

Institute of Actuaries of India

Subject ST8 – General Insurance: Pricing

September 2017 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) Tariff: Under this way of pricing, the regulator has significant influence over the rates or where the regulator only sets the rates – for example, Motor third Party rates in India. This may also refer to the approach where insurance companies are required to provide the details of their premium rates and may also have to justify any changes in the premium level.
- b) Qualitative: This refers to the pricing approach, where correct price cannot be determined purely by numerical analysis and subjective factors must be taken into account.
- c) Cost Plus: Under this approach, the price is set based on statistically driven analysis, using the expected cost of claims, appropriately loaded for expenses, profits and so on.

[3]

ii)

Reasons why written premium are not always appropriate as a measure of exposure

- Not suitable as a measure of exposure for premium rating
- Premium base change over time
- Market pressure may lead to distortion of premium bases
- Premiums may be set wrongly; if little experience of new type of risk
- Loadings applied to risk premium (for expenses, profits etc) change over time.
- Premiums are subject to inflation

[3]

[6 Marks]**Solution 2:**

Since the link function is Log and distribution is Poisson,

$$\lambda = e^{\beta_0 + x_1\beta_1 + x_2\beta_2}$$

And Likelihood

$$P_Y(y) = \frac{\exp(-\lambda) \lambda^y}{y!}$$

Therefore, log-likelihood = $-\lambda + y \ln \lambda - \ln y!$ To maximize log-likelihood, we can ignore the last term “ $\ln y!$ ”.Log-Likelihood for the data under the given model specifications:

$$1^{\text{st}} \text{ Data Point: } LL1 = -e^{\beta_0 + \beta_1 + \beta_2} + 0.25(\beta_0 + \beta_1 + \beta_2)$$

$$2^{\text{nd}} \text{ Data Point: } LL2 = -e^{\beta_0 + \beta_1} + 0.35(\beta_0 + \beta_1)$$

$$3^{\text{rd}} \text{ Data Point: } LL3 = -e^{\beta_0 + \beta_2} + 0.20(\beta_0 + \beta_2)$$

$$4^{\text{th}} \text{ Data Point: } LL4 = -e^{\beta_0} + 0.30(\beta_0)$$

Overall log-likelihood function for maximization,

$$LL = LL1 + LL2 + LL3 + LL4$$

Taking the first partial derivate of LL w.r.t. the beta parameters and setting them to 0:

$$\frac{\partial LL}{\partial \beta_0} = 0 \rightarrow - e^{\beta_0} (e^{\beta_1 + \beta_2} + e^{\beta_1} + e^{\beta_2} + 1) + (0.25 + 0.35 + 0.20 + 0.30) = 0 \quad (1)$$

$$\frac{\partial LL}{\partial \beta_1} = 0 \rightarrow - e^{\beta_1} (e^{\beta_0 + \beta_2} + e^{\beta_2}) + (0.25 + 0.35) = 0 \quad (2)$$

$$\frac{\partial LL}{\partial \beta_2} = 0 \rightarrow - e^{\beta_2} (e^{\beta_0 + \beta_1} + e^{\beta_1}) + (0.25 + 0.20) = 0 \quad (3)$$

Substituting $a = e^{\beta_0}$, $b = e^{\beta_1}$ and $c = e^{\beta_2}$:

Equation (1): $a(1+b+c+bc) = 1.1$

Equation (2): $ab(1+c) = 0.6$

Equation (3): $ac(1+b) = 0.45$

We can check that $a=0.2955$, $b=1.2$ and $c=0.6923$ satisfy the above three equations.

We can also see that the second partial derivatives are always ≤ 0 (for all values of betas).

Therefore, the values provided for the parameters maximize the log-likelihood for the given data and the model specifications.

[7 Marks]

Solution 3:

i)

- The data to be collected for the model should contain variables which can define the behavior of the policyholder and are able to decipher the underlying pattern to be modelled.
- The input data for the model can primarily be obtained from two sources:
 - a. Response from previous insurer – This data will contain clear and authentic information about the NCB status of the policyholder.
 - b. Internal Claims data of the company – the company may be able to find about the claim history of the policyholder from the garage or the information supplied by the policyholder at the time of claim
- We need the claims data with individual claim level flag to identify the policies wherein the declaration was incorrect.
- The declaration might be correct at the time of proposal if the policyholder applies for insurance well in advance for renewal and claims from the previous insurer afterwards. Thus, time to expiry of last policy is an important rating factor for this model.
- If the proposal form is not filled by the proposer but by the intermediary, then the proposer may be unaware of the declaration made. The intermediary might do this to offer insurance at lower premium. Thus, individual intermediaries are also an important rating factor for this model.
- Other than these two, general rating factors which can be used for this model are Make, vehicle segment, distribution channel, geographical location, age of the policyholder, gender of policyholder, occupation, age of the vehicle, NCB during expiring policy, Insured Value of the vehicle etc.

