



INSTITUTE OF ACTUARIAL  
& QUANTITATIVE STUDIES

**Subject:** PRLIP -2

**Chapter:**

**Category:** Assignment  
2 questions

1. Describe why a company might wish to use sensitivity analysis as part of its profit testing exercise.

2. A life insurance company issues a 4-year unit-linked endowment assurance contract to a male life aged 40 exact under which level premiums of INR 100,000 per annum are payable in advance. In the first year, 90% of the premium is allocated to units and 101.5% in the second and subsequent years. The units are subject to a bid-offer spread of 5% and an annual management charge of 0.5% of the bid value of the units is deducted at the end of each year.

If the policyholder dies during the term of the policy, the death benefit of INR 500,000 or the bid value of the units after the deduction of the management charge, whichever is higher, is payable at the end of the year of death. On surrender or on survival to the end of the term, the bid value of the units is payable at the end of the year of exit.

The company uses the following assumptions in its profit test of this contract:

- Rate of growth on assets in the unit fund: 6% per annum
- Rate of interest on non-unit fund cashflows: 4% per annum
- Independent rates of mortality AM92 Select
- Independent rate of withdrawal: 10% per annum in the first policy year; 5% per annum in the second and subsequent policy years.
- Initial expenses INR 2500
- Renewal expenses INR 500 per annum on second & subsequent premium dates
- Initial commission 10% of first premium
- Renewal commission 4.5% of the second and subsequent years premiums
- Risk discount rate 8% per annum
- Expenses and Commission, both initial and regular, occur at the same time as the payment of premium. Decrements are uniformly distributed over the year.

All cash flows are rounded to the nearest rupee.

i) Calculate and select the correct value of projected Unit Fund at the end of year 1, year 2, year 3 and year 4 from the following:

- a) 90,177; 196,809; 309,274 and 427,891
- b) 91,878; 202,350; 321,064 and 448,634
- c) 88,475; 191,335; 297,774 and 407,917
- d) 90,177; 196,809; 309,274 and 423,854

ii) Calculate and select the correct value of projected net cash flows at the end of each year of year 1, year 2, year 3 and year 4 from the following:

- a) 2,226; -777; -133 and 583
- b) 2,227; -772; -121 and 607
- c) 2,210; -785; -139 and 581
- d) 2,211; -779; -126 and 606

iii) Calculate the profit margin on the assumption that the office does not zeroise future negative cash flows.

Suppose the office does zeroise future negative cashflows, answer the following.

iv) Calculate and select the expected provisions that must be set up at the end of each year, per policy in force at the start of each year from the following:

- a) 776.83; 121.37; 0
- b) 763.03; 110.42; 0
- c) 788.48; 126.85; 0
- d) 773.03; 114.99; 0

v) Calculate and select the expected present value of profit allowing for the cost of setting up these provisions.

- a) 1688.90
- b) 1716.89
- c) 1662.11
- d) 1692.22

3. i) Define a profit vector.

ii) Explain what is meant by a Profit Criterion. Give two examples of Profit criterion.

iii) A regular premium endowment assurance has been issued to a life aged 42 exact for a term of 4 years. The regular premiums are not level; instead they increase at the rate of 4% per annum. The premiums are payable at the start of the year. The profit signature of the above contract is  $(-250, 150, 200, 225)$  and the profit margin is 5%. Assume that there are no lapses and the relevant mortality table is AM92 Ultimate. The cost of capital to the company is 10% and it would require a further premium of 3% to reflect the risks and uncertainties surrounding the cashflows.

Calculate the premium to be charged by the company in the first year of the contract.

4. i) State the different basis that may be used in the financial management of life insurance business and what experience do these bases represent.

ii) A student actuary has commented that since reserves are held such that there is an acceptably low probability of insolvency occurring in the future, we should assume that everyone dies on the next day of the valuation. You do not seem to agree with this statement. Give reasons to the student actuary for your views.

iii) A company calculates non unit reserves on its unit linked products by zeroising future negative cashflows. It has issued a six year unit linked policy to a life aged 70 years exact. The profit signature from the policy is  $(-20, -35.20, 50, -28.50, -20, 90.21)$

Calculate the non-unit reserves and the revised profit vector assuming the mortality rates to be AM92 Select and Interest rate of 6% per annum.

5. i) Explain the terms unit fund and non-unit fund in the context of unit linked products listing various items that make up the non-unit fund.

ii) Explain why a life company might need to set up non-unit reserves in respect of unit linked assurance contracts.

6. A life insurance company issues a four-year unit-linked policy to a male life aged 30. The non-unit cash flows (NUCF<sub>t</sub>,  $t = 1, 2, 3, 4$ ) obtained at the end of each year  $t$  per policy in force at the start of the year  $t$  are:

| Year $t$    | 1    | 2    | 3    | 4    |
|-------------|------|------|------|------|
| NUCF( $t$ ) | -250 | -400 | -600 | 1500 |

Assume that the annual mortality rate for the male life follows AM92 ultimate.

i) Calculate the net present value of profits using a risk discount rate of 6%.

ii) The company sets up reserves in order to zeroise future negative cash flows. The rate of interest earned on non-unit reserves is 3% per annum. Calculate the net present value of the profits after zeroisation.

iii) Comment on the results obtained in (i) and (ii) above

7. A life insurance company issues a 4 - year unit-linked endowment policy to a life aged 61 exact under which level premiums of Rs 30,000 are payable yearly in advance throughout the term of the policy or until earlier death. In the first policy year 40% of the premium is allocated to units, in the second year 90%, in the third year 100% and the fourth year 110% of the premium is allocated to units. The unit prices are subject to a bid-offer spread of 5%.

