This AY would release following MAD amount over next 2 FYs

- MAD Release in year 1 = 10% of EP for Year (i+1) *90% = 10% * (100*1.1) * 90% = .1*110*.9 = 9.9
- MAD Release in year 2 = 10% of EP for Year (i+2) *10% = 10% *(100*1.1*1.1) * 10% = .1 *121*.1 = 1.21

To have FY LR of 70%,
AY LR at the end of Development Year 0 = 70% + Prior Year Release%
Hence, AY LR at the end of Development Year 0 = 70% + 10% = 80%

Hence for any particular AY(i), where 'i' is between 3 to 10

- LR at the end of Development Year 0 = 80%
- LR at the end of Development Year 1 = 80% - 9.9% = 70.1%
- LR at the end of Development Year 2 = 70.1% - 1.21% = 68.8%

(2 Marks - 1 Mark each for correct year 0 and Year 1 LR)

As annual growth is constant 10% and FY LR is constant at 70%, Implied Ultimate LR development would be same for AY 4 , AY 5 and AY 6

	AY (4)	**AY (5)**	**AY (6)**
At the end of Development Year 0	80%	80%	80%
At the end of Development Year 1	70.1%	70.1%	
At the end of Development Year 2	68.8%		

[Max 6]

ii) Assuming NIl difference between Actual and Expected development for Paid Claims (0.5 Mark)

Incremental Paid LR development would be
68.8%*.8 = 55.04% in Year 0,
68.8%*.1 = 6.88% in Year 1 and
68.8%*.1 = 6.88% in Year 2.

Hence, Cumulative Claims Paid development would be

	AY (4)	**AY (5)**	**AY (6)**
At the end of Development Year 0	55.04%	55.04%	55.04%
At the end of Development Year 1	61.92%	61.92%	
At the end of Development Year 2	68.8%		

(1 Mark)

Assuming FY (6) EP of 100.
Hence Claims Paid in FY (6) would be,
100 * 55.04% + (100/1.1) * 6.88% + (100/1.21) * 6.88% = 66.98 (1 Mark)
Hence Paid LR would be 66.98% (0.5 Mark)

[Max 3]

iii) a) Outstanding claims at the end of FY (6) would be with respect to AY (5) and AY (6). As AY (4) and prior years are fully developed by the end of FY(6). (0.5)
Hence using result of part (ii)
EP for FY (6) = Claims Paid in FY (6) / 66.98%
i.e. 100 / 0.6698 = 149.3 Crores (0.5)
EP for FY (5) = EP for FY (6) /1.1 as 10% constant growth
i.e.149.3/1.1 = 135.72 Crores (0.5)

Outstanding claims for AY (5) = EP of FY (5) * (70.1% -61.92%) using results of part (i) and (ii)
= 11.10 Crores (0.5)

Similarly, Outstanding claims against AY (6) = EP of FY (6) * (80% - 55.04%)
= 37.26 Crores (0.5)

Hence Total outstanding reserve at the end of FY (6) would be
11.1 +37.26 = 48.37 Crores (0.5)
[Max 3]

b) MAD at the end of FY (6) would be with respect to AY (5) and AY (6).
As AY (4) and prior years are fully developed by the end of FY(6)

MAD with respect to AY (5) = EP of FY (5) * (70.1% - 68.8%) = 1.76 Crores (0.5)

MAD with respect to AY (6) = EP of FY (6) * (80% - 68.8%) = 16.72 Crores (0.5)

Hence Total MAD at the end of FY (6) would be 1.76 + 16.72 = 18.49 Crores (0.5)

Hence Total MAD at the Start of FY (6) would be 10% lower assuming 10% uniform growth i.e
18.49/1.1 = 16.81 Crores (0.5)
[Max 2]

c) EP for FY (6) = .5 * WP of FY (6) + 0.5 * WP of FY (5) = WP of FY (6) * (0.5 + 0.5/1.1) (0.5)
therefore, WP of FY (6) = EP for FY (6)/ (0.5+ .5/1.1) = 156.41 Crores (0.5)
[Max 1]

d) Assuming claims are paid uniformly (0.5)

