

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINATION

18 April 2019 (am)

Subject CP2 – Modelling Practice Core Practices

Paper Two

Time allowed: Three hours and fifteen minutes

INSTRUCTIONS TO THE CANDIDATE

1. *You are given this question paper and the Excel file.*
2. *Mark allocations are shown in brackets.*
3. *Attempt all questions. Questions are to be answered as per “exam requirements”.*

If you encounter any issues during the examination, please contact the Examinations Team at
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Exam requirements

- 1 Read the background document, which describes the scenarios that have been modelled and documented for this project.
- 2 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.

- 3 Expand the spreadsheet model to produce the required additional calculations for the Lump Sum (LS) proposal's cashflows. You should ensure that the additional work you undertake on the spreadsheet contains appropriate self-checks. The model should include the following:
 - (i) The expected lump sum payment outgoing cashflow as at 1 January 2020. [2]
 - (ii) The total expected payment cashflows for the 450 members, for each future year until the youngest age group is expected to die, if the LS proposal is offered. [2]
 - (iii) The expected present value of all future payments if the LS proposal is offered as at 1 January 2020, including the expected lump sum cashflow paid at that date. [2][Total 6]
- 4 Construct, for each of the following, a suitable chart to illustrate:
 - (i) The average starting pension per individual for each age group. [2]
 - (ii) All expected future cashflows on the existing arrangement and if 100% of individuals accepted the Pension Increase Exchange (PIE) proposal. [4]
 - (iii) The expected present value as at 1 January 2020 of all future pension payments under the existing arrangement, the PIE proposal and the LS proposal. [2]
 - (iv) All expected future cashflows from 1 January 2021, on the existing arrangement, if the PIE proposal is offered and if the LS proposal is offered (allowing for assumed take up rates). [3][Total 11]

[Sub-total 17]

- 5** 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 boss, a senior actuary, who will present the work to Martin, HR manager of Automake.

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 a valid next step.

The summary should cover the full scope of the project, including the existing scenario and PIE proposal cashflows which were modelled in the spreadsheet provided.

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

Marks available for the summary:

Methodology (including purpose, data, method and assumptions)	[25]
Results, including charts	[5]
Commentary on results and conclusions	[23]
Next steps	[20]
Drafting	[10]

[Sub-total 83]

[Total 100]

Background

In the past, Automake, a manufacturing company, provided a pension to its employees. Due to changes to pension provisions at Automake, no one who currently works for the company is entitled to this pension. There are 450 previous employees, who are currently under age 65, who are entitled to annual pension payments from 1 January in the year in which they turn 65 years old, for the rest of their lives. The oldest of these individuals will start to receive their pensions in 2021 and the youngest will start to receive their pensions in 2030.

The pension an individual is entitled to is calculated based on the length of time they worked for Automake and their salary when they left.

Details of the pension payments

The individuals entitled to pension benefits will receive a pension:

- annually in advance
- from 1 January in the year in which the individual attains age 65 (there is no option to start receiving the pension before or after this date)
- for the rest of their lives (in the year of their death they receive the whole year's amount, irrespective of when they die during the year)
- each year (after the pension starts being paid), the pension in payment increases in line with the National Inflation Index.

Paying the pension

The starting amount of the pension, due from 1 January in the year in which the individual turns 65, was known once the individual left employment with Automake.

However, the total amount paid to the individual over their remaining lifetime is unknown for two reasons:

- 1 The inflation increases applying to the pension once in payment are unknown.
- 2 When the individuals will die, and therefore stop being paid the pension, is unknown.

Automake saved money into a fund during the working lifetimes of the previous employees entitled to these pension benefits to meet the expected future cost of these benefits.

Automake has made a commitment that should experience be worse than anticipated it will put additional money into the fund to ensure that the promised pension benefits will be paid as they fall due.

The Board of Automake would like to reduce the uncertainty around the total amount of future pension payments and reduce the likelihood of unexpected additional payments needing to be paid into the fund.

You work for Sun Actuarial who provide actuarial advice to Automake. The HR manager of Automake, Martin, has approached your boss to assess the impact on expected future pension payment cashflows of two proposals which aim to reduce one or both of the unknown elements of the pension payments.

The two proposals are:

Proposal 1 – Pension Increase Exchange (PIE)

The 450 previous employees will be offered an option, on 1 January 2020, to choose either:

- (a) to keep their existing initial pension, from the date it falls due, with inflation pension increases each year after it starts being paid; or
- (b) to accept a higher initial pension, from the date it falls due, which will not receive any further increases after it starts being paid.

Automake intends to calculate the higher amount of non-increasing pension offered so that the total expected present value of all future pension payment cashflows (for all 450 previous employees) from either option is equal. They wish to offer all individuals the same fixed percentage increase to their existing starting payment in return for giving up future pension increases.

This proposal interests Automake because it removes the uncertainty regarding future inflation rates for those individuals who take up this option.

