Institute of Actuaries of India

Subject SA3 – General Insurance

May 2015 Examinations

INDICATIVE SOLUTIONS

Solution 1 :

(i) Relevant points relating to investments include:

- The higher the level of (positive) correlation between returns on investment and claims for this product, the better.
- The critical issue is to not invest in an asset where its value will fall, perhaps sharply, when claim experience worsens e.g. assets should not include a high allocation to agriculture stocks.
- Access to funds to pay many claims when experience worsens is important, liquidity is an issue. There is a significant accumulation risk with crop insurance which means that many claims may need to be paid at the same time.
- Geographical concentrations of assets and liabilities should be avoided.
- A mixture of fixed interest and growth assets (property and/or equities) in the investments backing shareholders' funds notionally allocated to this product is appropriate.
- Ecco should not have concentrated investments, in terms of either a large holding in a single investment (e.g. a single property) or in locations or assets whose fortunes are heavily tied to the rural sector underwritten by Ecco.

[3]

(ii) Relevant points relating to reinsurance include:

- The exact structure of the programme depends on the broader financial position of Ecco, both now and considering plans for the future.
- The main risk faced by a crop insurer is accumulation risk, given the potential for geographical concentration of risks and/or many claims from the same underlying cause. Catastrophe excess of loss cover should be considered or some form of protection from claims arising from the accumulation risk (e.g. stop loss). The level of protection largely depends on the geographical distribution of risk (e.g. does Ecco write this business all over India with no heavy concentrations in one area or does it write in one or two main regions?)
- If Ecco faces capacity constraints, a quota share treaty may be appropriate. A quota share cover may also be suitable if Ecco does not have the required level of knowledge to underwrite and manage this class of business (assuming Ecco does not currently underwrite this class of business).
- If there are a small number of exceptionally large risks, Ecco should consider a surplus treaty to transfer variability from these.
- Ecco may consider risk excess of loss to protect against large claims from individual insureds. This is unlikely to be the main source of claims risk though, so may not be required or may be written with a reasonably high retention.

[3]

(iii) The consequences of the reduced volumes are:

- There is less premium to spread fixed expenses (e.g. overheads) over, meaning this product is likely to be uncompetitive for the longer term, if the product is being allocated a fair share of fixed expenses.
- The short term competitiveness of the product should be assessed. How do premiums compare to competitors?

- If policies were written with rates set according to expected drought conditions, what is the current drought situation? Are premium volumes below expectations because:
  - **a.** rates have been adjusted since the budget was set due to different drought/weather conditions, while policy volumes have been comparable to the budgeted figures or
  - **b.** Fewer policies have been written because the product is uncompetitive, i.e. setting higher premium rates than competitors. But is this because competitors have mispriced the impact of drought and therefore this business is now unprofitable – in which case reduced volumes is a favourable outcome. What is the underlying profitability of this business?
  - **c.** The remuneration of intermediaries (i.e. commission rates) should be assessed. Perhaps the commission rates are too low, which might explain why brokers are not selling the product.

The following should be disclosed in the FCR:

- An assessment of recent experience, including premium and policy volumes, expense rates and actual levels of profitability.
- An assessment of pricing adequacy (including the effect of reduced volumes) and underwriting approach.
- An assessment of the business model including the distribution channels currently used and their viability.

[4]

(iv) Reasons why experience rating is not suitable for crop insurance are:

- Many, if not most insureds, are SMEs. Their individual experience is too small to justify experience rating.
- The claim frequency is too low. The experience rating approach would punish many insureds who are good risks and were unlucky to have a claim while rewarding poorer risks who were fortunate not to have a claim. While this is a general issue in all circumstances, it is a particular issue for this product.
- While there are risk factors that are specific to the insured, the weather is a key driver of the experience which is beyond the control of the insured. This should not form part of the experience rating.

Conclusion: experience rating should not be used for this product.

[2]

(v) The most likely reason for the rising loss ratios by accident year is:

- Multi-year crop insurance is not uniform in nature. The risk rises up to the time of harvest, when the crop is most valuable.
- If the crops covered are annual crops, there should not be a strong pattern from one year to the next. If Ecco wrote policies for new farmers, the crops would likely take a few years to grow and yield a harvest.
- As such, the risk in the first few years would have been negligible, leading to few claims. The risk would have risen in the last year or two. All else being equal, claims should also have risen.
- Premium has not been earned to the same pattern. Under the flat, pro-rata earning approach used, too much premium was earned in the early years when there was little risk of claims. Too little will be earned in the later years.

