

INSTITUTE OF ACTUARIES OF INDIA

EXAMINATIONS

29th July 2022

Subject CP2B – Actuarial Modelling (Paper B)

Time allowed: 3 Hour 30 Minutes (09.30 – 13.00 Hours)

Total Marks: 100

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 work done till date. This will assist you in following and understanding the calculations performed in the Excel model provided.

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

You should assume that your colleague's calculations have been checked and are correct.

Q. 1) Spreadsheet Model

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.

Calculate the revised BEL and RM under the following additional scenarios and summarize the movement in reserves between the old and new regime:

- i) Scenario 1: Same as Base Scenario with Attributable Expenses as 70% (4)
 - ii) Scenario 2: Same as Base Scenario with Liquidity Premium of 1% (4)
- [8]**

Q. 2) Illustrate in your model the following using suitable charts:

- i) Movement in Reserve between old regime and new regime split by each of the factors impacting the movement for the base scenario. (5)
 - ii) Reserve projection between the old and the new regime under all the scenarios viz. Base, Scenario1 and Scenario2. (5)
- [10]**

Q. 3) Prepare a summary sheet 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 the Chief Financial Officer.

Your summary should include the following:

- purpose of the project, data, method and assumptions used
- results, including charts
- comment on the results, key conclusion and suggested next steps

The summary should cover the full scope of the project, including the modelling already done by your colleague in the spreadsheet provided.

Marks available for the Summary:

Methodology (including purpose, data, Method and assumptions): (25)

Results, including charts	(15)
Comment on results and conclusions	(17)
Next steps	(15)
Drafting	(10)
	[82]

Background

You are working with a Life Insurance Company XYZ. The Regulator is proposing a new regulation that will require life insurance companies to follow fair value approach for reporting.

Under the old regime, the reserves are calculated using a prospective gross premium valuation approach allowing for any prudence through margins for adverse deviation (MAD) built within the assumptions. The reserves are floored to zero in case they are negative as at the valuation date.

The implications of the new regulatory regime are as follows:

- Removal of any floors on negative reserves built within the liability.
- Allowance for an explicit risk adjustment for non-financial risk arising from the insurance contracts compared to MAD built within the reserves in old regime.
- Estimated future cashflows to only include cashflows directly attributable to the contracts.
- Use of market consistent discount rate compared to the valuation interest rate in old regime.

Your team has been assigned with the task of analyzing the impact of these changes and present a high-level financial impact analysis, covering the impact on the reserves for a non-participating savings product that the Company sells.

Your manager has provided you with the data of portfolio of 1000 male policies aged 30 years issued together in Jan 2022 for the purpose of this analysis. The following additional details have also been provided along with the data:

- Policy Term = 20 Years
- Per Policy Sum Assured = Rs. 100,000
- Per Policy Maturity Benefit = Rs. 100,000
- Per Policy Premium paid yearly at the beginning of the year = Rs. 3,500
- Assume no policies surrender or lapse during the term of the product.

The mortality, expenses, expense inflation and discount rate assumptions (both best estimate and reserving) used by the Company for the calculation of reserves have been provided within the model.

For the calculation of reserves under the new regime, you have been asked to assume the following for the Base Scenario under the new regime:

- 100% of the expenses are directly attributable to the product
- Market consistent discount rate will be calculated as follows:

$$\text{Discount Rate} = \text{Risk Free Rate} + \text{Liquidity Risk Premium}$$

- Explicit Risk Margin to be calculated as a factor of best estimate liability. Use 5% as the factor.

Your colleague has already prepared the model and completed the following:

- Reserve calculation under the old regime.
- Reserve calculation for the base scenario under the new regime.
- Summary of movement of reserve between the old and new regime.

He has prepared an Audit Trail for the work done so far. Your manager has asked you to pick the model and perform the additional calculations required and prepare a summary report to be presented to the Chief Financial Officer.

