

Institute of Actuaries of India

Subject CP2B – Actuarial Modelling (Paper B)

June 2019 Examination

INDICATIVE SOLUTION

Introduction

The indicative solution has been written by the Examiners with the aim of helping candidates. The solutions given are only indicative. It is realized that there could be other points as valid answers and examiner have given credit for any alternative approach or interpretation which they consider to be reasonable.

Solution 5:**Summary – Project Assurances****Overview**

The purpose of this project is to calculate the premium for an endowment assurance product such that it produces the same profitability as a term assurance product.

Further, the sensitivity to the profitability of both the products is determined for a mortality stress of double the base scenario mortality.

Data

The details around the model point used for both the term insurance and endowment insurance and the other parameters was as follows:

- ❖ 45-year-old male
- ❖ Policy Term and Premium Term of 10 years.
- ❖ Sum Insured of \$1000
- ❖ Premium of \$10 per month (the premium for the term insurance model point)
- ❖ 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.

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

Calculation Approach

The present value of future profits is determined as follows:

- Age changes each year on policy anniversary.
- Premium cashflows are calculated by multiplying the monthly premium amount with survivors at start of month. *Survivors calculation is explained later.*
- Commissions are calculated as %age of premium income
- Variable expenses are calculated as %age of premium. 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 for month 1 are 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 as (Variable expenses+ Fixed expenses)* survival rate at end of month
- Annual mortality rate 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%.

- Monthly mortality rate is calculated using the below formula-

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

- Survival rate (at end of month) is calculated 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 -

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 as Sum Insured * Probability of death
- Profit is calculated as -

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

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

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

Endowment related adjustments

Initially, the premium for endowment product is taken as double the premium for term insurance.

A maturity benefit is introduced as below-

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

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

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

To calculate the Endowment Premium

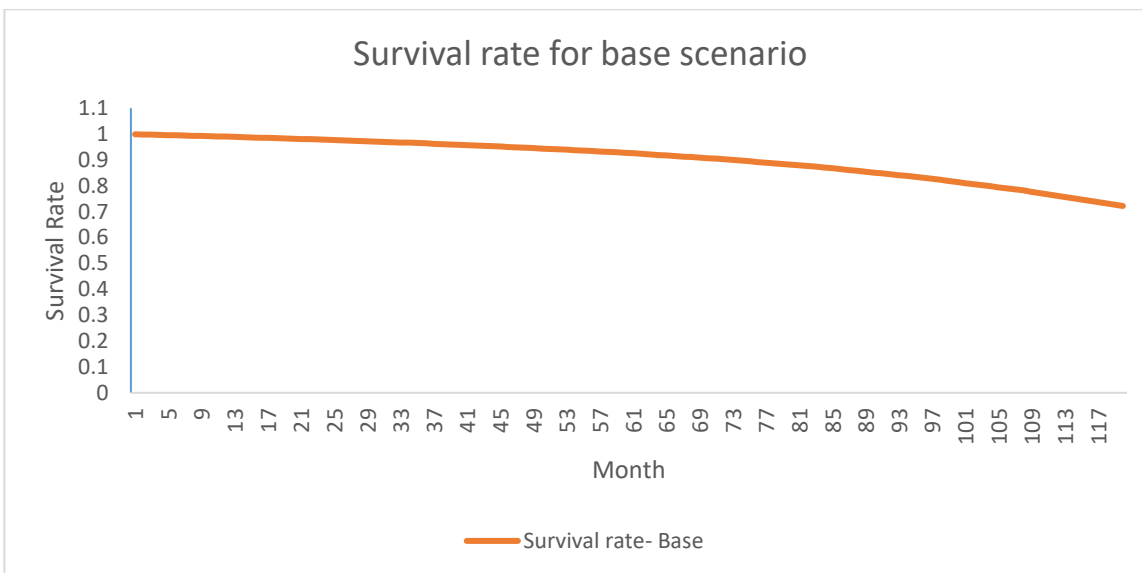
The difference between the Endowment PVFP and Term Insurance PVFP is taken and goal seek is used to vary the Endowment premium till the difference in PVFP becomes 0.

For Mortality Stress Scenario

Under stressed scenario of mortality being 2 times, the term insurance and endowment Insurance calculations are repeated to calculate the profits under revised scenario by multiplying the initial annual mortality by 2.

