# TIA Solutions to the Fall 2019 LPM Exam



 

# Introduction

This document contains my full solutions to questions on this exam. Since the syllabus evolves over time, please check the Analysis of Past Exams spreadsheet in the Supplementary and Review Material section of the course for questions that are still on syllabus and also newer reading titles that may be different from the original source mentioned in the solution.

In some cases my solution may be different from the model solution posted by the SOA. You can obtain past SOA exams and SOA model solutions here:

https://www.soa.org/multiple-choice/

It's important to remember that the SOA's model solutions are not intended to be perfect responses. Sometimes they are the best answer provided by an actual candidate that exam day. Other times, they represent a solution that the question writer and/or grader believes is sufficient for full credit. The exams are largely created and graded by volunteers, who, like all of us are human beings that sometimes make mistakes. As such, model solutions may be incomplete, may (unintentionally) contain errors, may contain superfluous information, and may represent only one of multiple possibilities for answering the question.

Because of these aspects of model solutions, they are not always the best instructional tool for future exam problems. My solutions and commentary in this document tend to focus on how best to solve the problem in a way that is most consistent with the syllabus readings and also present solutions with future exam problems in mind.

In many cases, the solutions in this document are much more thorough and complete than what you can reasonably produce under exam conditions. The chief goal of my solutions is to help reinforce the topics tested and present solutions in an instructional way. However, I try to emphasize solution writing "best practices" in my solutions (e.g. write formulas first before doing calculations).

General syntax:

- **Bold text** is generally text taken directly from the question.
- *Italicized text* is my commentary on the question and/or the SOA model solution.
- Regular text is my solution to the question.

When in doubt, always fall back on what you've learned in the online course materials and source material because that information is the most consistent with the current syllabus and will therefore prepare you the most for the next exam.

J. Eddie Smith, IV, FSA

 

# Question 1

## Question 1(a)

**Source: LPM-148: Taxes**

**Calculate the 2018 tax on earnings.**

Formulas (longer way):

$$\begin{aligned}
\text{ProdCashFlow}(t) &= \text{Prem}(t) - \text{Ben}(t) - \text{Exp}(t) \\
\text{PreTaxSolvEarn}(t) &= \text{ProdCashFlow}(t) + \text{InvIncome}(t) - \text{SolvResIncr}(t) \\
\text{TaxableEarn}(t) &= \text{PreTaxSolvEarn}(t) + \text{TimingDiff}(t) + \text{PermDiff}(t) \\
\text{TimingDiff}(t) &= \text{SolvResIncr}(t) - \text{TaxResIncr}(t) \\
\text{PermDiff}(t) &= -\text{InvIncome}(t) \times \text{NonTaxInvPct}(t) \\
\text{Tax}(t) &= \text{TaxRate} \times \text{TaxableEarn}(t)
\end{aligned}$$

Calculations

$$\begin{aligned}
\text{ProdCashFlow} &= 27{,}000 - 12{,}000 - 9000 = 6000 \\
\text{PreTaxSolvEarn} &= 6000 + 2800 - (92{,}500 - 91{,}000) = 7300 \\
\text{TimingDiff} &= (92{,}500 - 91{,}000) - (79{,}250 - 75{,}000) = -2750 \\
\text{PermDiff} &= -2800(0.32) = -896 \\
\text{TaxableEarn} &= 7300 + (-2750) + (-896) = 3654 \\
\text{Tax} &= 0.21(3654) = 767.34
\end{aligned}$$

Shorter, more direct way:

$$\begin{aligned}
\text{TaxableEarn} &= \text{ProdCashFlow} + \text{InvIncome} - \text{TaxResIncr} + \text{PermDiff} \\
&= 27{,}000 - 12{,}000 - 9000 + 2800 - (79{,}250 - 75{,}000) - 2800(0.32) \\
&= 3654 \\
\text{Tax} &= 0.21(3654) = 767.34
\end{aligned}$$

*Either way, be sure to write down formulas because you definitely don't want to botch an easy "plug and chug" question like this with a careless mistake in your calculator. Unfortunately, even if you took the shortcut approach above, you'd still be stuck doing some extra steps to get solvency earnings for part (b) next.*

## Question 1(b)

**Source: LPM-149: Earnings Measures**

**Calculate the 2018 distributable earnings.**

*This part builds off part (a). However, even if you made a mistake in part (a) and got the wrong tax*

 

*figure, you wouldn't lose points on part (b) as long as you used your number correctly in the distributable earnings formula.*

$$\begin{aligned}
\text{AfterTaxSolvEarn} &= \text{PreTaxSolvEarn} - \text{Tax} \\
&= 7300 - 767.34 = 6532.66 \\
\text{DistEarn} &= \text{AfterTaxSolvEarn} - \text{ReqCapIncr} + \text{ATInvIncRC} \\
&= 6532.66 - (2215 - 2000) + (1 - 0.21)(180) \\
&= 6459.86
\end{aligned}$$

## Question 1(c)

**Source: LPM-150: Tax Reform Impacts on Life Insurance Pricing and Profitability**

**Critique the following statements made by the Chief Actuary of the Company with regard to the 2017 Tax Cut and Jobs Act (Tax Reform).**