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

The regulator is proposing a new regulation that will require life insurance companies to start following fair value approach for reporting. The team has been asked to demonstrate the financial impact of the proposed change in reporting regime on the Company's liability to the CFO of the Company.

This spreadsheet calculates the reserves for a non-participating savings product under the old regime, new regime and summarizes the movement of reserves from the old to new regime basis the key differentiating principles.

Methodology

The following changes are being introduced as part of the new regime:

- Removal of any floors on negative reserves built within the liability. The old regime applied a floor of zero for any negative reserves on the valuation date.
- Allowance for an explicit risk adjustment (Risk Margin) for non-financial risk arising from the insurance contracts compared to any prudence through Margins for Adverse Deviation (MAD) built within the reserves.
- Estimated future cashflows to only include cashflows directly attributable to the contracts
- Use of market consistent discount rate compared to the valuation interest rate.

Data and Parameters

We have been provided with a portfolio of 1000 male policies aged 30 years issued together at the beginning of year 2022.

The following additional parameters have been provided along with the data:

- Policy details (policy term, sum assured and maturity benefit, premium amount, frequency of payment and maintenance expenses).

- Best Estimate (BE) assumptions for expenses, expense inflation and mortality.
- Valuation assumptions (post MAD) for expenses, expense inflation and mortality.
- Risk free rate and valuation interest rate under the old regime.

Assumptions

The following assumptions are applied for the calculations:

- Data is valid and suitable for use.
- All policies are issued on and aged 30 years as of 1st January 2022.
- No allowance for any surrender or lapses during the term of the product.
- 100% of the expense are directly attributable.
- No allowance made for liquidity premium while calculating the market consistent discount rate under the new regime.
- Risk Margin is calculated as 5% of best estimate liability (BEL).

Calculation_Old Regime

This sheet calculates the reserves for the non-participating savings product under the old regime by projecting the cashflows and then calculating present values.

Row 1 to 3 of Column B captures the parameters required for performing the calculation and links to the parameters ('Parameters' worksheet) provided for the assessment.

Cell H3 links to the valuation interest rate under the old regime picked from Row 5 of the 'Parameters' worksheet.

Column A contains the time of the projections where time 1 = Jan 2022, time 2 = Jan 2023 and so on. The projections are carried over for 20 years in line with the term of the product used for the assessment.

Column B to D provides the projections of per policy annual premium, sum assured and maturity benefit associated with the product (from the 'Parameters' worksheet).

Column E-F calculates the in-force probabilities at the end of each year. The in-force probability at the beginning of 2022 (time 0) is 1. In the following years, in-force probability is calculated as In-force probability at the end of previous year * (1 – mortality rate for the year)

E.g., In-force probability at time 2 = In-force probability at time 1 * mortality rate for time 2.

The mortality rate for the year is calculated using a VLOOKUP function based on age of the policyholders at the beginning of the year and the male valuation mortality table (From 'Mortality rates' worksheet – column F). The age of the policyholders at the beginning of 2022 is 30 years.

Column G calculates the Expected Death Benefit as Sum Assured * Mortality Rate for the year * In-force probability at the beginning of the year. The deaths are assumed to happen at the end of year.

Column H calculates the present value of expected death benefit recursively starting from time 20 using the formula Expected Present Value (EPV) Death Benefit at time t-1 = (EPV Death Benefit at time t + Expected Death Benefit at time t-1) / (1+ Valuation Interest Rate).

Column I calculates the Expected Maturity Benefit as Maturity Benefit * In-force probability at the end of the year. The maturity benefit shall be payable at the end of the policy term i.e. 20th year.

Column J calculates the present value of expected maturity benefit recursively starting from time 20 using the formula $EPV \text{ Maturity Benefit at time } t-1 = EPV \text{ Maturity Benefit at time } t / (1 + \text{Valuation Interest Rate})$.

Column K calculates the Expected Premium as $\text{Premium} * \text{In-force probability at the beginning of the year}$.

