INSTITUTE AND FACULTY OF ACTUARIES

EXAMINATION

22 September 2020 (am)

Subject CP2 – Modelling Practice
Core Practices

Paper Two

Time allowed: Three hours and fifteen minutes

If you encounter any issues during the examination please contact the Examination Team on T. 0044 (0) 1865 268 873.

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Exam requirements

Read the background document, that describes the scenarios that have been modelled and documented for this project, and the work that remains outstanding.

Read the audit trail that 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.

1 Spreadsheet model

Expand the spreadsheet model to determine how the two following aspects of the policy would need to be changed (independently) to maintain profitability at the levels expected before the reserve requirement was introduced:

(i) the policy premium

(ii) the policy excess.

You should ensure that the additional work you undertake on the spreadsheet contains appropriate self-checks and you should not overwrite the existing calculations. [7]

2 Charts

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

(i) the distribution of the number of claims (per claim amount bracket) incurred in the 2019 policy year for Never Worry.

(ii) the projected monthly cashflows and the monthly accumulation of profit for the 2021 policy year before allowance for the reserve requirement.

(iii) a comparison of the projected monthly cashflows for the 2021 policy year before and after the allowance for the reserve requirement.

(iv) the monthly accumulation of profit under the base scenario, under the scenario with the reserve requirement and under both additional options identified.

[11]

[Sub-total 18]

3 Summary document

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 boss, a senior actuary, who will present the work to the board of Accidents Happen.

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

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

Marks available for the summary:

(i)	Methodology (including purpose, data, method and assumptions)	[25]
(ii)	Results, including charts	[6]
(iii)	Commentary on results and conclusions	[22]
(iv)	Next steps	[19]
(v)	Drafting	[10]
		[Sub-total 82]
		[Total 100]

Background

You are an actuarial student working for Accidents Happen (AH), an insurance company that offers insurance policies for electronic goods. Another actuarial student in your team has been working on a new insurance product for mobile phones *(also known as cell phones or Global System for Mobile communication (GSM))*, which AH wishes to start selling from 1 January 2021.

The product will provide insurance cover for repairs on a policyholder's mobile phone following accidental damage (e.g. a cracked screen, water damage, etc.). The product will cover any type of mobile phone owned by the policyholder.

The AH Pricing Team has advised that the terms of the insurance policy should be as follows:

- The annual premium for each policy will be $20 per annum (paid monthly at the beginning of each month).
- The policyholder will pay the first $50 of each claim (i.e. the policy will have an excess of $50 for each claim).
- All policies start on the 1 January.
- The policyholder can make multiple claims over the year.

AH has sourced data from another insurer, Never Worry (NW), which had sold 10,000 similar policies on 1 January 2019 for the 2019 calendar/policy year. This data outlines the claims reported each calendar month over the 2019 policy year. Claims are before the deduction of any excess but are only included if they are higher than the claim excess amount for the policy.

NW has advised that the number of claims incurred during a year is expected to follow an exponential distribution with parameter (λ) 0.01.

To sell and maintain a policy, the Operations Team has advised that:

1. initial expenses for selling each policy will be $1.
2. monthly expenses for each policy will be $0.75.
3. claim expenses are expected to be $10 per claim.

For the purposes of the cashflow projections, the Operations Team has instructed your colleague to use an interest rate of 10% p.a.

Your colleague has been analysing the data that has been supplied by NW. They have completed a chi-squared test. Using this claims data and the terms provided by the Operations Team, your colleague has also projected a cash flow analysis for AH's 2021 calendar/policy year identifying the expected profitability for this collection of policies.

The Regulator has confirmed that from 2020 a reserve should be held for this type of policy. They have indicated that the reserve, at the start of the policy year, should be 110% of the expected total claims outgo, including the corresponding claim expenses from the policies written. (The reserve should be based on the claims outgo expected to be paid by AH and therefore does not include the policy excess.)

For the purposes of calculating the reserve, it can be assumed that the expected number of claims in 2021 is equal to the number experienced by NW in 2019 and the expected severity of the incurred claims per policy (before deducting the excess) can be determined from the following formula:

$$\text{Expected incurred claim} = \frac{1}{\lambda} + X$$

where X is the claim excess.

Under the reserve requirement, the amount of the reserve should be transferred to the Regulator, so your colleague has updated the cashflow analysis accordingly. This has shown that the expected profit on this collection of policies would reduce. Your colleague is handing the project over to you and has provided you with the model and the audit trail.

