

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINATION

14 September 2021 (am)

**Subject CP2 - Modelling Practice
Core Practices**

Paper Two

Time allowed: Three hours and twenty minutes

<p>In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator.</p>
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If you encounter any issues during the examination, please contact the Assessment Team at
T. 0044 (0) 1865 268 873.

Exam requirements

Read the background document, which describes the scenarios that have been modelled 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 that they performed. This will assist you in following and understanding the calculations performed in the Excel model provided.

You are not required to add to 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.

1 Modelling steps:

- (i) Calculate the Macauley duration of the projected cashflows. [3]
 - (ii) Repeat all the calculations completed by your colleague but under the new proposed structure, of up to \$7m in excess of \$3m, with the updated assumptions. This should include the re-calculation of the Macauley duration from step (i). [6]
- [Total 9]

2 Construct, for each of the following, a suitable chart to:

- (i) illustrate the number of claims occurring in each year under the original proposal. [3]
 - (ii) illustrate the average claim payout for each year under the original proposal. [3]
 - (iii) compare the projected (undiscounted) claim cashflows under each proposed policy. [3]
- [Total 9]
[Sub-total 18]

Prepare a summary document of around five to seven pages, capturing the main features and results of the work completed by you and your colleague. You can assume that the summary is being prepared for your manager, a senior actuary, who will present the work to the Managing Director of ABC Reinsurance (ABC Re).

Your summary should include the following:

- purpose of the project, data, method 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:

- analytical comments on each stage of the results, including explaining patterns in the results and any unusual features.
- an explanation of the differences between the results under the various scenarios modelled.

Next steps need to be specific to the project, with some mention of why each is a valid next step.

The summary should cover the full scope of the project, including the current approach, which was modelled in the spreadsheet provided.

You are not required to add to or amend the audit trail.

3 Marks available for the summary:

(i)	Methodology (including purpose, data, method and assumptions).	[26]
(ii)	Results, including charts.	[6]
(iii)	Commentary on results and conclusions.	[22]
(iv)	Next steps.	[18]
(v)	Drafting.	[10]
		[Sub-total 82]
		[Total 100]

Background

You are an actuarial student working for ABC Re, a reinsurance company that offers reinsurance policies to insurance companies.

DEF Insurance (DEF) sells commercial property insurance. DEF can incur large individual claims on its commercial property business. To help manage its risks DEF is looking to buy reinsurance cover from ABC Re.

Another actuarial student in your team has been working on a quotation for DEF. The quotation is for a reinsurance policy covering commercial property insurance policies sold by DEF in 2022. The policy will pay DEF up to \$5m for any individual claim that it has to pay in excess of \$5m. So, for example, if DEF has an individual claim of \$6m, ABC Re will pay DEF \$1m and for a claim of \$7m, ABC Re would pay \$2m etc. The maximum that ABC Re will pay is \$5m. DEF has offered to pay a premium of \$15m to ABC Re if they provide the policy. This would be a one-off payment, paid as a lump sum, at the date the policy commences.

The reinsurance policy covers all claims in respect of insurance policies sold by DEF in 2022, but typically there is a delay between claims being reported to DEF, being agreed and finally being paid by DEF. ABC Re will pay DEF the amount owed at the end of the same quarter that DEF has paid out to its clients. The reinsurance policy has a term of 6 years and any outstanding claims, which have not yet been paid by DEF, will be paid at the end of 6 years based on an estimate of the value agreed between ABC Re and DEF. This amount is not expected to be material.

To help ABC Re decide if it should write the policy DEF has provided a list of all the large individual claims, that are in excess of \$1m, that it has paid over the last 20 years.

Your colleague has performed the following calculations.

The first step was to adjust the claims figures to account for inflation over time. This is because a claim paid in the past would cost more today for an equivalent claim. This was done by recalculating the equivalent value of the claims in the present day, using a table of claims inflation data for commercial property claims for the years from 2001 to 2020. In addition, as the proposed policy is to cover the year 2022, it is assumed that claims inflation for 2021 and 2022 will be 3% p.a. (The claims inflation table is consistent with the way that DEF have reported their claims history so the table can be applied directly to the total claim amount given in the DEF data and no further adjustment for claims inflation is required.)

The next step was to calculate what ABC Re would have had to pay on each of the historic claims under the terms of the proposed reinsurance policy. Using these adjusted claims values it was possible to calculate the number of claims per year and the average amount ABC Re would have paid out per year.

The average of the number of claims per year was calculated to estimate the likely frequency of claims in a year. The weighted average of the payments was calculated to estimate the likely severity of claims under the reinsurance policy. The expected claim amount was calculated as the estimated number of claims per year (the frequency) multiplied by the estimated claims under the reinsurance policy (the severity).