[3]
[15 Marks]

Solution 2:

(i) Sound premium for 1,000 policies:

- Claims cost = (1,000 x 2%) x $8,000 = $160,000
- Claims handling costs = $160,000 x 7% = $11,200
- Other expenses = $140,000
- Profit Margin = ($160,000 + $11,200 + $140,000) x 17%/83% = $63,740

Total = $374,940

Premium = $374.94

Sound premium for 10,000 policies:

- Claims cost = (10,000 x 2%) x $8,000 = $1,600,000
- Claims handling costs = $160,000 x 7% = $112,000
- Other expenses = $160,000
- Profit Margin = ($1,600,000 + $112,000 + $160,000) x 11%/89% = $231,371
- Total = $2,103,371

Premium = $210.34 **[2]**

(ii) Reasons for different premium rates:

- Economies of scale means that fixed costs are spread over a larger number of policies which results in a lower charge, per policy, for other expenses.
- Higher policy volumes results in lower risk which translates to a lower required profit/solvency margin.

[1]

(iii) Other factors to consider include:

- Why is Tuff's price so much lower than its competitors? Is the pricing research adequate? Need to allow for additional uncertainty in the pricing process as no historical claims experience on which to base premiums.
- Will the lower price than competitors result in selection against Tuff?
- Need to undertake some sensitivity analysis around projected results to understand the impact of
  - **a.** Higher than expected premium levels - can Tuff's capital base support higher volumes than projected?
  - **b.** Lower than expected premium levels – will overall target return on capital requirements be met?
  - **c.** Lower than expected volume on profitability and ability to meet fixed expenses.
  - **d.** Higher than expected claim costs on profitability.

- What reinsurance will be in place for this product? Has the net cost of reinsurance been included in the premium calculation?
- Underwriting standards.
- Policy design such as exclusions etc.

[3]

(iv) Exclusions include:

- Pre-existing medical conditions.
- Conditions around employment history – for e.g. people that have been away from work for more than X months in the last Y years.

- Part-time or casual employees. May provide cover for permanent part time employees on a pro-rated basis.
- Dangerous/high risk occupations such as mining, labourers etc.
- People with dangerous hobbies such as parachuting, hang-gliding, scuba diving etc.
- Acts of war or terrorism. **[3]**

(v)

- Quota share should be used to support growth beyond the capabilities of the existing capital base. QS will have no impact on the total variability of results and the profit/solvency margins will be unchanged. QS can be used to support growth as an equal share of each risk is transferred to the reinsurer.
- Individual XOL cover should be bought to provide protection against large individual claims. Depending on the net retention level and the distribution and frequency of large claims, individual XOL cover can provide a substantial reduction in net retained variability. Profit/solvency margins will be reduced but so will the expected profit as a greater share of profits is transferred to the reinsurer (the net cost of reinsurance).
- Catastrophe XOL cover should be bought to provide cover against large catastrophic claims from a single event. Reduction in net retained variability will result in a lower profit/solvency margin. Reduced profitability as profit is transferred to reinsurers to support their capital. **[4]**

(vi) Items to be reflected in the FCR –

- Pricing section
  a. how the product has been priced.
  b. expected profit for the new product over the next three years.
  c. target sales, premium, loss ratios and profit levels for the new product over the next three years.
  d. reporting and monitoring requirements to track actual experience against expected.

- Reinsurance section
  a. summary of reinsurance arrangements for the new product.
  b. consider how they impact the existing program – e.g. impact on any aggregate limits.

- Capital management section
  a. impact on capital management strategy for new product.
  b. how does the new product impact the company's risk profile and capital requirements.
  c. what is the impact on capital requirements if Tuff sells more / less of the new product – i.e. sensitivity tests on capital requirements.

- Investment section
  a. is there any specific change to the investment policy due to this new product? E.g. does the new product warrant investment in more long dated securities to match the liabilities, or perhaps indexed bonds to hedge any inflation risk.