Impact of reserve requirement

Your boss is keen that the profitability of the product should not reduce as a result of the reserve requirement.

Your boss would like you to consider two options to maintain the profitability at the levels expected before the reserve requirement was allowed for:

1. increase the policy premium
2. increase the policy excess. (Note that under this scenario, a number of claims may now fall below the policy excess and should therefore be excluded for the calculation of the reserve requirement.)

Summary report

Your boss has asked you to prepare a summary covering all elements of the work (both the original work your colleague completed and the additional modelling you are undertaking), namely:

- the analysis of the data provided by NW and whether this does follow the suggested exponential distribution.
- the probable level of profit from the new policies in the 2021 policy year before and after allowing for the reserve requirement.
- the potential changes to the policy premium and policy excess required to maintain profitability after introducing the reserve requirement.

In this summary, your boss wishes you to include:

1. a chart illustrating the distribution of the number of claims incurred in the 2019 policy year for NW.
2. a chart illustrating the monthly cashflows and the monthly accumulation of profit for the 2021 policy year before allowance for the reserve requirement.
3. a chart comparing the monthly cashflows for the 2021 policy year before and after the allowance for the reserve requirement.
4. a chart illustrating the monthly accumulation of profit under the base scenario, allowing for the reserve requirement and then allowing for each option identified.

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 your results should be included in the summary.

Audit trail

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

Objective

Accidents Happen (AH) intends to introduce a new insurance product for mobile phones. AH would like to use data provided by another insurance company, Never Worry (NW), to project monthly cashflows and the monthly progression of accumulated profit. This will be used to determine the profitability of the new product in 2021.

This spreadsheet analyses the claims data provided by NW and uses the claims data to complete the financial projections. It projects the cashflows of the product, including premiums, charges and claims and the expected profit allowing for interest.

The model repeats the financial projections but with allowance for the new reserve requirements and the impact that this has on the profitability of the new product.

Data

The Data worksheet includes the claims data provided by NW. This data covers a full calendar year and includes the individual claims received by NW in each month. NW has advised that:

- these claims relate to 10,000 policies that NW had sold in 2019.
- the claims distribution is expected to follow the exponential distribution with parameter 0.01.

Further data is included in the Parameters worksheet. This includes information provided by the Pricing Team, namely:

- each policy is sold at a price of $20 per annum.
- premiums are paid by the policyholder to the insurer on a monthly basis at the beginning of each month.
- there is an excess of $50 for each claim.
- if a claim is made by a policyholder, the policy will continue for the remainder of the year.

The Operations Team has also advised that:

- initial expenses for writing each policy are $1.
- monthly expenses for each policy will be $0.75.
- claim expenses are expected to be $10 per claim.

The Operations Team has also advised that an interest rate of 10% p.a. should be used.

The Regulator has confirmed that the reserve, when introduced, at the start of the policy year should be 110% of the expected claims outgo from the policies sold, after allowing for the excess, and including claims expenses.

Assumptions

The following assumptions are applied to the projections:

- The number of claims between \$0 and \$50, i.e. claims not reported, is in line with the number you would expect from the exponential distribution with parameter 0.01.
- Premiums received and initial expenses are assumed to occur at the beginning of the month.
- Monthly expenses are assumed to occur uniformly over each month and therefore can be assumed to occur half way through the month.
- Claims are assumed to be paid out at the end of each month.
- The reserve will be released at the end of the policy year and there will be no change in the reserve amount over the policy year.

Data checks

The claims data is analysed in the Data worksheet.

Some initial checks are completed on this data. Cell Q3 calculates the minimum claim from the data and there is an automatic check to ensure this is greater than the policy excess using an IF statement.

The maximum claim is calculated in cell Q4 and this has been reviewed by eye. The number of claims made in 2019 is calculated in cell Q5 using the COUNT function.

The average and the standard deviation of the claim amounts is calculated in cells Q9 and Q10, respectively, using the standard Excel functions.

In range T1:Z20, we have completed a chi-squared test. We have created 10 equal tranches between 0 and 500. Column V calculates the observed cumulative frequency using the COUNTIF function, where the claims are counted if the claim amount is below the upper bound for this range. Note that, as claim amounts are above the policy excess, there is no value for the range 0 to 50.