Average MAD held by the general insurer during FY (6) =
(MAD at the start of FY (6) + MAD at the end of FY (6))/ 2 = 17.65 Crores (using results from Part c) (0.5)
Investment income generated by MAD = 10% * 17.65 i.e. 1.76 Crores (0.5)

Outstanding reserves excl MAD
Outstanding reserves excluding MAD at the end of FY (6) = 48.37 – 18.49 = 29.88 Crores
- Using results from part a and b (0.5)

Hence, outstanding reserves excluding MAD at the start of FY (6) = 29.88/1.1 assuming 10% uniform growth
= 27.16 Crores (0.5)

UPR
Unearned Premium Reserve at the end of FY (6) = 0.5 * WP of FY (6)
=78.2 Crores (0.5)

Unearned Premium Reserve at the start of FY (6) = 78.2 /1.1 assuming 10% average growth
= 71.09 Crores (0.5)

Hence, balance average Technical Reserve during FY (6) = (29.88 + 27.16 + 78.2 + 71.09)/2

=103.17 Crores (0.5)

Hence, Investment income generated by balance average Technical Reserves is equal to 103.17 *.08 =8.25 Crores (0.5)

Hence, total investment income generated by Technical reserves is 1.76 + 8.25 = 10.02 Crores (0.5)

[Max 5]

[20 Marks]

Solution 4:

Gross and Net FY LR for certain business segment can defer due to impact of following Reinsurance features

Proportional Reinsurance with no restrictive features

- Change in % ceded to treaty or obligatory cession over UW years with different underlying LR (as Mix of claims by UW would change in FY) would lead to difference in Gross and Net LR
- entering treaties mid-year
  - additional treaty to protect solvency
  - exceeding initial treaty capacity forcing to buy additional RI capacity - this may be available only with higher retention (or with other restrictive terms)
- Surplus treaty - retention of policies could vary depending on Sum Insured / Risk Category. Difference in LR by SI Band / Risk Category can translate into different Gross and Net LR
- Net Rate treaties (% ceded different for Premium and claims) resulting in difference in LR on Gross and Net basis (Max 2 Marks)

Proportional reinsurance with restrictive features

- if Gross reported LR goes beyond Loss Ratio Cap specified by reinsurer then Net LR would increase as claims beyond LR Cap of treaty would fall on Net
- if Gross reported LR goes beyond lower threshold of loss corridor where reinsurer has Nil or partial contribution then Net LR would increase due to limited loss contribution by treaty within loss corridor
- if treaty closure happens before 100% claims run off with treaty having clean cut features like limited contribution towards case estimates and NIL contribution towards IBNR then Net LR would increase
- treaty renewal with lower ceding may mean limited portfolio transfer leading to clean cut of balance share and hence higher Net LR (Max 2 Marks)

RI cover applicable for certain risks or claims

- (Difference between Direct cover and RI cover) - certain risks excluded by treaty (risks beyond certain SI Limit) / limit on no. of risks beyond certain SI (if these risks operate at different LR compared to remaining portfolio) could result in difference between Gross and Net LR
- facultative arrangements (with different retention) for certain large risks (if having different LR compared to other risks)
- Treaties not contributing towards certain claim expenses like
  - TPA Fees or investigation expenses (Govt Health)
  - Weather station charges or expenses towards crop cutting experiment (Weather and Crop)
- (Difference between Direct cover and RI cover) - certain perils excluded by treaties or having event limits or territorial limits could result in limited RI recovery and hence higher Net LR (Max 2 Marks)