- Risk management section

a. Reporting and monitoring requirements for the new product.
b. Risk identification process to identify the key risks of this new product, the frequency and severity (hence the financial impact) of these risks, how they will monitored and what steps are being taken to mitigate these risks.

[5]

[18 Marks]

<u>Solution 3</u> :

(i)

Model adequacy tests

Residual analysis – difficult to show plots for Poisson model but not for log-normal model. Standard plots include:

- Quantile-quantile plot to check for distribution (for log-normal the plot will be of the residuals from the fit to the logs of claim size and effectively a check for normality)

- Randomness of residuals – plot fitted versus residuals and the results should be a random burst

- Lack of fit plots – plot fitted versus predictors to check that no shape remains. Can also do this plot for variables not included in the model to confirm that they were safely left out.

- Fitted versus actual tables – for both frequency and size and for variables included and variables excluded. For variables that have been categorised, it is helpful to prepare these tables for different groupings of the variable as a check that the categorisation is appropriate.

[3]

(ii)

Sum insured could be fitted as a continuous curve or a piece-wise curve. In either case the aim would be to fit a curve using fewer than 5 parameters to give a more parsimonious model. If such a curve or piece-wise curve existed then the model would be better because it contained fewer parameters.

[2]

(iii)

Neither of these variables falls within the general GLM framework. In both cases they act to potentially modify claimant behaviour. For deductibles there are likely to be many different amounts, possibly with only a few having any substantial exposure. The additional model complexity is not normally justified.

In the case of NCB, the actual bonus allowed is likely to be more than that justified by analysis. The majority of exposure is likely to be concentrated in the highest NCB category and it will usually be sufficient to model on this data only and check model fit for the other NCB categories.

[2]

(iv)

Renewal effective Month	Development month				
	August	September	October	November	December
August	2,432	4,139	3,257	656	407
September	1,994	3,673	1,913	905	
October	1,645	1,661	1,598		
November	1,397	2,066			
December	775				

Cumulatives

Renewal effective Month	Development month				
	August	September	October	November	December
August	2,432	6,571	9,8282	10,484	10,891
September	1,994	5,667	7,580	8,485	
October	1,645	3,306	4,904		
November	1,397	3,463			
December	775				

Ratios	Development month			
	2/1	3/2	4/3	5/4
August	2.702	1.496	1.067	1.039
September	2.842	1.338	1.119	
October	2.010	1.483		
November	2.479			

Average	2.508	1.439	1.093	1.039	Tail
Selected	2.400	1.439	1.093	1.039	1.040
Product	4.078	1.699	1.181	1.080	1.040

	Projected Ultimate	Number processed	Renewals invited	Lapse rates – renewal effective month	Lapse rates – Processing month
August	11,327	9,034	49,010	23.1%	18.4%
September	9,167	11,363	49,790	18.4%	22.8%
October	5,791	10,566	32,760	17.7%	32.3%
November	5,884	6,243	28,990	20.3%	21.5%
December	3,160	6,105	22,100	14.3%	27.6%

Draft memo to portfolio manager

Memo To: Motor Portfolio Manager
From: Actuary
Date: dd/mm/2015
Re: Analysis of lapse rates

As per your request, I have reviewed the policy retention analysis that concludes the recent rating adjustments have not been effective and that policy retention is falling.

The data collected and lapse rates calculated, compared lapses processed each month with renewals invited. The problem with this analysis is that the lapses processed in any given month do not all arise out of the renewals invited in that month. Therefore it can be difficult to interpret changes in the lapse rate as calculated by you. The problem with this method becomes more pronounced when the number of renewals invited is subject to large variations as occurred between September and December.

I have recalculated lapse rates based on comparing lapses processed back to their corresponding renewal effective month. This results in a more precise calculation of the rate of lapse and removes the inconsistencies of the approach described above. Under my approach, each renewal effective month is at a different stage of "development" in respect of the lapses processed against it. The development must be projected out to an ultimate state in order to calculate and therefore compare lapse rates by renewal effective month. I have employed a simple actuarial projection technique in order to calculate the projected lapse rates.

The results indicate that there is no evidence of a deterioration in lapse rates. On the contrary, there is some evidence of a slight improvement in policy retention rates which is in line with the expectations of the rate review.

