

# **INSTITUTE OF ACTUARIES OF INDIA**

## **EXAMINATIONS**

**28<sup>th</sup> June 2019**

**Subject CP2B – Actuarial Modelling (Paper B)**

**Time allowed: 3 Hour 15 Minutes (14.45 – 18.00 Hours)**

**Total Marks: 100**

**AT THE END OF THE EXAMINATION**

**Please return this question paper to the supervisor separately. You are not allowed to carry the question paper in any form with you. You are requested to save and submit the work before leaving the examination premises.**

## **Examination instructions**

- 1. Mark allocations are shown in brackets.*
- 2. Do save your work in Excel files on a regular basis.*
- 3. Please check if you have received complete Question Paper and no page is missing. If so, kindly get new set of Question Paper from the Invigilator.*
- 4. Please note that you should use your Roll Number and NOT your name on all of the material you submit for marking.*
- 5. You would be provided with a digital platform for the examination which will show the time remaining for the examination at all times, once the exam starts. Once the exam duration is over, any work done on MS Excel will automatically get submitted and the platform will get frozen.*
- 6. There will however be a 'Submit' button available. Ensure that you click the "Submit" button only when you have answered all questions including sub-parts and then final submission is made. If done erroneously at any point earlier, this step can't be un-done.*
- 7. Students are required to submit all their work i.e. model, audit and summary using MS excel only.*

## Exam Requirements

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

- 3) Build on the model provided to produce the following additional calculations. You should ensure that the additional spreadsheet work which you perform contains appropriate self-checks.
  - i) Calculate the Present value of future profits (PVFP) for the endowment insurance to determine the refined monthly premium that the company should charge on the endowment product to achieve the same PVFP as the term product. (3)
  - ii) Calculate the PVFP under the alternate scenario of mortality rate being 2 times the base scenario for:
    - Term Insurance
    - Endowment Insurance (6)

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

- 4) Illustrate in your model the following using suitable charts:
  - Survival rate under the base scenario
  - Profit for term insurance contract over the term of the contract under base scenario
  - PVFP under base and alternate scenario, for both term insurance and endowment insurance (6)
- 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 the Chief Executive Officer. [15]

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 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.

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

**Marks available for the summary:**

<b>Methodology (including purpose, data, method and assumptions):</b>	(20)
<b>Results, including charts</b>	(10)
<b>Commentary on results and conclusions</b>	(20)
<b>Next steps</b>	(25)
<b>Drafting</b>	(10)
	<b>[85]</b>

**Background**

In the country of Actuarialia, the Vanilla Insurance Company (VIC) offers life insurance products. Their portfolio consists of only low-cost individual Term Insurance product. You are an actuarial student working for VIC.

The marketing manager of the company has highlighted the preferences of customers towards the endowment business. He has proposed that VIC should come up with a competitive endowment product. Your boss, a senior actuary, is in-charge of the pricing of the endowment product.

*(Description of a term insurance and endowment insurance is provided later in this booklet.)*

One of your colleagues has already built a model to calculate the profits for the term insurance product, which he was hoping to use for the endowment work.

He had started work on the pricing for endowment product but has to leave for some other assignment and is unable to finish. The responsibility has now been assigned to you.

Before going, your colleague has calculated the present value of future profits (PVFP) for the endowment product, where he has used premium amount twice as that of term insurance, thinking that the endowment offers ‘double payout’ - on death *and* maturity, and hence the premium should double that of term insurance.

Your boss has asked you to refine the calculations and calculate the premium that should be charged on the endowment product that generates the same PVFP as the term insurance.

The calculation is required using the same model point and assumptions that the colleague used for the term insurance working:

- ❖ 45-year-old male.
- ❖ Policy Term and Premium Term of 10 years.
- ❖ Sum Insured of \$1000.
- ❖ Premium of \$10 per month.
- ❖ Initial Annual Mortality Rate from experience of 0.01 increasing by 20% every year for first five years and 30% every year for the remaining term of contract.
- ❖ Expenses per month-
  - 5% of premium and
  - \$1
- ❖ Expense Inflation of 5% p.a.

- ❖ Commission rate of 10%.
- ❖ Profits to be discounted at 5% p.a. to calculate present value of future profits.

Your boss also wants to see the impact on PVFP if the mortality were to worsen to two times the current assumption. He wants this to be assessed for both term insurance and endowment insurance. For endowment product, he wants you to use the refined premium that you have calculated.

Your boss would like your additional modelling to include appropriate checks wherever necessary.

Your boss would also like you to prepare a summary document covering both the Base Scenario (performed by your colleague, including the refined premium calculated by you) and the Alternate Scenario (of profitability under mortality stress), performed by you.

Your boss is out of the office and cannot be contacted for the next three hours. He would like the additional calculations finished and the summary document written up ready for his return, when he will review them and present your findings to the Chief Executive Officer.

Your colleague has produced an audit trail of his model, which is provided below. An electronic copy of the model is also provided.

**You are not expected to include the additional modelling request in the audit trail, but your results should be included in the summary.**

*Below is a description of Term and Endowment Insurance product:*

#### ***Term Insurance Product***

*Term insurance product is a product which pays a death benefit to the policyholders who die during the term of the product. There are no benefits paid at the time of maturity or surrender.*

#### ***Endowment Insurance Product***

*Endowment insurance product is a product which pays a death benefit to the policyholders who die during the term of the product and a maturity benefit to the people who survive at the end of the term. For the product in question, the amount maturity benefit is same as the death benefit. There is no surrender benefit.*

## **Audit trail**

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

### **Purpose of the Model**

The purpose of the model is to complete the following calculations:

- Calculate the present value of future profits for the term insurance product for a 45-year old male.
- Calculate the PVFP for an endowment insurance product with similar terms as the term insurance plan with double the premium of term insurance plan.
- Calculate the revised premiums for endowment insurance business to generate same profit as the term insurance business.
- Compare the PVFP for term and endowment plan with above calculated premium under base and alternate scenario.