Results – Survival Rate progression

The survival rate for base scenario is shown below-

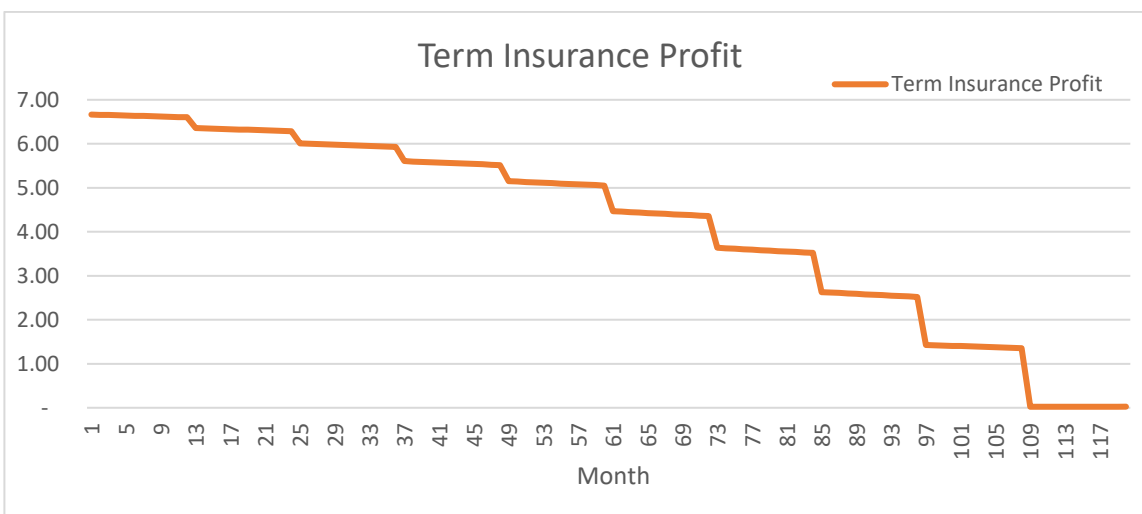


Comments:

- The survival rate starts at 1 and progressively falls due to mortality decrement of every month.
- The survival rate shape is further curved (concave) in the latter half of the term of the contract as the level of mortality is higher in the second phase.
- The survival probability at end of 10 years is around 72%.

Results – Term insurance profits

The chart below is showing the profit progression of term insurance, under base scenario



Comments-

- The profits for term insurance are following a downward sloping and a stepped path.
- This is because of level premiums but increasing mortality payouts with each passing month.
- Further, the stepped nature arises due to annual increases to the death rate and expenses (annual application of inflation).

Results – endowment premium of double the term premium

The PVFP for term and endowment contract (when double the premium of term insurance is charged) is-

	Term Insurance	Endowment Insurance (2x premium)
PVFP	\$420.57	\$706.45

And the Premium required for endowment contract to generate same present value of future profits as term insurance is-

	Term Insurance	Endowment Insurance
Premium (per month)	\$ 10.00	\$ 16.08

Comments-

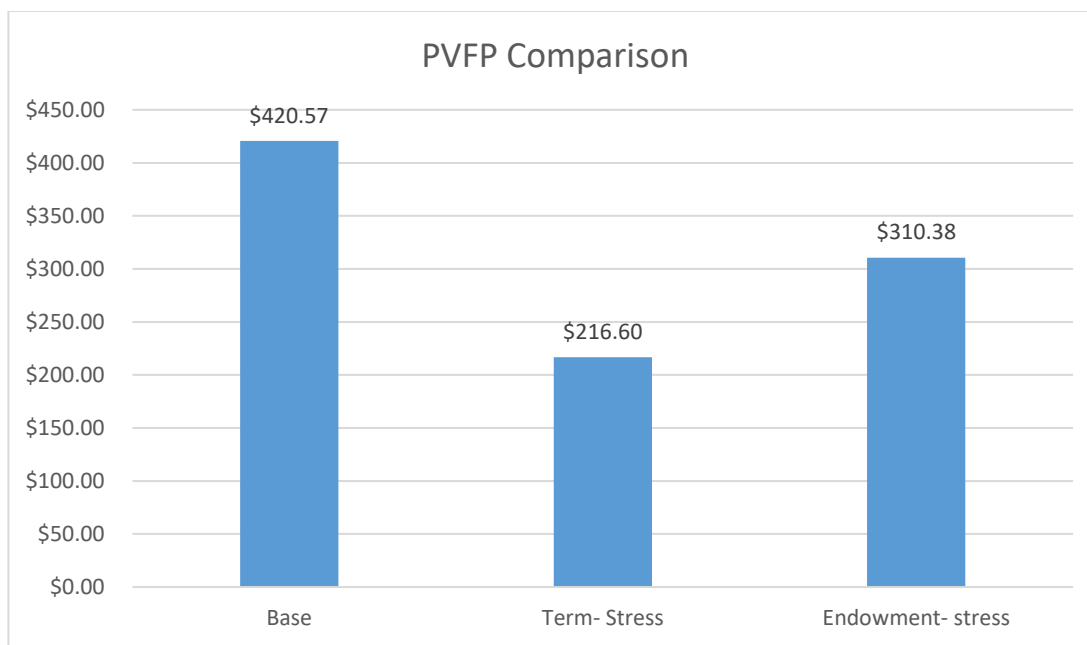
- When a double premium is taken for endowment contract, the PVFP for endowment contract is around \$280 more than term. This means that a smaller increase in premium is required to fulfill the additional maturity benefit and make same PVFP.
- This is because-
 - The maturity payout of \$1000 is smaller than the \$1,200 addition to premium inflows (\$10 every month * 120 months)