I would be happy to discuss these results with you if required.

Regards,
A.N. Actuary

[11]
[18 Marks]

<u>Solution 4</u>:

(i) Curve Fitting method:

- A curve fitting method is a numerical analysis whereby a curve is fit based on claims development till date and the curve is then used to extrapolate the tail development factors.
- The curve may be fit either on the paid claims / incurred claims or on the link ratios at various development ages observed till date.
- The underlying principle of a curve fit method is fitting a curve that best represents the development decay in the claim development i.e. as time progresses, claims are expected to accumulate at a diminishing rate (monotonically decreasing rate).
- The parameters / coefficients are then estimated based on available data till date and the most common estimation technique is the least –squares method.
- Typically the exponential family of curves is used in the curve fit method.

Uses:
- Extrapolation of tail development specially where the insurer has adequate data but not fully run-off (i.e. incomplete history)
- Since paid claims data are typically used for fitting the curve, the method weeds out the volatility of outstanding claim reserves
- Where an insurer's data has anomalies or is distorted due to aberrations in claim experience, the method can be used for smoothing out
- The method can be used to understand the underlying data by plotting residual plots to investigate deviation of actual observations from the fitted model
- Once the curve is fit, it is a straight forward application for estimating reserves

Limitations:
- The method is exposed to the possibility of over-parameterization and hence could lead to spurious accuracy. This typically arises where data is sparse.
- Like in any other model, the robustness of this method is as good as the assumptions underlying the method.
- Most curve fit methods assume decay in development pattern. Therefore if the insurer's data does not represent the same (e.g., deliberate slow settlement procedures; hump shaped payment curves), the method may not be relevant.
- Also, most of these curves may fall through when negative incremental development is observed in claims paid data on a consistent basis since these curves typically produce development factors not less than 1.

[9]

(ii)
- From the question x represents year of development and is an integer > 0 and b represents ultimate length of development. Therefore, logically x< = b
- Besides, 'b' may not be an integer and since the variable x is represented as an integer and minimum period for a claim to development is one year (which is the 12 months development) b>=1. However, if x were represented in fraction of year then 'b' would take a minimum value accordingly.
- From the deductions above (b-x) >=0. Since the function is expected to be between 0 and 1, the parameter 'a' has to lie between 0 and 1. If 'a' is less than 0 then f(x) would take negative values and if 'a' is greater than 1 then f(x) would take values greater than 1.

From above reasoning, the lower and upper bounds are:
$b \in [1, \infty)$
$a \in (0,1)$
$x \in [1,b)$ **[5]**

(iii)

Motor OD

Accident Year	12 months	24 months	ATUF to be used	ATUF	Ultimate = ATUF * Incurred till date	IBNR = Ultimate - Incurred till date
31 Mar X	50		Use 12 m ATUF	1.0307	51.53	1.53
31 Mar X-1	10	12	Use 24 m ATUF	1.0152	12.18	0.18
					IBNR (INR Mn)	1.72

Motor TP

Accident Year	12 months	24 months	ATUF to be used	ATUF	Ultimate = ATUF * Incurred till date	IBNR = Ultimate - Incurred till date
31 Mar X	12		Use 12 m ATUF	7.6840	92.21	80.21
31 Mar X-1	2	4	Use 24 m ATUF	5.9551	23.82	19.82
					IBNR (INR Mn)	100.03

[3]

(iv)

a)

Development pattern (percentages) – Motor OD

Accident Year cohort	Motor OD (age to ultimate factor)	Motor OD (development %)
12 months	1.0307	=1/1.0307 = 0.9702 = 97.0%
24 months	1.0152	= 1/1.0152 = 0.9850 = 98.5%
36 months	1.0000	=1 = 100%

Development pattern (percentages) – Motor TP

Accident Year cohort	Motor TP (age to ultimate factor)	Motor TP (development %)
12 months	7.6840	= 1/7.6840 = 0.1301 = 13.0%
24 months	5.9551	=1/5.9551 = 0.1679 = 16.79%
36 months	4.6152	=1/4.6152 = 0.2167 =21.67%
48 months	3.5768	=1/3.5768 = 0.2796 = 27.96%
60 months	2.7720	=1/2.7720 =0.3608 = 36.08%
72 months	2.1483	=1/2.1483 = 0.4655 =46.55%
84 months	1.6649	=1/1.6649 = 0.6006 = 60.06%
96 months	1.2903	=1/1.2903 = 0.775 = 77.5%
108 months	1.0000	=1= 100%