### **Data worksheet**

*This worksheet includes details of the term insurance plan provided and the requirements of the two scenarios.* The key parameters driven from this worksheet are:

- Policy Term and Premium Term
- Sum Insured
- Monthly Premium
- Initial Annual Mortality Rate and the increase factors for first 5 years and thereafter
- Expenses per month, fixed and variable
- Expense inflation
- Commission rate
- Discount rate

### *Assumptions*

- The mortality rate is increasing annually with the given rate of increase
- Deaths follow constant force of mortality so monthly mortality can be approximated as below-

$$\text{Monthly mortality} = (1 - (1 - \text{annual mortality})^{(1/12)})$$

- The selected model point is enough to provide the view to the profitability of the product
- Discount rate is constant over the term of the policy
- The premiums and commissions are paid at start of month
- All the expenses, death benefit and maturity benefit to be paid at end of month

- Taxes are ignored for the purpose of this project
- Reserving requirements are ignored while calculating the profits
- Investment income is ignored on net cashflow during a month

*Caution: The formula in first cell of a column is different in some columns and cannot be dragged. These are highlighted in blue.*

### ***Term Insurance worksheet***

*In this worksheet the details from data sheet are used to calculate the present value of future profits for the term insurance product.*

The present value of future profits is determined as follows:

- Month of the policy, age and monthly premiums are shown in columns A, B and C for 10 years.
- Age changes each year on policy anniversary and is calculated as previous cell if it is not start of a policy year and previous cell +1 in case of start of policy year i.e.  $\text{mod}(\text{policy month}, 12) = 1$ .
- Premium cashflows are calculated by multiplying the monthly premium amount (from data sheet) with survivors at start of month from column J using previous month's reference. *Survivors calculation is explained later.*
- Commissions are calculated in column D as %age of premium income in column C.
- Variable expenses are calculated as %age of premium in column E. For month 1 this is calculated as:

*Premium of month 1 \* Variable expense rate*

For month 2 onwards, this is calculated as:

*Variable expense of previous month; if not a month post policy anniversary*

*Variable expense of previous month \* (1+annual inflation rate); if it is a month just post policy anniversary – like month 13, 25, 37 etc*

- Fixed expenses per month are in column F. For month 1 this is calculated as:

*Fixed expense per month*

The logic of applying inflation at only annual time steps follows the same logic as for variable expenses.

- Expense Outgo is then calculated in column G as (Variable expenses + Fixed expenses)\* survival rate at end of month.
- Annual mortality rate is given in column H and is increased by the increase %age every year. This is done in two stages as per the assumptions-

For the first 60 months, the mortality rate is increased by 20% for all months post the policy anniversary.

For next 60 months, it is increasing by 30%.

While increasing the mortality rates, I have checked that it is start of a policy year to apply the increase as the increase should be applied only once a year. For other months, the rate at start of policy year is used.

- Monthly mortality rate is calculated in column I using the annual mortality from column H by applying below formula-

$$\text{Monthly mortality} = (1 - (1 - \text{annual mortality})^{1/12})$$

- Survival rate (at end of month) is calculated in column J as below-

For month 1:

$$\text{Survival rate}_1 = 1 - \text{monthly mortality}_1$$

For other months:

$$\text{Survival rate}_t = \text{Survival rate}_{t-1} * (1 - \text{monthly mortality}_t)$$

- Probability of death is calculated as below in column K as below-

For month 1:

$$\text{Probability of death}_1 = 1 * \text{monthly mortality}_1$$

For other months:

$$\text{Probability of death}_t = \text{Survival rate}_{t-1} * \text{monthly mortality}_t$$

- Death benefit is calculated in column L as Sum Insured \* Probability of death
- Profit is calculated as below in column M-

$$\text{Profit} = \text{premium} - \text{commission} - \text{expense outgo} - \text{death benefit}$$

$$\text{i.e. Profit} = \text{Income} - \text{Outgo}$$

- As the cashflows are monthly, the discount rate is converted to monthly rate in cell R4 as  $(1 + \text{Annual rate})^{(1/12)} - 1$ .
- Present value of future profits is calculated in cell R5 by using NPV of profit stream in column M and discount rate in cell R4.

*Checks are highlighted in green-*

- In cell R10, it is checked that total commission as a ratio of total premium is same as given in data.
- Reasonableness check in cell R7 to see that 12 times monthly discount rate is close to annual discount rate.



**Endowment worksheet**

*This worksheet is created by copying the term insurance worksheet and extending it to calculate maturity benefit.*

The premium for endowment product in cell S3 is taken as double the premium for term insurance.

A new column is added after death benefit column L to calculate the maturity benefit in column M as below-

- **Sum Insured \* Survival rate (t)** for t=120
- **0** for t<120

i.e. sum insured is multiplied with column J to calculate the maturity benefit at time 120. This is 0 for other months as maturity is paid at end of term.

The profit is then revised to incorporate maturity benefit pay out i.e.

Profit = premium-commission-expense outgo- death benefit- maturity benefit.

Link for Data Set: [http://www.actuariesindia.org/downloads/ModelData\\_CP2B.xlsx](http://www.actuariesindia.org/downloads/ModelData_CP2B.xlsx)

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