If the policyholder dies during the term of the policy, the death benefit of Rs 100,000 or the bid value of the units, whichever is higher, is payable at the end of the policy year of death. On maturity, 105% of the bid value of units is payable. An annual management charge of 1.5% of the bid value of units is deducted at the end of each policy year before death and maturity benefits are paid.

The company uses the following assumptions in carrying out profit tests of this contract:

|                                                                 |                      |
|-----------------------------------------------------------------|----------------------|
| • Rate of growth on assets in the unit fund                     | 5% per annum         |
| • Rate of interest on non-unit fund cash-flows                  | 3.5% per annum       |
| • Independent rate of mortality                                 | AM92 Select          |
| • Independent rate of surrender                                 | 6% per annum         |
| • Initial expenses                                              | Rs 5000              |
| • Renewal expenses (second and subsequent premium dates)        | Rs 2000              |
| • Initial commission                                            | 20% of first premium |
| • Renewal commission (of second and subsequent years' premiums) | 2%                   |
| • Risk discount rate                                            | 7% per annum         |

- i) Calculate the profit margin for this policy, assuming no zeroisation of negative cashflows.
- ii) How would profit margins be impacted if surrender benefits are payable (at the end of the year) and why?
- iii) Why would you expect the first year allocation rate to be low?

8. A life insurance company issues a 4-year non-par endowment insurance policy to a male life aged 61 exact for a sum assured of Rs 500,000 payable on survival to the end of the term or at the end of the year of death if earlier. Premiums are payable annually in advance throughout the term of the policy. Surrender benefit equal to a return of premiums paid, with no interest is payable at the end of year of the surrender.

The life insurance company uses the following assumptions to price this contract:

|                                                               |                                                           |
|---------------------------------------------------------------|-----------------------------------------------------------|
| Mortality                                                     | AM92 Select                                               |
| Surrenders                                                    | None                                                      |
| Interest                                                      | 4% per annum                                              |
| Initial expenses                                              | Rs 800                                                    |
| Renewal expenses (on the second and subsequent premium dates) | Rs 100 per annum plus 2.5% of the premium                 |
| Surrender rates                                               | 5% of all policies in force at the end of year 1, 2 and 3 |

In addition, the company holds net premium reserves, calculated using AM92 Ultimate mortality and interest of 4% per annum. To profit test this contract, the life office assumes the same mortality and expense assumptions as per the pricing basis above. In addition, it assumes it earns 5% per annum on funds.

Calculate, using a risk discount rate of 8% per annum, the expected profit margin on this contract.



9. A life insurance company issues a 3-year unit-linked endowment policy to a life aged 42 exact under which level premiums of Rs.10000 are payable at the start of policy year contingent upon survival. In the first policy year, 30% of the premium is allocated to units. In the second and third year, there is a premium allocation charge of 20% and 7.5% respectively. The units are subject to a bid-offer spread of 2.5% and an annual management charge of 1.25% of the bid value of units is deducted at the end of each policy year. Management charges are deducted from the unit fund before death, surrender and maturity benefits are paid. If the policyholder dies during the term of the policy, the death benefit of Rs. 20000 or the bid value of the units, whichever is higher, is payable at the end of the policy year of death. The policyholder may surrender the policy only at the end of each policy year. On surrender, the bid value of the units is payable at the end of the policy year of exit. On maturity, 115% of the bid value of the units is payable.

The company uses the following assumptions in carrying out profit tests of this contract: Unit fund growth rate 9% per annum Interest on non-unit fund cash flows 7% per annum Mortality AM92 Select Initial expenses Rs. 2000 Renewal expenses Rs. 750 per annum on the second and subsequent premium dates Initial commission 10% of first premium Renewal commission 3% of the second and subsequent years' premiums Risk discount rate 13% per annum Surrender rate in the first two years 10% of all policies still in force at the end of a year (prior to surrender).

- i) Assuming that the company does not set up reserves, calculate the profit margin for the policy.
- ii) Assuming that the interest earned on reserves is equal to the risk discount rate, without doing any calculations state with reasons the impact on profit margin had the company set up reserves by zeroising future negative cashflows.
- iii) Calculate the expected reserve that must be set up at the end of each policy year, per policy in force at the start of each policy year assuming that the reserving basis is the same as the pricing basis, except for expenses and unit fund growth rate, which are prudent. The profit vector under the reserving basis is (3800.50, -760.10, -4532.25).

10. A four-year unit-linked endowment policy is sold to a life aged 50 exact. Level regular annual premiums of Rs. 25,000 are payable throughout the policy term. 70% of the first years' premium and 110% of each subsequent years' premiums are invested in the unit fund. The bid price of the units is 90% of the offer price. The company deducts a Fund Management Charge of 0.50% of the value of the policyholders' fund and a Policy Administration fee of Rs. 500 at the end of each year. The death benefit, which is payable immediately on death, is the bid value of the units subject to a minimum of Rs. 65,000. The maturity value is equal to the bid value of the units. The insurance company incurs an initial expense of Rs. 3,500 at the start of the first year and renewal expenses of Rs. 1100 in the subsequent years.

Basis: Mortality probability of 0.015 at each age.

Withdrawals to be ignored.

Unit growth rate and Non unit interest rate of 7% p.a.

- i) Assuming that the insurance company holds unit reserves equal to the value of units and zero non-unit reserves, calculate the expected profit emerging in each policy year.
- ii) Calculate the revised profit emerging each year assuming that the office sets up non unit reserves to ensure that the expected profit emerging in the second and subsequent policy years is non-negative.



INSTITUTE OF ACTUARIAL  
& QUANTITATIVE STUDIES