

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINATION

13 September 2022 (am)

Subject CP2 – Modelling Practice Core Practices

Paper Two

Time allowed: Three hours and twenty minutes

In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator.

If you encounter any issues during the examination please contact the Assessment Team on 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 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 Expand the spreadsheet model to:

Calculate the cost of the change in legislation to the company at 1 January 2023, using the annuity factors provided. You should allow for the Chief Executive Officer's (CEO's) proposed method that if annuitants are worse off after amendment, when considering the net present value (NPV) of each annuitant's remaining annuity, their annuity is not amended.

You should ensure that the additional work you undertake on the spreadsheet contains appropriate self-checks. [5]

2 Charts

Data manipulation work will be required to create these charts. The marks available include marks for this.

(i) Construct one suitable chart to illustrate the increase in NPV of the total remaining payments for the 100 annuities as a result of the amendment, for:

- all annuities.
- just current 5% p.a. increasing annuities.
- just current 3% p.a. increasing annuities.

[3]

(ii) Construct a suitable chart to illustrate, by grouping all 100 affected annuitants by the remaining term of their annuity and calculating subtotals, for each group:

- the average proportion of their payment affected.
- the percentage increase, as a result of the amendment, in annual annuity payment projected to the end of term.

You should show the remaining term of annuity on the x-axis. [6]

(iii) Construct a chart as in part (ii) above for current 5% increasing annuitants only. [2]

(iv) Construct a chart as in part (ii) above for current 3% increasing annuitants only. [2]

[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 done 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 CEO.

Your summary should include the following:

- The 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 strategies 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).	[26]
(ii)	Results, including charts.	[5]
(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 XYZ insurance company ('XYZ Insurance'). XYZ Insurance sells fixed-term annuities to individual consumers.

Individuals buying annuities from XYZ Insurance can choose, at the outset of their policy:

- the fixed term of the annuity – which can be from 15 years up to 25 years.
- the annual rate of increase of the annuity – which can be either 3% p.a. or 5% p.a.
- the starting amount of the annuity payments – from \$10,000 p.a. up to \$40,000 p.a.

All annuity policies begin on 1 January in the year the policy is set up. Annuity payments are made annually in advance each 1 January. Increases in annuity payments occur annually on 1 January, starting 1 year from the date the policy is set up.

A recent change in legislation means that XYZ Insurance will need to amend the annuity payment amounts for a small number of annuity policies that are currently in payment.

After the change in legislation, each annuity policy that is impacted will have two different portions of their annuity payments increasing at different annual rates.

The annuity payment for each annuity policy that requires amendment will be impacted in the following way:

- A proportion of the annuity in payment at 1 January 2023 (before allowing for the 1 January increase) will be increased by a flat, one-off 10% (as specified by the legislation). This affects the annuity from the 1 January 2023 payment onwards.
- Future annual increases (including the 1 January 2023 increase) applied to the affected proportion of the annuity will also need to be amended to 4% p.a. This impacts all annual increases from the 1 January 2023 increase onwards.
- The unaffected proportion of the annuity payment will not receive the flat one-off percentage and will continue to grow at the rate of increase chosen at the outset of the policy (i.e. 3% p.a. or 5% p.a.).

The proportion of the annuity amount receiving the flat one-off percentage and change to future annual increases will vary by annuitant.

XYZ Insurance's administration department has identified, and provided data for, 100 annuity policies that will be impacted by the change in legislation and hence will require amendment. This data is described further in the audit trail below.

It has been determined that XYZ Insurance will have to meet 100% of any additional costs of amending the annuities.

It has been decided that XYZ Insurance will not amend an individual annuity if the annuitant would be worse off after the amendment. The CEO of XYZ Insurance has proposed determining whether an individual annuitant would be worse off by comparing the NPV of the remaining annuity payments before and after amendment (the 'value check'). They have requested that a discount rate of 6.5% p.a. is used for the NPV calculations.

The CEO has instructed that no allowance for mortality is applied in the calculations and therefore it can be assumed that all annuitants will survive for the duration of the remaining term of their annuity.

The CEO wishes the following to be calculated:

- A projection of all annuities that require amendment to the end of their terms both without adjustment and after adjusting to allow for the change in legislation
- Charts, using the above projection calculations, to illustrate if annuities with a) different terms remaining and b) different annual increases are affected by the change in legislation differently
- The NPV of the overall additional cost to XYZ Insurance of having to amend the benefits after allowing for retaining, without adjustment, the annuities of annuitants who would be worse off using the CEO's proposed method above.

Another actuarial student in your team has been working on the project to analyse the effect of the legislation changes requested by the CEO and has already calculated:

- the individual annuity amounts after 1 January 2023 increases on both the current annuity details and after the amendments.
- the individual annuity amounts at the end of each annuity's term both on the current annuity details and after the amendments.
- individual annuity in advance factors at 1 January 2023 for both the current and amended annual increases for each annuity.

Your manager has asked you to complete the project by calculating the NPV of the total remaining payments from 1 January 2023 for all 100 annuities, both before and after the amendment. They have asked that you allow for the CEO's proposed method of retaining, without adjustment, the original annuities for annuitants where the NPV of the remaining annuity payments would be lower after amendment.

Your manager has also asked for charts to illustrate the results of the calculations that are set out in detail in the 'Exam requirements' section.

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

Your summary document 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 methodology and results for all of the modelling should be included in the summary.

Audit trail – Modelling annuity amendments

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

Objective

XYZ Insurance has determined that 100 of the fixed term, increasing annuity policies it has previously provided will need to be amended from 1 January 2023 to allow for a change in legislation.

A proportion of the current annuity in payment at 1 January 2023 (before the 1 January 2023 increase) must have its amount increased by 10% and the annual increase applied to that proportion amended from 1 January 2023 onwards.