Proposal 2 – Lump Sum (LS)

The 450 previous employees will be offered the option to take the expected present value of all their future pension payments calculated at 1 January 2020 as a lump sum. The lump sum would be paid on 1 January 2020 and individuals who choose this option will not receive a pension.

To encourage individuals to take the lump sum, the company is proposing to increase the expected present value of an individual's expected future pension payments by 10% when determining the lump sum payable to the individual.

This proposal interests Automake because it removes all future uncertainty with respect to the pension benefits it needs to pay out for individuals who take up this option.

Data and parameters provided

Martin has provided summary data of the pension amounts as at 1 January 2020 for the 450 previous employees still due a pension. This data is grouped by age next birthday.

Martin has also instructed your boss to assume that 40% of individuals would take the higher non-increasing initial income if the PIE proposal was offered and 30% of individuals would take the lump sum payment if the LS proposal was offered.

Sun Actuarial statistics department has informed your boss to assume that the National Inflation Index annual inflation increases remain equal to the 1 January 2019 level which was 3.35% p.a.

Sun Actuarial statistics department has instructed that a 4.5% p.a. discount rate is appropriate for discounting the future cashflows.

Martin has requested you assume that all members survive until retirement age 65 and has provided an estimate of life expectancies after age 65 for each age group, i.e. you are to assume that individuals die when they reach their life expectancy and are paid a pension each year from 1 January in the year they turn age 65 up to and including the year in which they die.

Martin has stated that Automake will only offer one of the proposals.

Modelling required

Your boss has requested that your colleague determines the following for the 450 individuals:

- 1 The percentage increase to the initial pension payment at retirement that would need to be offered for the PIE proposal so that the expected total present value of all future pension payments as at 1 January 2020 is equal to the expected total present value under the existing arrangement.
- 2 The total expected pension payment cashflow for each future year (from 1 January 2020 until the youngest age group is expected to die) on the existing scenario and also if the PIE proposal was offered.
- 3 The total expected pension payment cashflow for each future year (from 1 January 2020 until the youngest age group is expected to die) if the LS proposal is offered.

Additional guidance

- You should include the lump sum cashflows expected at 1 January 2020.
 - You should assume that individuals who do not take up the LS offer receive the existing inflation increasing pension. The inflation increasing cashflows have already been calculated for all age groups as part of calculation 2 but will need to be adjusted to remove the individuals who are expected to take up the LS offer.
- 4 The expected present value of all future payments as at 1 January 2020 if the LS proposal is offered (including the present value of the lump sums expected to be paid on 1 January 2020).

Your colleague completed the first two calculations and produced an audit trail for these steps but unfortunately has fallen ill before completing the remaining steps. Your boss has asked you to complete the additional calculations using the existing model as your starting point.

Your boss would also like you to construct, for each of the following, a suitable chart to illustrate:

- the average individual starting pension for each “age next birthday” group
- all expected future cashflows on the existing arrangement and if 100% of individuals accepted the PIE proposal
- the expected present value of all future cashflows under the existing arrangement (inflation increases post-retirement), PIE proposal and LS proposal
- the expected future cashflows, for each future year until the last members die, under the existing arrangement (inflation increases after age 65), if the PIE proposal is offered and if the LS proposal is offered (allowing for assumed take up rates).

Finally, your boss needs 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 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

Automake is considering running one of two proposals as at 1 January 2020 to reduce the uncertainty of the expected future pension payment cashflows for the 450 individuals currently under retirement age, entitled to pensions.

Proposal 1 – A Pension Increase Exchange (PIE)

Proposal 2 – A Lump Sum (LS)

The purpose of the spreadsheet is to perform the following calculations:

- Project the future expected pension payment cashflows of the 450 individuals on the existing benefits and calculate the total present value (“PV”) of expected future pension payments.
- Use this to calculate (using goal seek) the fixed ratio to be applied to the existing starting pension at retirement age so that the PV for the expected number of individuals who take up the PIE offer is the same as the PV on the existing scenario.
- Project the future expected pension payment cashflows of the 450 individuals after the PIE proposal is carried out.

Note: input cells are shown in blue. Cells shaded in yellow do not copy down/across.

“Data” worksheet

This worksheet details the data used in the projections.

The HR manager of Automake, Martin, has provided the following data:

- A summary of the total initial pension amounts at retirement of the 450 previous employees grouped by age next birthday at 1 January 2020.

Data checks

A check has been performed in column F to check the average starting pension per member by dividing the total starting pension amount for each “age next birthday” grouping by the number of members in the age group.

The number of members per “age next birthday” band is charted and does not show a particular pattern but appears to be reasonable. No changes have been made to the data provided.

“Parameters” worksheet

This worksheet details the inputs used in the projections.

Martin has also provided the following parameters to perform the cashflow projections:

- expected take up rates for the proposals
- an enhancement percentage of 10% for the LS proposal transfer value
- life expectancies from 1 January in the year in which the individuals turn age 65 for each current age next birthday.