- With decrements, premium increase will be lesser than \$1,200 but maturity outgo will be further smaller as it is at end of 120 months so all months' decrements impact it cumulatively
- Further, the impact of discounting further creates a PVFP increase as the maturity benefit is paid at end of contract while increased premiums accrue through the term.
- An offsetting impact of increased commissions and variable expenses linked to premiums will exist which will lead to a higher requirement of increase in premium.

Results – endowment premium with same PVFP and stressed PVFPs

The present value of future profits (PVFP) for the term and endowment contract under base and alternate scenario is as below-

	Base	Term- Stress	Endowment- stress
PVFP	\$420.57	\$216.60	\$310.38



Conclusions-

- Under alternate scenario of two times the mortality, the PVFP for term contract becomes almost half. This is because the payments in term insurance are highly sensitive to mortality (as outgoes are only death payouts).
- For endowment contract, profits have gone down but %age decrease is less than that for term under same stress on mortality. This is because the contract pays in case of death and maturity both and hence profits are not completely sensitive to mortality change and in case of high mortality, there are less survivors and hence the maturity payout becomes lower than earlier. This is in a way, a natural hedge.

- Even though same outgo happens (higher for death exits, lower for survivors), PVFP still falls due to timing of higher payouts being earlier than the savings.
- In case it is expected that mortality rates can be high and volatile, the endowment insurance will be a good to have product to stabilize the profitability and reduce the variability in profits.

Next Steps

- Review the appropriateness of the model point to serve as a proxy for product development.
- The company should do the pricing for other model points and analyze final profits on expected population
- The assumptions used for endowment contract may be different as there may be additional expenses and the mortality experience may differ due to different underlying population. The discount rate may be different depending on assets backing them. Hence the profits should be analyzed by looking at all the new assumptions which are more valid for an endowment contract.
- Assess the reasonableness of inflating the mortality two times. Is there enough supporting experience to show such a high volatility in mortality?
- Analyze the target market for the company - How the market would take up the release of endowment plan by the company which is almost 60% higher than the premium of term insurance
- Check for any tax implication in selling the endowment plan i.e. are there favorable tax treatments given to the protection plans rather than an endowment contract?
- Consider the regulatory requirements for selling the endowment Insurance contract.
- Profit stream of endowment contracts is different from term insurance. Term Insurance is generating steady profits while endowment contract gives better profits over the term but heavy loss at end of term. Check if shareholders are willing to accept that uneven profit pattern? – If reserves need to be set up to change the profit profile, is the new business strain acceptable to shareholders?
- Consider if the company has processes and systems to support maturity claim payouts, profit analysis and other operations for the endowment contracts otherwise how much cost is required to do that
- Reinsurance terms available in market should also be checked for these two types of contracts if the company is looking for reinsuring any of these businesses
- Capital position of the company needs to be analyzed as the reserve requirement for endowment contract is higher than term.
- Any favorable treatment for term or endowment as promoted by government to be checked. This can be via taxation relief or reserve requirements
- Analyze market conditions and customer needs to understand the market acceptance

[85 Marks]