Non-Proportional reinsurance

- Non proportional cost (premium) leading to lower Net Earned Premium + possible reinstatement premium payment requirement (in case of layer burnout) would contribute to higher Net LR
- In case of reported large losses / cat events beyond Risk / CAT XL threshold + significant layer utilization - Net LR could look better than Gross LR
- in case of NIL / low utilization of non-proportional layers - Net LR would look worse than Gross LR (Max 2 Marks)

Reserving Approach

- Gross and Net Reserve release / increase (from prior years) is expected to be different % of FY GEP and NEP and hence would cause difference in Gross and Net FY LR
- Different reserving strength between Gross and Net basis (because of grossing up / netting down approach adopted by insurer to set reserves)
- breach of Risk XL, CAT XL threshold requiring limited Net reserves but very high Gross Reserves
- Additional Net Reserves allowing for restrictive features of treaty
- Loss Ratio Capping for treaty
- Clean cut of treaty with limited contribution towards IBNR/ IBNER
- Equal allowance for indirect claims handling expenses in Gross and Net IBNR could mean Net LR > Gross LR (Max 2 Marks)

Other

- RI Inward business not ceded to obligatory treaty (if having different actual LR compared to other business)
- Commutation of Treaty at mutually agreed LR could mean different Gross and Net LR particularly for long tail segments
- Default by reinsurer / dispute with Reinsurer (delayed claims reporting when beyond certain threshold or not involving reinsurer in investigation) if adjusted through retention change
- (Terrorism / Nuclear / Other Industry) Pools - Depending upon the component of premium ceded to Pools and insurer's share in Pool (with different actual LR) can result in different Gross and Net LR
- Solatium Fund in case of Motor TP would mean higher Net LR compared to Gross LR (Max 2 Marks)

[12 Marks]

Solution 5:

i)

a. Buyer: EL is purchased by employer vs this is bought by employee
b. Indemnification: EL indemnifies the employer vs this pays a fixed benefit irrespective of the actual salary loss of the policyholder
c. Term: EL is usually 1 year vs. this is 3 years.
d. Payout: EL payout can vary depending on actual loss vs payout is fixed
e. Cause: EL policy is triggered due to employer negligence, whereas, this policy is triggered upon unemployment due to accident, irrespective of the party at fault, at work or otherwise

[Max 5]

ii)

a. URR or UPR
b. OCR
c. IBNR (or) IBNER and IBNYR (*its fine if IBNER was ignored*)
d. DAC
e. Claims expense reserve [Max 2]

iii)

a. UPR
   i. Cannot use $1/365^{th}$ formula since risk is not constant and also multi-year policy
   ii. If policy is triggered in the same month as purchase (i.e. 0^{th} month), benefit = 10k * 36 = Rs.3.6L
   iii. If policy is triggered in last month, benefit = 10k.
   iv. Generalising, if policy is triggered in month n, then benefit will be 10k * (36-n)

v. The amount of premium earned should reflect this and should be proportional to 36-n. (where n can take values 0 to 35)
vi. The sum of these weights is 36^2 – 36*35/2 = 666
vii. After m complete months of the policy, the proportion of the risk remaining will be:

$$\sum_{n=m}^{35} (36-n)/666$$

viii. Adjustment might be made for the day of the month, if required, for higher accuracy
ix. The above algorithm can be easily fed in by the tech company in their data systems.
x. This will calculate the correct amount of UPR for each policy.
xi. *The risk of accident, etc is assumed to be even throughout the term, hence no explicit adjustment has been made.

b. DAC
i. 10% of the UPR calculated above maybe held as DAC

c. OCR:
i. This is a straightforward exercise, with negligible uncertainty
ii. We know exactly how many monthly payments remain on each claim.
iii. If this is z, then we should reserve 10000*z
iv. We may need to add and unpaid payments, if the payment has not yet started, for instance if the nominated survivor's details are incomplete
v. For disputed claims, a pre-decided proportion of full reserve might be set up.