Under the terms of the reinsurance policy, ABC Re would receive the whole premium at the start date on 1 January 2022 but will only pay claims at the end of each quarter as they fall due under the terms of the policy. Therefore, ABC Re will benefit from the investment return on the reinsurance premium received less any claims paid. To reflect this benefit, the discounted value of the expected claims is calculated based on an assumed annual discount rate of 3% (the expected investment return) and an assumed payout pattern of claims over the 6 years of the policy. The payout pattern is the percentage of the total expected claims that have actually been paid after each quarter end by ABC Re. The payout patterns is 100% after 6 years as all claims have been paid by ABC Re. Based on ABC Re's past claims experience the assumed cumulative payout pattern for claims is a log normal distribution with a mean of eight quarters and a standard deviation of 1.5 quarters.

The present value of reinsurance claims can be calculated by projecting the expected claims over the 6 years of the policy using the assumed payout pattern and then discounting these values back to the start of the policy.

ABC Re requires a profit margin of 10% on any policy to reflect the risks that it is taking on. To determine if ABC Re would accept the current proposed policy terms the net premium is calculated as the proposed premium of \$15m multiplied by (1 – required profit margin). If the net premium is greater than the present value of expected claims, then ABC Re would accept the proposed policy terms.

The analysis has shown that the proposed policy terms would be profitable enough for ABC Re to reflect the risk taken. Your colleague, who has completed the analysis described above, is handing the quotation over to you and has provided you with the model and the audit trail.

Further development

Your manager wants to confirm with the Investment Manager that the assumed investment return of 3% p.a. is achievable. The Investment Manager wants to know what the average duration of the reinsurance policy will be as, in general, they believe that the longer the term of the investment, the higher the return they can achieve. The average duration of the reinsurance policy can be determined using the Macauley duration of the projected claims cashflows, which can be calculated with the following formula:

$$\frac{1}{k} \cdot \frac{\sum_t t \cdot PVCF_t}{\sum_t PVCF_t}$$

where k is the number of cashflows per year (so four in this case) and $PVCF_t$ is the present value of the cashflow for quarter t (where $1 \leq t \leq 24$).

Your manager would also like you to repeat the analysis but for a policy where ABC Re pays up to \$7m of a claim in excess of \$3m. So, for example, for a claim of \$5m, ABC Re would pay DEF \$2m. Your manager wants you to calculate what the minimum premium would be that would have to be paid for such a policy, for ABC Re to still make its required profit margin of 10%. As the policy would cover smaller claims your manager thinks the payout pattern will be quicker than under the original policy so you should assume a mean of seven quarters and the same standard deviation as before.

Summary report

Your manager has asked you to prepare a summary report covering all elements of the work (both the original work your colleague completed and the additional modelling you are undertaking).

Within this summary, your manager also wishes you to include:

1. a chart illustrating the number of claims occurring in each year under the original proposal.
2. a chart illustrating the average claim payout for each year under the original proposal.
3. a chart comparing the projected (undiscounted) claim cashflows under each proposed policy.

Your summary should include the following:

- purpose of the project, data, method and assumptions used by you and your colleague
- results, including charts
- commentary on the results and key conclusions
- suggested next steps.

You are not expected to include the additional modelling you undertake in the audit trail, but the approach and results to all elements of the scenario (both those completed by your colleague and by you) should be included in the summary.

Audit trail

The following audit trail should be read alongside the model provided.

Objective

The overall objective is to assess whether a proposed reinsurance policy for DEF Insurance (which sells commercial insurance) should be written by ABC Re at the proposed premium. To do this, a model was developed with the following steps:

- Adjust the historic loss data to reflect the effects of inflation over time.
- Calculate the payments by ABC Re under the proposed terms of the reinsurance policy.
- Estimate the likely frequency and severity of potential claims.
- Determine the assumed payout pattern over the 6 years of the proposed policy.
- Prepare the quarterly cashflows and check whether the proposed premium allows ABC Re to make its required profit margin.

Data

DEF has provided a history of all claims over \$1m for the last 20 years.

A history of claims inflation in the commercial property insurance market over the last 20 years has been provided by the Research and Statistics department of ABC Re.

Assumptions

The assumptions used in the model are:

- the claims data provided by DEF is complete and accurate.
- the claims inflation data provided is suitable for use for DEF's business.
- claims are assumed to be evenly spread over the year and the claims inflation data is consistent with that, so no calendar adjustment is required.
- the policy is for 6 years and we assume that all outstanding claims are settled in the final quarter.

Methodology

The following steps were taken to complete the analysis.

Claims history

This is the history of large claims provided by DEF. There is a check in column C to ensure that all values are greater than \$1m.