Column L calculates the present value of expected premium recursively starting from time 20 using the formula $EPV \text{ Premium at time } t-1 = \text{Expected Premium at time } t-1 + EPV \text{ Premium at time } t / (1 + \text{Valuation Interest Rate})$

Cell M7 is linked to the year 1 valuation maintenance expenses (post MAD) from Row 17 of the 'Parameters' worksheet. The year 2 onwards maintenance expenses are calculated as $\text{Maintenance expenses at time } t-1 * (1 + \text{Expense Inflation Rate (post MAD)})$. The expense inflation rate is picked from Row 13 of the 'Parameters' worksheet. The expenses are assumed to be incurred at the start of each year.

Column N calculates the Expected Maintenance Expenses as $\text{maintenance expenses} * \text{In-force probability at the beginning of the year}$.

Column O calculates the present value of expected maintenance expenses recursively starting from time 20 using the formula $EPV \text{ Maintenance Expense at time } t-1 = \text{Expected Maintenance Expense at time } t-1 + (EPV \text{ Maintenance Expense at time } t / (1 + \text{Valuation Interest Rate}))$.

Column P calculates the per policy reserves prospectively as $EPV \text{ Death Benefit} + EPV \text{ Maturity Benefit} + EPV \text{ Maintenance Expense} - EPV \text{ Premiums}$ with a floor of zero in case of negative reserves. The per policy reserve is multiplied by the total number of policies to calculate the reserves at the portfolio level.

Calculation_New Regime

This sheet calculates the BEL for the non-participating savings product by projecting the cashflows and then calculating present values. The Risk margin (RM) is then calculated as a factor of BEL to calculate the total reserves under the new regime as sum of BEL and RM.

Row 1 to 3 of Column B captures the parameters required for performing the calculation and links to the parameters ('Parameters' worksheet) provided for the assessment.

Cell H3 is linked to the market consistent discount rate picked from Row 7 of the 'Assumptions' worksheet.

Column A contains the time of the projections where time 1 = Jan 2022, time 2 = Jan 2023 and so on. The projections are carried over for 20 years in line with the term of the product used for the assessment.

Column B to D provides the projection of per policy annual premiums, sum assured and maturity benefit associated with the product (from the 'Parameters' worksheet).

Column E-F calculates the in-force probabilities at the end of each year. The in-force probability at the beginning of 2022(time 0) is 1. In the following years, in-force probability is calculated as $\text{In-force probability at the end of previous year} * (1 - \text{mortality rate for the year})$

E.g., $\text{In-force probability at time 2} = \text{In-force probability at time 1} * \text{mortality rate for time 2}$.

The mortality rate for the year is calculated using a VLOOKUP function based on age of the policyholders at the beginning of the year and the male base mortality table (From 'Mortality rates' worksheet – column C). The age of the policyholders at the beginning of 2022 is 30 years.

Column G calculates the Expected Death Benefit as Sum Assured * Mortality Rate for the year * In-force probability at the beginning of the year. The deaths are assumed to happen at the end of year.

Column H calculates the present value of expected death benefit recursively starting from time 20 using the formula EPV Death Benefit at time t-1 = (EPV Death Benefit at time t + Expected Death Benefit at time t-1) / (1+ Discount Rate)

Column I calculates the Expected Maturity Benefit as Maturity Benefit * In-force probability at the end of the year. The maturity benefit shall be payable at the end of the policy term i.e. 20th year.

Column J calculates the present value of expected maturity benefit recursively starting from time 20 using the formula EPV Maturity Benefit at time t-1 = EPV Maturity Benefit at time t / (1+ Discount Rate)

Column K calculates the Expected Premium as Premium* In-force probability at the beginning of the year.

Column L calculates the present value of expected premium recursively starting from time 20 using the formula EPV Premium at time t-1 = Expected Premium at time t-1 + EPV Premium at time t / (1+Discount Rate)

Cell M7 is linked to the year 1 BE maintenance expenses from Row 16 of the 'Parameters' worksheet. The year 2 onwards maintenance expense is calculated as Maintenance expense at time t-1 * (1+ BE Expense Inflation Rate). The BE expense inflation rate is picked from Row 12 of the 'Parameters' worksheet. The calculated expenses are then multiplied with the assumption of directly attributable expenses from 'Assumptions' worksheet to arrive at the per policy directly attributable expenses under the new regime. The expenses are assumed to be incurred at the start of year.

