

INSTITUTE AND FACULTY OF ACTUARIES

Audit Trail

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Subject CA2

Model Documentation, Analysis and Reporting

Paper One

Experience Analysis

Objective

The purpose of the spreadsheet is to complete the following calculations in respect of ten year term assurance policies:

- Check the data and correct where necessary.
- Determine Actual (A) and Expected (E) claim amounts for a given investigation period and calculate A/E ratios for each age band and for the overall portfolio.
- Use the A/E ratio for the portfolio and a provided mortality benchmark table to calculate assurance and annuity factors for each age band.
- Determine a level annual premium for each age band and an overall weighted premium rate and expected total premium for the new business portfolio.

NB: Input cells are shown in blue

Data

The following data have been provided by different departments within Life Co and are included in this worksheet:

- Exposure data from an experience investigation performed on term assurance business over the period 1 January 2010–31 December 2014. This includes the amount of sum assured exposed to risk split by age band;
- A claims file for the same investigation period. This details individual claim amounts and the corresponding age at time of claim;
- An expected new business profile for 2016 split by age band. The percentage of the total sum assured in each age band is included.

Checks: A quick check by eye on the exposure data and expected new business portfolio does not suggest that anything has been materially misstated. In particular, there is no negative exposure and the age range [30, 60) corresponds to the ages at which policies could be sold, namely [30, 50].

Furthermore, it has been checked that the % of policies in each age band sums to 100% overall.

Parameters

Life Co has also provided the following information which is input here:

- pricing margin (to cover capital, expenses and profit)
- flat discount rate used for premium setting
- total amount of new business sum assured expected in 2016
- minimum and maximum ages of exposure (latter = maximum entry age + term – 1)
- maximum sum assured

Data Checks

This worksheet performs a number of checks and adjustments on the claims data

The following four auto-checks have been performed on the claims data in columns G to J:

- There should be no claims under the minimum exposure age.
- There should be no claims over the maximum exposure age.
- There should be no claims which are not positive.
- There should be no claims which are larger than the maximum sum assured.

If the above check is successful, it returns a 0 otherwise it returns a 1. The total number of failed checks is summed in row 4.

Several potential errors have been found. The errors and adjustments applied are detailed below:

Record 12: Age exceeds the maximum, so set it to the maximum.

Record 44: Claim is negative. Minus sign may be a typo, so take the absolute value.

Record 49: Claim is 0. Likely that it has not been entered. Take the average value of all other claims.

Record 61: Claim exceeds the maximum sum assured. It looks as if there are too many trailing zeros, so remove these.

Age exceeds the maximum so set it to the maximum.

Record 76: Age exceeds the maximum, so set it to the maximum.

Record 228: Age is lower than the minimum entry age, so set it to the minimum.

The same checks have been applied to the corrected data in columns P to S to ensure that no errors remain.

Additionally a scatter-graph of the claims has been drawn to ensure there is no anomalous pattern and that they fall within the permitted range. Age has been plotted on the x-axis against amount on the y-axis. *(The pattern looks reasonable.)*

Mortality Table

This worksheet contains the mortality table and some basic checks

- The provided mortality table is shown on this worksheet. It is a unisex mortality table for ages 16 to 120.

Checks: It is checked in cells H4 and H5 that $q(x)$ is always non-negative and never greater than 1. Furthermore it is checked in column D that $i(x)$ increases as x increases.

Assumptions

- The corrected claims data does not contain any further errors.
- All claims incurred during the investigation have been reported.
- The exposure data provided by the Insurance Company have been calculated correctly.
- Policies are uniformly distributed by age across each age band. Hence the average age for policies can be taken as the mid point of each age band.
- The experience investigation has been performed on a pool of business whose experience is expected to be comparable to the experience expected on this portfolio. In particular:
 - The gender mix in the experience investigation is similar to that in the new portfolio
 - The smoker mix in the experience investigation is similar to that in the new portfolio
 - There was no unusual event (e.g. catastrophe or pandemic) during the investigation period
- No allowance has been made for mortality improvements between the end of the experience investigation and the start of the cash flow projection.
- No mortality improvements are allowed for in the cash flow projection.
- It is assumed that premiums will be paid at the start of each year.
- The expected new business mix will be achieved and a total sum assured of \$220m will be written in 2016.
- The internal mortality table is an appropriate table to compare the experience against.
- No allowance is made for expense inflation or changes in capital requirements.

The gender mix used to derive the internal mortality table is consistent with the gender mix in the term portfolio or mortality does not differ by gender in Actuarialia.

AvE

In this worksheet the Actual vs Expected claims ratio for each age band and for the overall portfolio is determined

The lowest and highest exact age in each age band is set out in columns B and C respectively.

