

INSTITUTE OF ACTUARIES OF INDIA

EXAMINATIONS

27th May 2023

Subject CP2B – Actuarial Modelling (Paper B)

Time allowed: 3 Hour 15 Minutes (14.45 – 18.00 Hours)

Total Marks: 100

INSTRUCTIONS TO THE CANDIDATES

- 1. Mark allocations are shown in brackets.*
- 2. Do save your work in solution template on a regular basis.*
- 3. All the detailed guidelines are available on exam screen.*
- 4. If Any, Data set file(s) accompanying the question paper is available for download on the exam screen.*
- 5. Please check if you have received complete Question Paper and no page is missing. If so, kindly get new set of Question Paper from the Invigilator.*

AT THE END OF THE EXAMINATION

Please return this question paper to the supervisor separately. You are not allowed to carry the question paper in any form with you. You are requested to save and submit the work before leaving the examination premises.

Exam requirements

Read the background document, which describes the approach that has been used to model 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) Additional information and modelling steps

- i) Estimate the impact on Best Estimate Liability (BEL) if an additional mortality uncertainty factor is to be also introduced in the model. No change is required to the base reserves as these are based on previous year's assumptions.
[Hint: the mortality adjustment factor value will be further adjusted by a factor equal to:
First projection year: 1
Second projection year: $(1 + \text{uncertainty factor})$
Third projection year: $(1 + \text{uncertainty factor})^2$
And so on] (5)
- ii) Recalculate the mortality adjustment factors by basing the actual mortality experience on the amount of sum assured inforce and claim paid (instead of the count of inforce policies and number of mortality claims). (4)
- iii) Estimate the impact on BEL using the proposed assumption based on the amount of mortality claims (calculated above). The base will still remain the mortality assumption used in the previous valuation period. (2)
- iv) Estimate further the impact on BEL of applying the same mortality uncertainty factor to the proposed rates calculated above, i.e. experience based on the amount of claim paid. (2)
- v) Show a comparison of results:
 - Comparing the actual v/s expected mortality ratios under the two methods, i.e. based on number of claim paid and based on amount of claims paid.
 - Comparing the impact on reserves from the last years assumptions with different scenarios tested. (3)

[16]

- Q. 2) Prepare a summary in excel capturing the main features and results of the work completed by you and your colleague. You can assume that the summary is being for the Chief Actuary of the company, who will use this to set the mortality adjustment assumption for the next valuation cycle.

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 different approaches and how they compare with the reinsurers rates
- How Covid-19 impacted years impact the average
- An explanation on how the Adjustment factor varies across age groups and the weighted average
- Impact of basing the calculation on number of claims v/s amount of claims.
- Next steps specific to the project with underlying rationale

The summary should cover the full scope of the project, including the additional approaches, 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:**

i) Purpose data and assumptions	(10)
ii) Methodology	(20)
iii) Data Checks and reasonableness checks	(5)
iv) Results, including charts. Results should include the actual mortality experience, the proposed mortality assumption and the impact on best estimate liability	(8)
v) Commentary on results and conclusions	(17)
vi) Next steps	(14)
vii) Drafting	(10)
	[84]

Overview of the project

‘LifeCo’ is a life insurance company operating since last 10 years in the country. So far, because of lack of credible data, it was not performing mortality experience study at its own and was using the reinsurers rates so far to set its mortality assumptions.

A new Senior Actuary has come in and wants LifeCo to conduct the mortality study using the data it has. Last 7 years data has been summarised and made available for this purpose.

The data contains information around the number of policies at the start of the years along with the total sum assured (assumed to represent exposed to risk) and the number and amount of mortality claim. The information is grouped according to age and the year.

The Senior Actuary had initially recommended that:

- The data be divided into age groups. The age groups and the reference age in that group to look up the expected rate from the mortality table has also been provided.
- Actual mortality experience be then taken out in each of those age groups by dividing the number claims by the number of inforce policies. This should be done over all years.
- Average experience over last 7 years for which data is present (2016 to 2022) be compared against the expected mortality experience. The expected mortality will directly be calculated from the mortality table being used.
- The ratio of actual and expected mortality will be used to form the best estimate assumptions. The age group wise results will be combined with the expected population weightage across these groups to calculate the weighted average mortality adjustment factor. This will be set as the proposed assumption.

The objective of this exercise to calculate the actual / expected mortality experience, which can be used as a mortality adjustment factor (applied over the mortality table) to set the best estimate mortality experience.

Further, the Senior Actuary has also recommended that a high level estimate on the Best Estimate Liability (BEL) value be calculated to show how the BEL will move with the new assumption. For the same, he has provided a set of already developed calculation which uses an average term policy to calculate the best estimate liability value.

This model was already set up by a colleague of your, who has now left the organisation.

Further inputs/suggestions to refine the model, post the exit of the colleague who originally made the model:

There are two more recommendations from the Senior Actuary:

- The experience study can also be calculated using the inforce sum assured and the amount of claim paid. He thinks calculations should be done under both the approaches and presented to the Chief Actuary for him to take the decision.
- Allow for an additional uncertainty factor to the mortality. With this uncertainty factor, the mortality value will increase in later projection years. This adjustment factor is suggested to be 0.25%.