- The data will be required at individual policy level and also individual claim level.
- The premium and claims should be combined into one single file with the flagging of policies wherein the wrong declaration by the policyholder has been identified.
- The total number of policies wherein wrong declaration has been identified should be large enough to be reliable for modelling. [5]

- ii) Customer behavior could change quickly. The propensity to make false declarations could change. This could be more pertinent if the agents bring the business.
Also the business mix of the rollover portfolio could be rapidly changing.

[2]

[7 Marks]**Solution 4:**

i)

- Direct and Indirect expenses
- Categories of expenses like initial, admin, renewal, claims, investment
- Allocate by class and rating group
- express the expenses as a proportion of number of policies or claims, or of amounts of premium, sum insured or claims. [1]

ii) The possible reasons for lower expense loadings in commercial line of business are

- The property class of business is usually of large size in terms of large sum insured.
- The corresponding premium ticket size is also large.
- But the manual efforts in terms of man hours required to underwrite a property policy or say claims servicing is comparatively lesser than the other lines of business.
- The acquisition costs are also comparatively lower than the other lines of business when expressed as a percentage of the premiums due to the same economies of scale reasons.
- The underwriting is normally supported by the brokers whereas claims supported by the surveyors resulting in the reduction of overall percentage of expenses.
- The IT system costs are also proportionately similar to other line of business in term of per policy issuance cost compared to a very high ticket size of the premium per policy.

The possible reasons for lower expense loadings compared to the other players in the market are

- High volume of business reaching economies of scale
- Through a vast historical experience, achieving optimal system utilisation
- Better bargain with the intermediaries in terms of procurement costs due to relationships as well as volume of business
- Well diversified portfolio in property business, diversification achieved through almost all the channels including the lowest cost channels.
- Diversification in terms of business of all sizes.
- System automation at the intermediaries end also lowering the procurement costs built through years of experience
- Because of reach and large network, built in through years of experience, direct business constitutes a substantial portion of the business where there is virtually no procurement costs.

[6]

[7 Marks]

Solution 5:**i)**

a) A time limit, usually defined in the policy wording or through legislative precedent, placed on the period within which claims must be reported.

It generally applies to classes of business where several years may elapse between the occurrence of the event or the awareness of the condition that may give rise to a claim and the reporting of the claim to the insurer. [1]

b) A claims made basis may be appropriate when it is not clear when the loss actually occurred. This might be true for certain types of liability classes, where the loss emerges gradually over time, e.g. deafness caused by continual exposure to loud noises at work under an employer's liability product. [2]

ii)

Claim characteristics in an employer's liability policy

- Latent claims
- Low frequency and high severity claims
- Inflationary impact very high especially towards the medical claims
- High risk of accumulation of claims when there are multiple claims of similar nature are lodged
- Long tailed in nature as the loss emerges gradually over time e.g. deafness caused by continual exposure to loud noises at work under an employer's liability product.

The last point is the primary reason why the discovery period is required to cap the unlimited liability of the policy issuing insurer. In such a policy, it takes several years to elapse between the occurrence of the event or the awareness of the condition that may give rise to a claim and the reporting of the claim to the insurer.

Claim characteristics in a professional indemnity policy for medical practitioners

- Latent claims
- Low frequency and high severity claims
- Inflationary impact very high especially towards the medical claims
- Long tailed in nature as the loss emerges gradually over time

A claims made basis may be appropriate when it is not clear when the loss actually occurred. This might be true for certain types of liability classes, where the loss emerges gradually over time, e.g. difficult and time consuming exercise to ascertain the exact medication error when a patient undergoes through many medication exercises in a professional indemnity claim against a medical practitioner. [4]

iii)

The risk profile would go for a change in the following manner.

- IBNR claims becoming a large proportion of the total unpaid claims.
- IBNR estimate uncertainty increasing leading to greater solvency capital requirements
- Chances of litigation cases increasing due to disagreement of occurrence of a claim at a particular time period or due to disagreement on causes of a claim.

- Conflicts with other insurers and reinsurers regarding sharing of claims due to disagreement on the claims occurrence as well as the causes of it.