Parameters a & b for Motor OD
Since b is the ultimate length of development and at b = 36 months, ATUF is 1, **b = 3**.
Substituting this at x = 24 months = 2 (in years), **a = 0.985**

Parameters a & b for Motor TP
Since b is the ultimate length of development and at b = 108 months, ATUF is 1, **b = 9**.
Substituting this at x = 96 months = 8 (in years), **a = 0.775**

[8]

b)
Results:
Motor OD:

- Shows 98.5% of the development in 2 years which appears reasonable and the ultimate time to full development at 3 years also seems reasonable in Indian context,
- However 97% development in year 1 could be arguably on a higher side. But, given that the results are based on a fitted curve, this higher development percentage could be a result of smoothening.
- It would be important to look at the deviation between the actual and fit value, specially, in year 1, as a higher percentage could lead to a possible underestimation. The actuary may want to look at the residual plots and if needed, refit the curve

Motor TP

- The pattern appears to be slow up to year 4 (~27% i.e. around one-fourth of development) and begins to pick up speed fourth year onwards. This appears an appropriate development basis in Indian context considering the reporting time-lags observed in this portfolio.
- Also, it shows 77.5% of the development in 8 years and 100% in 9 years thus representing a rather fat tail. Therefore, though the time to ultimate development of 9 years appear reasonable in Indian context; the jump between 8^{th} & 9^{th} years appears rather steep.
- Besides, the value of parameter ‘a’ appears to be the development percentage value at the penultimate year to development (i.e. year 2 for Motor OD and year 8 for Motor TP). Therefore, again, the actuary may want to revisit (i.e. increase) the estimated value of ‘a’ for Motor TP in view of the above after appropriate study of residuals.
- However, the downside of increasing only the value of ‘a’ keeping the ultimate time to development unchanged would be that the development in the initial years would be sped up which could lead to a possible underestimation of IBNR reserves.
- Also, the insurer has completed two financial years but it is not clear whether it has two full years of operation. Besides, even with two full years, the year 1 AY would be shrunk by six months. Therefore, the actuary needs to consider some specific adjustments to the first year development factor (derived from industry experience) that is slower than what the industry experience suggests and thus, similarly, for year 2 as well. This point would be applicable for Motor OD also.

[6]

(v)

The Actuary would have made this suggestion considering that the co. has only two financial years of business. If these are two full years then UW year would give two full year’s information whereas AY could possibly give only half a year’s information in year 1 and full year’s information in year 2. Besides, even if the first year has been a partial year of operations, the development till date in a UWY cohort would be more than the AY cohort.

- The above curve has been fit based on AY year cohort with ultimate time to development taken as 3 years and 9 years respectively for OD & TP. Therefore, to convert to UWY cohort, the ultimate age needs to be increased basically to account for the occurrence lag.
- Assuming all policies are annual (which is currently the situation in Indian context) and assuming on an average claims occur mid-way during a policy year, the length factor 'b' needs to be increased by 0.5 for above curve.
- For the above curve, parameter "a" can be kept unchanged as it is dependent on parameter "b". Therefore if "b" is increased by 0.5 then "a" would be applicable for the penultimate year i.e. (b-1) year.
- The main limitations:
    - Where multi-year policies are also issued along with annual policies, it would be more difficult to estimate the "additional" length (not applicable at present in Indian context though going forward it would be with IRDA approving Motor policies up to 3 years) and this assumption of 0.5 could be incorrect
    - Also, in case of only annual policies as well, the limitation here would be in cases where there is seasonality in writing policies and claim emergence, which is typically the case in reality.
    - Other major limitation is around assumptions on the speed factor within a development year.
    - Poor underwriting could lead to more close proximity claims that could lead to a smaller additional length than reasonably expected.