The purpose of the model is to perform the following:

- Determine the projected level of the annuity payments p.a. after the 1 January 2023 increase for each annuitant before and after amending the annuity payments.
- Determine the projected level of the annuity payments p.a. at the end of the term of each annuitant before and after amending the annuity payments. **The CEO's proposed method – of retaining without adjustment the annuities for annuitants where the NPV of the remaining annuity payments would be lower after amendment – has not yet been applied in the model.**
- Calculate annuity in advance factors from 1 January 2023 on both current and amended annual increases for each annuity.

Data

This sheet contains details for 100 annuities in payment, annuity start date, starting amount, total term, annual increases p.a. and the proportion of the annuity payment affected by the amendment. This data was provided by the company's administration department.

Parameters

This sheet summarises the parameters used in the calculations.

These include details of the annuity structure, details provided by the regulator including the date of the amendment, the new annual increase rate for the affected proportion of annuities and the percentage uplift to be applied.

The discount rate to use for NPV calculations was provided by the CEO.

Data checks

This sheet performs checks on the data. All checks were as expected and no changes were made to the data in the 'Data' tab.

The following checks are made:

- All annual increases p.a. are either 3% or 5% as expected.
- The annuity is still in payment.
- There are 100 records, and no items of data are missing.
- The starting annuity amounts are within the expected range of \$10,000 to \$40,000 p.a.
- The total terms are between 15 and 25 years.

Assumptions

The following assumptions are made in the model:

- There is no allowance for mortality before the end of each annuity's term.
- The data is complete and correct, in particular, the proportion of the annuity payment affected by the amendment.
- Any other annuities in payment with the company, other than the 100 analysed, are not affected.

‘Annuity projection’ sheet

This sheet projects the annuity amounts to 1 January 2022 by applying existing annual annuity increases and then projects both the original and amended annual annuity amounts to the end of each policy.

It also calculates annuity in advance factors as at 1 January 2023 using current and amended annual increases for each annuity.

Projections to 1 January 2023 before and after amendment
(to be used with annuity factors to determine value)

Data is pulled from the ‘Raw Data’ sheet into the ‘Basic Information’ section in columns B:G.

Column J deducts the year of the annuity start date from the year of the amendment date for each of the policies to calculate the number of payments that have been made up to 1 January 2022. Column I checks that both the annuity start date and the amendment date are the same day (1 January).

Column K calculates the number of annual increases that have been made up to and including 1 January 2022 by deducting one from the payments to that date (column J). There was no increase applied to the first payment because it was made immediately.

Column L calculates the payment amount p.a. after the 1 January 2022 increase as:

Starting annuity amount (column F) \times (1 + each annuitant’s increase rate from column G) ^{number of increases to that date (column K)}.

Column M calculates the total annuity payment p.a. after the 1 January 2023 increase **before** amendment by applying one further increase to the annuity value at 1 January 2022 (column L). This is to be used alongside annuity in advance factors at 1 January 2023 to calculate the value of annuities before amendment.

Column N calculates the annuity payment p.a. after the 1 January 2023 increase **for the unaffected proportion of the annuity** by multiplying the annuity payment after 1 January 2022 increase by (1 – the proportion affected from column E) and applying one further increase. This is to be used alongside annuity in advance factors at 1 January 2023 to calculate the value of the proportion of annuities not amended.

Column O calculates the annuity payment p.a. after the 1 January 2023 increase **for the proportion of the annuity that is amended** by multiplying the annuity payment after 1 January 2022 increase by the proportion affected from column E and applying one increase at the amended rate (from the ‘Parameter’ sheet). This is to be used alongside annuity in advance factors at 1 January 2023 to calculate the value of the proportion of annuities that is amended.

Projections to end of annuity terms for analysis

Column Q calculates the number of increases remaining from 1 January 2024 onwards by taking total increases over term (total term less one) less increases to 1 January 2022 (column K) less one 1 January 2023 increase.

Column R calculates the payment p.a. projected to the end of each annuitant's term before the amendment as:

Total annuity payment p.a. **before** amendment, after the 1 January 2023 increase (column M) $\times (1 + \text{annual increase (column G)})^{\text{no. of increases remaining (column Q)}}$.

Column S calculates the payment p.a. (before any check on the value before and after amendment) projected to the end of each annuitant's term after the amendment as:

Proportion of the annuity payment p.a. **unaffected by amendment** after the 1 January 2023 increase (column N) $\times (1 + \text{annual increase (column G)})^{\text{no. of increases remaining (column Q)}}$

plus

Proportion of the annuity payment p.a. **that is affected by amendment** after the 1 January 2023 increase (column O) $\times (1 + \text{amended annual increase from the 'Parameter' sheet})^{\text{no. of increases remaining (column Q)}}$.

Annuity factors for CEO check on value

Column U calculates the number of payments remaining from 1 January 2023 to the end of term (inclusive) by deducting payments made to 1 January 2022 (column J) from the total term.

Columns V and W calculate the current and amended net discount rates respectively for use in the annuity factor calculations. These are calculated as:

$(1 + \text{discount rate p.a. (from the parameter tab)}) \div (1 + \text{annual increase rate (either annuitant's current increase or the amended increase respectively)}) - 1$.

Columns X and Y calculate the current and amended annuity in advance factors respectively to value the remaining annuity payments from 1 January 2023 onwards. These are calculated as:

$(1 - (1 + \text{applicable net discount rate from column V or W})^{\text{Annuity term remaining (column U)}}) \div \text{applicable net discount rate} \times (1 + \text{net discount rate})$

These factors are intended to be applied to the annuity payments after the applicable 1 January 2023 increases have been applied.

END OF PAPER