- As it takes several years to elapse between the occurrence of the event or the awareness of the condition that may give rise to a claim and the reporting of the claim to the insurer, there arises an additional risk of non-existence of other co-insurers or reinsurers at the time of final claim settlement putting huge financial burden on the company.

[2]

[9 Marks]

Solution 6:

i)

- If the increase is due to low premium rates, the increase may indicate future losses
- It could indicate deteriorating experience because of anti-selection or relaxation in underwriting standards; low underwriting restrictions
- Administration strains could cause service standards to intermediaries and policyholders to fall, leading to bad publicity
- The solvency margin could be reduced to close to the regulatory minimum level or even below, if the minimum is based on premium level
- Internal controls may be weekend, eg risk management, expenses [3]

ii)

- Premium rate at which the business is being underwritten. Comparison with internal historical rates and also with the competitors rates
- Profitability by the source of the business i.e. distribution channels to check for the loss making distribution channels and changing the business sourcing pattern accordingly
- Change in mix of business shall be monitored and compared with the target business mix
- Renewal rates: Low renewal rates may signify customer dissatisfaction which will earn bad name for the company.
- Monitor that volume of business is in line with capital available
- The company shall need to monitor the statistics relating to claims like claims count per month, settlement time and manpower requirements. Rapid business growth will result in rapid growth in number of claims as well and possible delay in claim settlement.
- The company needs to monitor aggregate geographical risk accumulation specially in commercial lines.
- Other aspects of the business that the company shall monitor are:
 - Target vs Actual policyholder segment
 - %age of proposals deviating from underwriting guidelines
 - Cost of acquiring business
 - Statistics like Loss ratio, frequency, severity by business segment, distribution channel, geography
 - Actual vs Target business mix in terms of New and Renewal business
 - Robustness of internal controls like risk management practices
 - Management of fast flowing data; both premium and claims

[6]

[9 Marks]

Solution 7:

i) In casualty line of business, the sum insured is not the maximum amount of a claim since claims can effectively be limited, but instead is the limit of indemnity chosen by the policyholder, which varies with each risk. [1]

ii) The assumption is that each time the sum insured doubles, the loss cost increases by a constant factor (x%).

The deductible d on the original policy written by the direct writer is unlikely to exceed five times the expected losses. Hence, we cannot use Riebesell curve to estimate ILF(d). This makes it difficult to adjust for original deductibles using Riebesell curves. [2]

iii) The limit beyond which the Riebesell curve assumptions should be 20 Cr, the upper limit in the ILF table. From the ILF table, it is reasonable to assume the $E(X)$, expected value of the claim, will be not much more 4 crores, which is one fifth of 20 Cr.

To gain more comfort with this assumption, one may test several distributions which lead to similar ILF values and check where their mean lies. The overall expected value could vary depending on the distribution, even if they give more or less the same ILF values at various limits as the ones provided for this situation.

The Excess of Loss layer has been given at 20 Cr XS 20 Cr.

$$\begin{aligned} \text{Therefore ILF (40 Cr)} &= (1 + 0.1) * \text{ILF (20 Cr)} \\ &= 1.1 * 2.8 = 3.08 \end{aligned}$$

$$\begin{aligned} \text{Therefore the loss cost for the layer is} &= 2000 * [\text{ILF (40 Cr)} - \text{ILF (20 Cr)}] / [\text{ILF (1)}] \\ &= 2000 * (0.28) / 1 \\ &= 560 \text{ Rs.} \end{aligned}$$

[7]

[10 Marks]**Solution 8:**

- i) Challenges:
- The biggest challenge is the availability of the data.
 - Since, the data available is only for annual policies, few assumptions need to be made to rate the long term policies
 - Customers of annual policies and long term policies may behave differently. It is challenging to take this aspect into rating
 - You might need to propose different levels of claims deductible depending on the number of claims made during the policy term. For the pricing for these new deductibles, there may not be any data available as in one way, this is linked to customer behavior.
 - Long term policies are subject to inflation (part cost and wage inflation) as well. There is difficulty in predicting inflation rates over future years. The inflation assumption taken

by different insurers in the market may be different thus making the final rates more or less competitive.

- The initial amount of expenses (other than commission) incurred by the company are same for an annual policies and for long term policy. The company might want to pass on this benefit to customers, but it is difficult to arrive at exact savings in the expense.
- NCB is an important rating parameter in rating annual policies. NCB at the time of renewal depends on the claim history during the immediately expiring policies. For long term policies, calculating NCB at the end of policy term may be a challenging task.
- Since the premium is received at the start of the year, it might lead to higher capital requirements at the start of policy to support this product, if the capital requirement is calculated as a proportion of premium.