[4]

(vi)

a)

Motor OD	**Net IBNR as on 31 Mar X**	
UWY	X-1	X
A - NWP	15	70
B - NEP	15	35
C - ULR (a priori)	65%	65%
D - age	24 months	12 months
E - a	0.985	0.985
F - b	3.5	3.5
G - x	2	1
H - a^(b-x)	97.76%	96.29%
I - Balance ULR yet to develop (1-H)*C	1.46%	2.41%
J - Net IBNR (INR Mn) (I * C)	0.22	0.84
K - Total (INR Mn)		1.06

Motor TP	**Net IBNR as on 31 Mar X**	
UWY	X-1	X
A - NWP	12	60
B - NEP	12*	30*
C - ULR (a priori)	145%	145%
D - age	24 months	12 months
E - a	0.775	0.775
F - b	9.5	9.5
G - x	2	1
H - a^(b-x)	14.78%	11.46%
I - Balance ULR yet to develop (1-H)*C	123.56%	128.39%
J - Net IBNR (INR Mn) (I * C)	14.83	38.52
Total (INR Mn)		53.34

Assumptions:

1. Policies are written uniformly hence for UWY 31 Mar X, 50% taken as NEP
2. No non-proportional RI costs affecting NWP & NEP and hence the exposure
3. All annual policies and uniform claim pattern hence value of b increased by 0.5
4. Value of ‘a’ is kept unchanged – assumed the same value is now applicable at a longer development age (in effect slowing down the speed)
5. Since B-F used on UWY cohort, actual incurred claims ignored.

[6]

b)

Motor OD appears more comparable possibly owing to smaller volumes and the relatively quick claims development pattern and hence better predictability. Also ULR could also be estimated with greater certainty in this line.

However, Motor TP appears significantly different. The extremes could be possibly explained by the fact that BCL ignores premium exposures and the UWY B-F method ignores the incurred claim costs. A more suitable method could have been AY B-F method that takes into consideration both.

From appropriateness perspective, the UWY cohort B-F method could be more reasonable as it takes into consideration in-house exposures as well as development based on industry trends. However, the ULR estimate appears quite under (145%). Need to investigate the reasons (mix? price increase?) and revised.

Besides, the mix of TP business could also be relevant. It needs to be investigated further whether the analyst has considered industry experience of similar classes of vehicle written by the said insurer.

The trends in the reporting patterns across accident years in the industry data needs to be further checked. More recent data could be given greater weight and needs to be checked whether the analyst has considered this while fitting the curve.

The actuary would want to revisit the development factors in view of the internal claim management practices of the insurer. A more prudent claim reserving practice like early recognition of claims, case estimates in line with expected payouts, etc. would weed out possibility of ‘artificial’ delays in reporting and humps in claim amounts. Quick settlement practices could also save the interest rate costs and hence the ultimate costs.

The uniform distribution assumption for estimating NEP could be incorrect (perhaps it is actually higher) which led to lower estimation in method 2. Hence the exact computed value of NEP needs to be considered.

It should also be checked if the NWP has been underestimated owing to significant amounts of non-proportional RI costs incurred, for any reason. If so, NWP before XL costs need to be considered.

[3]

(vii)

The above curve is fit on incurred claims however industry incurred claims could be prone to non-standardised volatility as various insurers could be following varied case estimation methods. Therefore a likely suggestion could be to look at paid data only as these are crystallized numbers.

A curve fit is useful specially to estimate the tail development given the claims development till date. However, since the insurer is a new entrant, the appropriateness of wholly relying on the method could be arguable. A possible option would be to have a credibility weighted estimate at various age points based on in house experience as well, particularly Motor OD

The fitted curve is assumed to be applicable for all accident years. However, in reality, different accident years could exhibit different patterns of development owing to various internal and external factors. A possible suggestion for improvement could be to look at different fits for different AYs taking into consideration all possible internal & future external factors.

In this case a single curve has been used to estimate development factors whereas at different intervals, the characteristics of the development could change. This is particularly the case with long-tailed lines. It would be worthwhile to break the periods into shorter periods and fit curves within these intervals. This could also improve the fit by reducing the residual error.

Since the insurer is relatively new, it might want to look at more frequent intervals, say quarterly, to analyse the development trends. Therefore, if such granular level industry data is available, it might be more appropriate to reparameterize such that the length is expressed in sub-units of a year, say quarter/half-year.

[5]
[49 Marks]

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