Inflation rates

This contains the historic claims inflation data for each year of business written back to 2001. The annual inflation rate estimates relate to business written in each year rather than relating to the calendar year.

In order to adjust the historic claims values to a value for policies to be written in 2022, there is also an assumption that the claims for business written in 2021 and 2022 will experience claims inflation of 3% p.a.

Column C is the annual inflation rates plus 1 to help in the next step of the calculation. The cumulative inflation calculation for year X is done by taking the product of the annual inflation factors in column C for all the years from X + 1 up to 2022.

Adjusted claims inflation

This sheet takes the historic claims data from the 'Claims history' sheet and multiplies each amount by the relevant cumulative inflation factor calculated in the 'Inflation rates' sheet. The unadjusted claim amounts are in column B. In column C the cumulative inflation factor for year X is taken from the table of factors using the VLOOKUP function. The adjusted claim amounts are the product of columns B and C and are given in column D.

Policy features 5xs5

This sheet calculates, for each adjusted historic claim, what ABC Re would have had to pay under the proposed terms of the reinsurance policy. The parameters of the policy are included in cells B4 and B5, first the excess amount and then the maximum claim amount for which ABC Re will pay its share of.

In column B, for each adjusted historic claim amount, the amount payable under the proposed policy is calculated as follows: subject to a floor of zero, the reinsurer will pay the lesser of \$5m, or the amount of the claim minus the excess of \$5m.

So, for a claim of \$3m, the answer is zero as the claim minus the excess is negative and the calculation is subject to a floor of zero. For a claim of \$7m the answer is \$2m, as this is \$7m minus the excess of \$5m. And for a claim of \$12m the answer \$5m as this is the most that will be paid out under the proposed policy.

In column C the year is given if the calculated amount payable is positive. This is to assist the counting of the claims in the next step below.

Expected claims 5xs5

This sheet calculates an estimate of the frequency and severity of the historic claims and consequently the expected claims.

First in column B the number of claims in each year is calculated using the COUNTIF function on column C of the 'Policy features 5xs5' sheet. This column only contains the year of the claim if there was a positive payment required.

The average claim per year is calculated in column C using the AVERAGEIF function. So, for each year X this calculates the average of all the relevant claims that happened in year X.

The expected claims are calculated in columns E and F. First the average of the number of claims per year is calculated in F3 using the AVERAGE function over the number of claims in each year in column B.

The weighted average of all the claims is calculated in F4 as the sum of the product of number of claims per year and the average claim amount per year divided by the total number of claims. This was done using the SUMPRODUCT function in Excel.

The expected claims to be paid under the proposed policy are calculated in F5 as the product of the expected frequency (F3) and the expected severity (F4) as calculated above.

Payout pattern 5xs5

This sheet calculates the cumulative payout pattern of expected claims over the 6-year term of the policy. The payout pattern is expressed as a percentage and for each quarter gives the portion of the expected claims that have actually been paid up to that quarter.

The expected payout pattern is given by a cumulative log normal distribution with mean eight quarters and a standard deviation of 1.5 quarters. This is calculated in column B using the LOGNORM.DIST function in Excel with the parameters natural log of eight for the mean and the natural log of 1.5 for the standard deviation. The cumulative parameter of the function is set to TRUE.

Cashflow projection 5xs5

This sheet projects the expected cashflows and calculates the present value of the expected claims and thus determines if ABC Re should write the policy.

In column B the payout percentage for each quarter is calculated as the difference between the cumulative payout pattern percentage for that quarter and the previous quarter. In column C the payout percentage for each quarter is multiplied by the expected claim to give the expected claim amount for that quarter. In the final quarter, quarter 24, it is assumed that all outstanding claims will be paid so the claim amount for quarter 24 is the total expected claims minus all claims assumed to be paid to date.

The discount factor for each quarter is calculated in column D using the assumed annual discount rate of 3%. The discount factor is calculated as 1 plus the discount rate raised to the power of minus the relevant quarter divided by 4.

In column E the present value of the expected claims for each quarter is calculated as the claims payment calculated in column C multiplied by the discount factor in column D.

The margin test to determine if ABC Re should write the policy is done in columns H and I as follows. First the net required premium is calculated in cell I6 as the proposed premium for the policy of \$15m (I4), multiplied by 1 minus the required margin of 10% (I5).

The total present value of claims is calculated in cell I7 as the sum of column E, as described above. The expected profit/loss is then calculated in cell I8 as the net premium (I6) minus the present value of expected claims (I7). If this expected profit/loss is positive, then the policy can be written as proposed and if it is negative then it does not pass this margin test. There is a check in cell I9 that determines if the result is positive or negative.

END OF PAPER