[4]

ii) Overcoming the challenges

- Since the company has reliable and credible data, basic premium for long term policies can be calculated by using either the GLM model or by making use of frequency severity approach.
- The NCB model for this product can be created by using claim incidence rate and then calculating the proportion of policyholders at different NCB levels in steady state.
- A detailed expense analysis may be required to arrive at the level of expense saving in long term policies. The level of savings will be different depending on the policy term.
- All these factors/assumptions need to be monitored on regular basis so as to remain profitable and have the opportunity to change the pricing if any of the underlying assumptions change.

[4]

iii) Given claim frequency = 5%

a) The policyholder will be at 0% NCB at the start of 3 years if:

There is claim in both the years or

There is no claim in first year and claim in 2nd year

$$\text{Probability} = 5\% * 5\% + 95\% * 5\% = 5\%$$

b) The policyholder will be at 20% NCB at the start of 3 years if:

There is only one claim in first year and no claim in 2nd year

$$\text{Probability} = 5\% * 95\% = 4.75\%$$

c) The policyholder will be at 25% NCB at the start of 3 years if:

There is no claim in both the years

$$\text{Probability} = 95\% * 95\% = 90.25\%$$

[2]

[10 Marks]

Solution 9:

i) AEP file considers the probability that the aggregate losses from all loss events in a year exceeds a particular threshold.

OEP file considers the probability that the largest individual event loss in a year exceeds a particular threshold.

[1]

ii)

- (a) Japan is an Earthquake prone country and therefore chances of multiple earthquake events of all intensities are much higher against much lesser earthquake prone India.

Although some small difference may be there at the lower return periods for the Indian exposure.

- (b) Very high intensity events are rare against the low intensity events which are frequent. Therefore the chances of low intensity events occurring more than once in year are high which leads to much higher AEP limit at the lower return periods than the OEP limit at the same return period.

[4]

iii) The possible reasons are

- (a) The property Sum Insured exposure is concentrated more in the high earthquake zones now. E.g. some industrial hubs opened in these zones, underwriting more business in these areas perceived to be profitable here, etc.
- (b) The geographical spread now has changed. Not much geographical diversification anymore
- (c) Because of some recent events in other countries, the scientists have revised the event module assumptions in the model. E.g. frequency or return period increasing from the earlier level for a particular intensity event.
- (d) Because of some recent events in other countries, the scientists have revised the hazard module assumptions in the model. E.g. hazard level increasing due to increase in more ground shaking assumptions.
- (e) Vulnerability model assumptions changing due to certain change in assumptions related to engineering structures.
- (f) The modellers may have changed
- (g) The modellers may have used blend of different earthquake models for different geographic regions
- (h) New ground structure and soil structure reports may have surfaced and the same have been incorporated in the model. This will have impact on the hazard module.
- (i) Statistical model assumptions fitting the historical events like frequency modelling may have changed.

[6]

[11 Marks]

Solution 10:

i)

- The company may not be able to achieve the growth targets if the persistency rates are consistently low.
- With falling business volumes, it becomes more expensive (per policy) to spread fixed costs over each policy

- Being a new insurance company, having low persistency rates might not be a big problem in initial years and the company might be able to grow on the basis of new business, it might become an issue for the company in the long run.
- A large proportion of the costs may be fixed, so this could have a material impact on profits. With better persistency rates, the company has the opportunity of recouping the initial expenses over the customer lifetime.
- The company is at a greater risk if the profitable customers are lapsing their policies and only the claim-making customers are renewing. This will directly impact the profitability of the insurer.
- With low persistency rates, the company will not be able to have a large pool of loyal customers, to whom the company may try to do cross-sell or up-sell.
- It is usually more expensive to acquire/regain new business than it is to process renewals
- There might be different premium rates charged to new and renewal customers.
- It might be a sign of customer dissatisfaction or miss-selling, and so low persistency may imply a poor level of service and/or that premium rates are not competitive.
- Persistency and profitability are closely linked and the segments of business with high persistency rates are generally more profitable.