The Senior Actuary has provided you with the model and Audit trail written by your colleague. This does not include the calculation based on the additional information received after the colleague had left the company. You are required to use the model provided and complete the additional changes required. Also, you are required to prepare a summary report which he/she can present to the Appointed Actuary, including the results under different method, which can then be used to set up the mortality assumption.

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

So far, LifeCo has not been performing mortality experience study and rather using the reinsurers' rates to set its mortality assumptions. However, given the company has now collected credible data, it is proposed that we perform mortality study in-house using the mortality claims data of the company. This is the first time this exercise has been performed by the company. The actual mortality experience will then be compared against the expected mortality rates (which would be obtained by standard mortality table available). The Actual v/s expected ratio calculated will be used to set the mortality assumption, which is a multiplier applied to the standard mortality table. A high level impact on the Best Estimate Liability (BEL) value will also be shown on a average policy.

Objective

The objective of this Excel file is to calculate the actual mortality experience and then using the same, calculate the mortality adjustment factor which is required to be applied to the mortality table.

Further, this file also uses an average policy detail of a term insurance policy to show how the BEL will change with the proposed mortality adjustment factor assumption value.

Data

The records team of the insurance company has provided the claims and the inforce records. The data is grouped by age and year. Looking at the date received, it is noted that the data is made available under the following groups

- Year: The data is from 2016 to 2022 (both inclusive)
- Age: Ranging from 21 years to 80 years

The following information is present in the data

- Inforce count at the start
- Number of mortality claims
- Inforce amount of sum assured
- Amount of mortality claims paid during the year

A total of 562 data rows are present. This data has been pasted in sheet 'Data' in columns B:G.

Check: A check was performed to ensure that the claim (number as well as amount) is not more than the inforce value. This has been done in columns 'J & K' of Sheet 'Data'. No errors were observed.

The maximum and minimum age and year ranges were noted from the data.

Additional inputs/assumptions

It was agreed that the data be grouped into age groups, based on which the analysis will be done. A age group look up table was created for the same based on internal discussion. This table also provided the reference age which will be used to calculate the expected mortality rate from the mortality table.

Besides, the mortality table which is the base mortality table for the company in all its models, has also been obtained and pasted here. This table contains age wise mortality rates.

The Actuarial models of the company require that a single mortality adjustment factor as it cannot handle age group wise factors. The marketing team has provided the business mix by age groups, to calculate a weighted average adjustment factor.

Age group	Weightage
21-30 years	8%
31-40 years	28%
41-50 years	23%
51-60 years	18%
61-70 years	13%
71-80 years	10%
Total	100%

All these information are pasted in sheet 'Other Info'

Assigning age group to the records

An age group has been assigned to each data row based on the information present in sheet 'OtherInfo' under 'Age group lookup table' using Excel VLOOKUP function. Each age group size is of 10 years. Given the data ranges from 21 to 80 years, the following age groups are made in column 'H' of sheet 'Data'

- 21-30 years
- 31-40 years
- 41-50 years
- 51-60 years
- 61-70 years
- 71-80 years

The analysis has been done for these age groups only, given we have data for only these groups and assuming that the target market for the insurance company lies in these age groups.

Summarising the data

In sheet 'Summary data' the data present in sheet 'Data' has been summarised into tables with year as the column headers and age group as the row headers. Four such tables have been made, one each for:

- Inforce count of the policies (exposed to risk)
- Number of mortality claims
- Inforce sum assured (exposed to risk)
- Amount of mortality claims paid

The data has been summarised using Excel 'SUMIFS' function.

Check: Checks have been made to ensure that the total of each table matches the corresponding column total in the 'Data' sheet and that all rows have been included. No errors were observed.

Calculating the expected mortality

The expected mortality rate has been directly taken from the mortality table present in the sheet 'Other Info'. For each of the age groups being analysed, the reference age has been set by VLOOKUP from the 'Age group lookup table'. Then the mortality rate for that reference rate has been taken from the base mortality rate table.

Calculating the actual mortality experience

This has been calculated in sheet 'Actual vs exp - no. of claims'.

From the summarised data, actual mortality experience has been calculated as:

$$\frac{\text{Number of claims paid during the year}}{\text{Number of lives inforce at the start of the year}}$$

Here, number of lives inforce at the start of the year has been assumed to represent the population 'exposed to risk'. This has been calculated year wise and age group wise.

Average experience has been calculated in column 'J' as the average experience of last 7 years (i.e. 2016-2022) by using the AVERAGE function of MS Excel.

Calculating the mortality adjustment factor (The result)

In Sheet 'Actual vs exp - no. of claims', the average experience has been compared against the expected mortality which was calculated in sheet 'Expected mortality'. A ratio of Actual/Expected is then calculated. Here Actual is the actual mortality experience, averaged over last 7 years.

A weighted average rate is calculated by using the population weight (column L) in cell M10.

This factor needs to be reviewed as this will form base of setting up the mortality adjustment multiplier assumption.

BEL

This sheet shows the Best Estimate Liability (BEL) of a sample term insurance policy taking into consideration only death benefit payable. The calculations in this sheet up to column X were received directly from the Senior Actuary and is assumed to be correct. In order to see the impact of the new mortality adjustment factor calculated, columns P to X

have been copied into columns Z to AH. In column M (additional column inserted) the new mortality assumption has been put. The same has been linked in column AC. The BEL under the new assumption has been compared against the base BEL. This gives a net impact of 10%, shown in column M.