Sun Actuarial has provided:

- assumptions for the future National Inflation Index increase p.a (“inflation”) and discount rate to use for discounting future pension cashflows.

The net discount rate is calculated in C9 using the formula:

$$(1 + \text{discount rate}) / (1 + \text{inflation}) - 1$$

Parameter checks

The take up rates appear reasonable as they are between 0 and 1. The life expectancies increase steadily as age decreases which is in line with general findings that life expectancies are increasing over time.

Note: where cell names have been defined these are shown in red next to the relevant cells.

Assumptions

The following assumptions are applied to the projections:

- the data provided by Martin and Sun Actuarial is accurate
- the take up rate of the proposals are as assumed
- inflation is assumed to remain constant.

“Cashflows Pre & Post PIE” worksheet

This worksheet calculates the expected total cashflow for each future year before and after the PIE proposal.

Column A sets out the year start dates of all future years payments that are expected to be made. The youngest “age next birthday” group currently aged next 55 are expected to die by $2020 + (65 - 55) + 24.5 = 2054.5$ and so the final year of payments begins on 1 January 2054.

Column B calculates the number of years from 1 January 2020 to the future year start date as:

(future year start date – 1 January 2020)/365.25 rounded to the nearest two decimal places.

Column C calculates the discount rate from the future year start date to 1 January 2020 as:

$$1 / ((1 + \text{Discount_rate})^{(\text{number of years from 1 January 2020 to future year start date})})$$

Indicators for years when pension payments are expected to be made

Columns D to M set out payment indicators which show whether payments are expected to be made for each age group and each future year. This is set out in a matrix showing future year start dates in column B and age next birthday at 1 January 2020 across D6:M6.

Each cell in the matrix shows the formula result = 1 if the age group is expected to be age 65 or greater next birthday by the future year start date **and** if they are not expected to have reached the end of their life expectancy. Otherwise the formula result = 0.

- The retirement year for each age group is calculated in D3:M3 using the Date function and adding (65 – current age next birthday) years to the year 2020.
- The expected date of death for the age group is calculated in D4:M4 by taking the 1 January of the year when the individuals are 65 at their next birthday plus the life expectancy from that 1 January for each age group (which is pulled into D2:M2 from the life expectancy date in the “Parameters” tab by age group).

Inflation increases

Cells P7:Y41 set out the cumulative expected inflation increases in a matrix for each future year start date and across all current age next groups by multiplying:

the 0 or 1 indicator in the payment indicator matrix $\times (1 + \text{inflation})^{\wedge}$ number of years the pension has been in payment

The number of years the pension has been in payment is calculated as the sum of the relevant payment indicators from 1 January 2020 to the current year –1.

Starting pension payments at retirement age

Cells P2:Y2 set out the existing starting pension payment at retirement for each age group pulled in from the “Data” tab.

Cells P3:Y3 set out a calculation for the non-increasing starting pension payment at retirement age for each age group for the PIE proposal. This is calculated as the existing starting pension payment from P2:Y2 multiplied by a fixed PIE ratio parameter from cell C12 in the “Parameters” tab.

Existing scenario’s expected future cashflows and NPV

Column AA sets out the total expected cashflows for all age groups for each future year on the existing scenario by using the SUMPRODUCT function on the cumulative expected inflation increases for the relevant year (from the inflation increase matrix in P7:Y41) and the existing starting pensions (in P2:Y2).

The expected NPV of the existing scenario cashflows is calculated in cell AA4 by discounting the total expected cashflows for each future year back to 1 January 2020 using the SUMPRODUCT function to multiply the future cashflows in column AA with the calculated discount rates in column C.

Calculation of the fixed PIE ratio parameter

The calculations in column AA are repeated in column AB with changes to allow for the expected future cashflows after the PIE proposal as follows:

The total expected cashflows are calculated as:

PIE take up rate × *SUMPRODUCT of the payment indicator matrix (in cells D7:M41) and the non-increasing starting pension calculations (in P3:Y3); plus*

(1 – PIE take up rate) × SUMPRODUCT (the inflation increases indicator matrix (in cells P7:Y41) and the existing starting pension (in P2:Y2).

The expected NPV of the PIE proposal cashflows is calculated in cell AB4 by discounting the expected future PIE proposal cashflows to 1 January 2020 using the SUMPRODUCT function to multiply the future cashflows in column AB with the calculated discount rates in column C.

A goal seek is performed to set the expected PIE proposal NPV in AB4 to the expected existing NPV in AA4 by changing the PIE ratio in “Parameters” cell C12.

Reasonableness check

A check that the goal seek does not need to be rerun is included in cell AE9 returning “goal seek ok” if the expected NPV of the existing scenario and PIE proposal are equal and “re-run goal seek” if not.

END OF PAPER