[6]

ii)

- The level of discount to be offered at policyholder level depends on certain primary factors like:
 - Perceived and current profitability of the policyholder
 - Discount offered by competitors in the market
 - Vintage of the policyholder with the company
 - Number of other policies/products the customer may have with the company; it is an indication of customer loyalty.
- The company needs to gain market intelligence to assess if the discount can be the only factor to retain the customer.
- How the overall profitability of the company varies by such an offer.
- Does it lead to change in business mix, average premium rate, premium size, average sum insured and whether this shift is favorable or not
- Does this offer need any further capital requirements; need to consider the cost of capital.
- This offer would require changes in policy rating systems. Need to quantify the cost of system change
- Whether the company has available in-house expertise to determine the costing of such an offer. Deployment of external consultants will increase the overall cost of the offer
- After retaining the customer, need to devise the pricing strategy for future renewals. If the probability of renewal of certain customers is consistently low at all renewals, the company may not be able to recoup the total expenses during customer lifetime

[5]

[11 Marks]**Solution 11:**

- i) An aggregate excess of loss reinsurance that provides protection based on the total claims, from all perils, arising in a class or classes over a period. The excess point and the upper limit are often expressed as a percentage of the cedant's premium income rather than in monetary terms. [1]

ii) The primary differences are

- The reserves backing the claims are still with the insurer in ADC whereas they are passed to the reinsurer in case of LPT. The investment income is managed and collected by the insurer only in ADC whereas this is not the case in case of LPT.
- The liability for a specified book of business is passed in its entirety in LPT whereas the liability still lies with the insurer in case of ADC.

[1]

iii) The key factors determining the amount of premium to be charged under an ADC cover

- Claims development pattern (tail length) determining the time duration for the investment of premium received from the insurer.
- Claims settlement practices of the insurer for the same reasons mentioned above.
- The rate of return on investment
- Nature of business especially the riskiness of claims e.g. latent claims not visible at the outset of the contract.
- Premium payment mode (in lumpsum or in instalment)
- The layer purchased i.e. the attachment point and the ultimate limit of liability.

[3]

iv) Usefulness of the quota share treaty to the reinsurers under these conditions

- May not be useful if the underwriting practices of the insurer are not sound. Underwriting practices become more important in these conditions.
- In quota share, the business is ceded to the reinsurer at the same price as charged by the insurer. No pricing control on the premium rate charged by the insurers.
- A percentage of large business through the quota share arrangement can be large and can impact the reinsurer's balance sheet.
- A high loss ratio from the business is anticipated under these conditions and can impact the reinsurers through the quota share arrangements. Losses can be simply unlimited without any loss caps.
- Lack of underwriting control on the reinsured business by the reinsurers.

Usefulness of the stop loss treaty to the reinsurers under these conditions

- Very useful as more control on the reinsurance pricing independent of the pricing adopted by the insurers.
- More protection of the balance sheet of the reinsurers under such probable high loss scenario conditions due to EL NINO.
- Control on the business volume also as the stop loss premiums are based on some business volume level.
- Attachment points and upper limits are mostly percentage of premiums as loss ratios so that insurers do not indulge in undercutting and simply pass losses to the reinsurers.
- Helps to cover up any spill over from the inuring quota share treaties where the level of protection may be deliberately lower.
- The upper limit in the stop loss treaty helps to control the total business exposure.

[5]

v)

If the reinsurer perceives the risk to be very high, then it might propose lower quota share protection and more stop loss protection instead.

In any such combination, the net retention in the inuring reinsurance arrangements like quota share is protected by the stop loss treaties.

For example, in a crop insurance business of 2000 Cr premium, if the quota share treaty percentage is only 60%, then the retention of 40% after the quota share arrangement will be protected by the stop loss arrangement.

Therefore the projected business to be protected by the stop loss arrangement in this case will be Rs. 800 Cr.

If the attachment limit of the stop loss treaty is 120% and the upper limit is 200%, then the net retention to the reinsured in this entire arrangement is Rs.960 Cr. which is quite substantial.

If the loss ratio exceeds 200%, then the residual losses over and above the upper limit which is Rs. 1600 Cr, will come back to the reinsured book.

From the historical loss data, reinsurer can find out how often the losses have exceeded the loss ratio of 200%. For example, if this has happened once in every five years, then the rate of line should be 20% i.e. $1/5 = 20\%$ for the layer 80% XS 120%.

Therefore the adjusted rate will be $20\% * 80\% = 16\%$.

Therefore at the loss ratio of $120\% + 16\% = 136\%$, the reinsurer will be at no loss and no profit assuming there are no other expenses. Beyond the loss ratio of 136%, the reinsurer will start making losses.

If there are any loss caps in the quota share arrangement, then the stop loss might protect the spill over business from the quota share treaty also.

[3]

[13 Marks]