d. IBNR:
i. IBNER will be negligible for this policy since the amount is fixed
ii. To calculate IBNYR, the time taken to report must be investigated.
iii. We can then multiply, the delay period calculated with 10000 to estimate IBNR.
iv. For instance, if delay is y months on average, then IBNR = 10000*y
v. (OR)
vi. We can calculate claim amount of each policies if they had become claims in each previous month, in a similar fashion to OCR calculation, and get an average value across all policies for each individual month.
vii. We can get expected number from a delay table.
viii. This should be constructed from the record of past claims by month of occurrence and by number of months delay until reporting.
ix. This may be used to give the proportion of claims being reported by the m^{th} calendar month end after unemployment.
x. Let this proportion be p_m
xi. Let the number of claims reported m^{th} month prior to the valuation be N_m
xii. Let the average amount of claim on policies in force during that month be C_m.
xiii. Then,

$$IBNR = \sum_{m=1}^{\infty} \left(\frac{1-p_m}{p_m}\right) N_m . C_m$$

(Either of the approach is fine: 1 mark for correct formula with explanation, 1 mark for correctly identifying negligible IBNER, 1 mark for other reasonable points, max 4 marks)

e. Claims expense reserve:
i. Can be held as a % of the total OCR or URR. [Max 14]

[21 Marks]

Solution 6:

i)

a. Value at Risk (VaR) generalises the likelihood of underperforming by providing a statistical measure of downside risk. VaR assesses the potential losses on a portfolio over a given future time period with a given confidence level

b. Tail VaR is the expected value of the loss in those cases where it exceeds the predefined confidence level. It is sometimes also called conditional tail expectation, expected shortfall or expected tail loss. Thus the Tail VaR is equal to the average loss a company will suffer in case of (extreme) situations where losses exceed a predefined confidence level (eg 99.5%).

c. Key difference:
   i. Var is a point estimate whereas TVaR is an average
   ii. TVaR can become distorted by extreme simulations towards the end of the distribution, no such risk in VaR
   iii. The proportion of contributing risks in the VaR simulation may vary significantly under different runs, however, the proportion of risks in TVaR is expected to remain similar.

[Max 4]

ii)

a. Risk Clash / diversification
   i. Diversification between risk types

b. Class correlation / LoB diversification
   i. Diversification between classes /LoBs

c. Regional diversification
   i. Diversification between different regions / countries

d. Group risk diversification
   i. Diversification between various entities. [Max 3]

iii)

a. Capital held for the LoB before "LoB correlation matrix" = 3000

b. Diversification benefit from risk clash = 4500 – 3000 = 1500 [Max 3]

iv)

a. Assume that the company models 1000 simulations

b. Assume that the company includes VaR simulation for calculation of TVaR

c. TVaR of each risk types:
   i. Reserve risk
   ii. UW
   iii. Cat
   iv. Market
   v. Credit
   vi. Operational
   vii. Total = 5166

d. Diversification benefit calculated in part (iii) was 50%

e. Applying the same proportion => 5166/1.5 = 3444 [Max 9]

v)

a. VaR is a point estimate, whereas TVaR is a conditional average

b. In this case, the TVaR capital has increased vs VaR capital required.

c. This increase could be driven by the slightly higher Cat risk in +5 sim compared to others.
   i. The +5 sim CAT risk is 150% higher than the VaR sim.
d. This could be because of a limitation of TVaR where it gives weight to all the simulations beyond the VaR simulation.

Modifications (either):

a. If we exclude the +5 simulation, the TVaR capital will be 3119, which is not significantly different from capital required using VaR
b. Alternatively, we can use a modified TVaR approach where we consider +2 and -2 simulations around the confidence interval
   i. Under this approach the capital required will be 3007, which is almost exactly same as under VaR approach.
c. This modified approach helps us overcome limitations of both the risk measures
   i. Where for VaR it provides consistency in the risk proportion between different runs
   ii. And for TVaR it is not distorted by the extreme simulations [Max 10]

[29 Marks]

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