The frequency for each tranche is then calculated in column W. Note the entries for the first two rows are different. For the 0 to 50 range, the frequency has been assumed to be in line with the empirical frequency. For the 50 to 100 range, this is set equal to the cumulative frequency for this range. For all other ranges, the frequency is calculated as the cumulative frequency for this range less the cumulative frequency for the previous range.

Columns X and Y calculate the expected frequency. The cumulative frequency is first calculated using the Cumulative Distribution Function for the exponential distribution using the upper bound of the range.

The expected cumulative claims is then calculated by multiplying this by the total number of claims from the observed calculations. Therefore, for each range, the cumulative frequency is equal to

$$\left(1 - \mathrm{e}^{-\lambda U}\right) \times \text{Total observed number of claims}$$

where U is the upper bound for that range.

The frequency is calculated in a similar manner to the observed frequency column except for the fact that the formula in the first row is different, where the value is set equal to the cumulative frequency.

Column Z calculates the observed statistic for that range using the formula

$$\frac{(O-E)^2}{E}$$

where O is the observed frequency and E is the expected frequency.

The observed statistic for each range is summed in cell Z14. The number of degrees of freedom is calculated in cell Z16 by counting the number of ranges and subtracting 1. The test statistic then needs to be input into Z18 and the result of the chi-squared test is included in Z20 using an IF statement.

The observed data is then reformatted in the range O25:T35 so that a chart can be constructed. A check is included in cell T35 to ensure the total number of observed claims have been included in the graph data.

'Cashflows' worksheet

This sheet projects monthly cashflows over the policy year. The month is included in row 1 from January to December.

The monthly income is calculated for each month in row 3. For each month, this is calculated as

Number of policies sold × Policy Premium / Payment frequency.

Monthly cash outgo is then calculated in rows 5 to 10. Row 5 includes the initial expenses. These only occur in the first month and this outgo is calculated by multiplying the number of policies sold by the initial expense per policy.

Row 7 calculates the monthly expenses as the number of policies sold multiplied by the monthly expenses per policy. This amount is incurred in each month.

Row 9 calculates the total expected claim payments in each month. This is calculated by:

- summing the claim amounts reported in that month, and then subtracting
- the policy excess multiplied by the number of claims reported in that month (calculated using the COUNT function).

Row 10 calculates the claim expenses for each month by multiplying the number of claims reported in that month (as calculated above) by the claim expense per claim.

Row 12 calculates the net cashflows by subtracting all cash outgo elements from the income amount for that month.

Row 14 calculates the accumulated profit at the end of the month. For the first month, this is calculated by:

- taking income less initial expenses and multiplying by (1 + Interest rate)^(1/12), less
- monthly expenses multiplied by (1 + Interest rate)^(1/24), less
- the total expected claims plus the claims expenses.

For subsequent months, i.e. columns C to M, the same calculations are completed but the accumulated profit from the end of the previous month is added to the 'income less initial expenses' item.

'Cashflows with reserve' worksheet

This sheet is a copy of the 'Cashflows' worksheet with the following amendments made.

New rows have been added at the top of the worksheet to calculate the reserve required. This has been determined by first calculating the expected claim reported in cells G1:G2. This has been calculated using the formula provided, i.e.

$$\text{Expected incurred claim} = \frac{1}{\lambda} + X$$

The expected claim less excess is then calculated in cell G3 by subtracting the excess per policy amount from the expected incurred claim.

The expected annual number of claims is then calculated in cell G4 by counting the total number of claims in the claims data. The total expected claims plus claim expenses is then calculated in cell G5 by multiplying:

- the 'expected claim less excess' plus the claim expense, by
- the 'expected annual number of claims'.

The required reserve is this figure multiplied by the reserve requirement, 110%.

A check is included in the range I4:K5. We have calculated the total claims outgo from the cashflow projections by summing the net claims over the calendar year plus the total claim expenses. This figure is then compared to the required reserve. An automatic check has been included to check that the difference between these two amounts is less than 5% of the required reserve.

The cashflow analysis is then completed in the same manner to the original scenario in rows 9 to 25 but two new cashflows have been added. The reserve is now an outgo at the beginning of the first month – this is included in row 13. The same amount is also a positive cashflow at the end of the last month when the reserve will be released back to the insurance company. This is included as a cashflow in row 21.

The accumulated profit projections in row 25 also make allowance for these additional cashflows, allowing for the relevant interest adjustment depending on when the cashflow occurs.

END OF PAPER