The Initial Amounts Exposure has been provided by age band and this is fed through from the “Data” worksheet into column E.

For each age band the following calculations are made:

- The mid point of each age band is determined as the average of the lowest and highest exact age (column D).
- The Actual Claims for each age band are determined in column F by summing over the adjusted claims amounts (from “Data Checks”) using a SUMIF function. Any claims which fall within the age band are summed using \geq and \leq comparisons.
- The Expected Claims for each age band are determined in column G as the product of the mortality rate corresponding to the average age and the Initial Amounts Exposure from column E. Namely:

$$\text{Expected Claims} = q(\text{Average Age}) * \text{Initial Amounts Exposure}$$

The mortality rate used in this formula is obtained from the “Mortality Table” worksheet, using VLOOKUP on the mid point age that was calculated in column D.

- The Actual over Expected ratio in column H is simply the total actual amount of claims in the age band (column F) divided by the expected claims (column G).

The Actual over Expected for the portfolio is determined by summing the total amount of claims in the portfolio and dividing by the total of the expected claims in the portfolio. This is shown in row 12.

The A/E results for each age band are plotted on a bar chart below the calculations table. A line showing the total A/E for the portfolio has been added to the chart.

Sense Checks: The A/E at portfolio level sits between the lowest and highest A/E by age band. And the overall ratio is close to 100%, suggesting that the calculations do not contain material errors. However, it is noted that there is considerable variability in the A/E by age band. This suggests the shape of the benchmark table may be inappropriate and should be investigated further.

Projection

In this worksheet the assurance factor and annuity factor for each age band is determined. This enables a level premium to be calculated for each age band.

The portfolio data is read in from the “Data” worksheet. For each age band the average age is assumed to be the mid point, calculated in column E.

The projection is performed as follows:

- Take time periods from $t = 0$ to $t = 9$, which are the time periods at the start of each year of a T-10 policy (column B)
- For each age band take the age at the mid-point, say x (column C).
- For $t = 0$ to $t = 9$, lookup the initial mortality rate $q(x + t)$ (using VLOOKUP) and multiply by the portfolio A/E ratio (from the AvE worksheet) (column D)
- An assurance factor gives the expected present value of claims for a sum assured of 1. The assurance factors are determined in column E using the recursive relationship:

$$A(x + t) = [q(x) + (1 - q(x)) * A(x + t + 1)](1 + i)^{(-1)}$$

where the boundary condition $A(x + 10) = 0$ applies and the mortality rates are those from column D, i.e. they have been multiplied by the A/E ratio.

- An annuity factor gives the expected present value of a premium of 1 per annum. The annuity in advance factors are determined in column F using the recursive relationship:

$$a_adv(x + t) = 1 + [(1 - q(x)) * a_adv(x + t + 1)](1 + i)^{(-1)}$$

where the boundary condition $a_adv(x + 10) = 0$ applies and the mortality rates are those from column D, i.e. they have been multiplied by the A/E ratio.

- The expected claims payment for a \$1,000 sum assured is $1,000 * A(x)$. This is loaded by multiplying by $\{1 + \text{margin}\}$ to cover expenses, capital and profit, where the margin is taken from the “Parameters” worksheet.

The calculated quantity is divided by $a_adv(x)$ to obtain the net level premium per \$1,000 sum assured.

- The above process is repeated for each age band [30, 34], [35, 39], [40, 44] and [45, 49].

Sense Checks: As expected higher ages have:

- higher assurance factors, as there is a greater chance of the claim being paid and it is more likely to be paid earlier.
- lower annuity factors, as there is a greater chance of the policyholder dying and therefore not paying all of the premiums.

- a higher premium rate, as the probability of dying during the policy term will be greater and so there is a higher chance of having to pay out the sum assured and because fewer premiums on average will be received.
- a total weighted premium for the portfolio is obtained by weighting the calculated premiums by the percentage of sum assured falling into each age band. This weighted premium is then applied to the total expected new business sum assured (taken from the “Parameters” worksheet) to obtain the expected first year premium (see cell F28).

Sense Check: A sense check is performed on the calculated weighted premium for the portfolio. The average age of the expected new business portfolio (weighted by sum assured) is calculated from the new business data; in this case it is seen to be 41. It is further noted that the rate for a 42 year old is 2.17. Given that the average age of the portfolio is slightly below 42, the premium of 2.15 looks reasonable compared to 2.17.

A bar chart showing the calculated premium rate of each age band has been produced below the calculation tables.

Check: Setting the ages to the same for each of the four sets of premium rate calculations gives the same rate, which checks that there has not been any error in copying across the blocks of formulae.