Column N calculates the Expected Maintenance Expenses as maintenance expenses * In-force probability at the beginning of the year.

Column O calculates the present value of expected maintenance expenses recursively starting from time 20 using the formula EPV Maintenance Expenses at time t-1 = Expected Maintenance Expense at time t-1 + (EPV Maintenance Expense at time t / (1+Discount Rate))

Column P calculates the per policy BEL prospectively as EPV Death Benefit + EPV Maturity Benefit + EPV Maintenance Expenses – EPV Premiums. The per policy BEL is multiplied by the total number of policies to calculate the overall BEL at the portfolio level.

Column Q calculates the Risk Margin as the absolute value of a factor of the BEL. The factor is picked from row 8 of the 'Assumptions' worksheet.

Column R calculates the total reserves under the new regime as the sum of BEL and RM.

Calculation_Remove Flooring

This sheet is a copy of the 'Calculation_Old Regime' worksheet with the following changes:

The formula in column P is updated to remove the floor of zero in case of negative reserves. The per policy reserves are calculated prospectively as EPV Death Benefit + EPV Maturity Benefit + EPV Maintenance Expenses – EPV Premiums. The per policy reserve is multiplied by the total number of policies to calculate the reserves at the portfolio level.

Calculation_New Discount

This sheet is a copy of the ‘Calculation_Remove Flooring’ worksheet with the following changes:

The formula in Cell H3 is linked to the market consistent discount rate picked from Row 7 of the ‘Assumptions’ worksheet.

Calculation_Replace MAD with RM

This sheet is a copy of the ‘Calculation_New Discount’ worksheet with the following changes:

The formula in column F is updated to pick the mortality rate from the male base mortality table (From ‘Mortality rates’ worksheet – column C) instead of valuation mortality table.

The maintenance expense linked in cell M7 is updated to pick the BE maintenance expense from Row 16 of the ‘Parameters’ worksheet instead of the valuation maintenance expense.

Column Q is added to calculate the Risk Margin as the absolute value of a factor of the BEL. The factor is picked from row 8 of the ‘Assumptions’ worksheet.

Column R calculates the total reserves under the new regime as the sum of BEL and RM.

This sheet also acts as the control check to ensure that reserve in column R should match with the reserve in column R of the Calculation_New Regime worksheet.

Summary

This sheet summarizes the movement of reserves from the old regime to the new regime as at Jan 2022, split by factor impacting the movement of reserves.

Row 5 shows the reserves under the old regime picked from column P (time 1) of the ‘Calculation_Old Regime’ worksheet.

Row 6 shows the change in reserves due to the removal of floor of zero and is calculated as reserve from column P (time 1) of the ‘Calculation_Remove Flooring’ worksheet minus the reserve from column P (time 1) of the ‘Calculation_Old Regime’ worksheet.

Row 7 shows the change in reserves due to the change in discount rate to market consistent rate and is calculated as reserve from column P (time 1) of the ‘Calculation_New Discount’ worksheet minus the reserve from column P (time 1) of the ‘Calculation_Remove Flooring’ worksheet.

Row 8 shows the change in reserves due to the change in directly attributable expenses.

Row 9 shows the change in reserves due to the removal of any prudence through MAD built within the reserves and explicit allowance for risk adjustment for non-financial risks. This is calculated as reserve from column R (time 1) of the ‘Calculation_Replace MAD with RM’ worksheet minus the reserve from column P (time 1) of the ‘Calculation_New Discount’ worksheet.

Row 10 sums the changes in reserves and the reserve from the old regime to arrive at the reserve from the new regime. This should match with the reserve calculated in column R (time 1) of the 'Calculation_New Regime' worksheet.