***(A) "The company is anticipating a significant tax benefit due to the tax reform rate change. However, this is largely offset by the RBC, DAC tax and tax reserve changes."***

- This is generally true. The reduction in tax rate from 35% to 21% improves after-tax profits and is the dominate change. However, these other 3 effects all lower after-tax profit, and the sum of these nearly offset the tax rate reduction:
  1. Higher DAC tax rates and longer DAC tax amortization
  2. New tax reserve method based on 92.81% scalar applied to stat reserve
     - Lower tax reserve leads to higher taxable income
  3. RBC factors will likely be scaled by a factor of $\frac{1-0.21}{1-0.35} \approx 122\%$
     - Higher capital requirements = lower lower A/T profits
     - This change is tentative, as there is no guidance from NAIC yet though

***(B) "In addition, the tax reform impact on the company will not vary by product groups or blocks of business."***

- False
- Product-specific characteristics like the size of tax reserves relative to stat reserves and capital requirements will result in variations by product
- Some products' profits will increase due to tax reform:
  - Current assumption universal life
  - Term under VM-20
  - IUL
  - Fixed indexed annuity with GMWB
- Some products' profits will decrease due to tax reform:

 

- Par whole life
- Term under peak statutory (XXX) and AG 48 ("TermAG48")
  - Loss of tax leverage (less value in tax loss deductions)

 

# Question 2

## Question 2(a)

**Sources:**

- **HFIS Ch. 9: U.S. Treasury Securities**
- **HFIS Ch. 10: Agency Debt Securities**
- **HFIS Ch. 11: Municipal Bonds**
- **HFIS Ch. 12: Corporate Bonds**
- **HFIS Ch. 16: Private Money Market Instruments**
- **HFIS Ch. 24: Mortgages**
- **HFIS Ch. 25: Agency MBS**

**(i) Rank NIN's current holdings from least to most credit default risk. Justify your ranking.**

*Keep in mind, you were only focused on credit risk here. Chapter references are noted for each below.*

1. (Ch. 9) Treasury Bond – Issued by the US Government, which is generally considered risk-free

2. (Ch. 25) Mortgage Backed Security – guaranteed by Fannie Mae, which is a GSE. While GSEs are not technically backed by the full faith and credit of the US government like Treasuries, government actions during the 2008 crisis provided "implicit" backing of GSEs. Therefore, while not as "risk-free" as Treasuries, Fannie MBS are considered less risky than AAA assets.

3. (Ch. 16) AAA-rated commercial paper – AAA is the highest credit rating available for a debt issued by a corporation, making this item less credit risky than the remaining 3 securities below

4. (Ch. 12) AA-rated swap – AA securities are more credit risky than AAA
    - *HFIS Ch. 62 covers swaps, but that chapter never provides a rating scale specifically for swaps, so I would just assume the AA rating provided is similar to the description for corporate bonds in Ch. 12.*

5. (Ch. 11) MIG 3 municipal bond – MIG 3 is a municipal note rating and is considered "acceptable quality." MIG 3 is above SG-rate municipal notes, where SG = speculative grade.
    - *Technically MIG 3 is a municipal note rating, not a municipal bond rating according to HFIS Ch. 11. Municipal bond ratings have a different rating symbol scheme (Aaa, Aa, A, Baa). Municipal notes are typically 12 months or less. However, a footnote in Ch. 11 says that it's possible for notes to extend up to 3 years. That probably caught the eye of the person writing the question. However, they should have described this security as a municipal note in the question since the "MIG" rating scheme is specific to notes.*

 

6. (Ch. 12) BB-rated bond – BB is considered a non-investment grade or speculative grade, so this would be the most credit-risky security in the group

**(ii) Assess how the ranking would change if based on expected yield in a normal yield curve environment. Justify your answer.**

*This question wanted you to rank the securities in order of lowest yield to highest yield.*

A normal yield curve is upward sloping. Therefore, all else equal, securities with longer terms will have higher yields.

- *Defining "normal" these days is kind of impossible. I'm sure the person that wrote the question simply wanted you to picture the classic upward sloping historical yield curve. However, there is nothing really in the source material that defines "normal yield curve." A few more notes on this below.*

Credit risk and liquidity risk also increase yield

1. 3-mo commercial paper – has shortest term of all the securities listed, so it will be based on the lowest yield on the yield curve. Credit risk is low at AAA. Secondary market volume is low; however, issuer will often repurchase the paper if the investor wants to sell it, so liquidity risk is not high.
2. 3-year municipal bond – longer than the 3-mo commercial paper, and shorter than the 5-year bond, so the muni falls between those. This muni also has less credit risk than the BB-rated bond.
3. 5-yr bond – this falls between the 3-yr muni and the last 3 securities below, which are all 10-year. Therefore, this bond's yield would likely fall at this spot on the ranking assuming its credit spread is not larger than the difference between the 10-yr and 5-yr Treasury yields.
    - *This is probably a bold assumption, and there isn't a right or wrong answer here. As of the date I'm typing up this solution in 2020, the spread between the 5- and 10-yr CMT is a measly 35 bps. The credit spread on a BB-rated bond would almost certainly be greater than 35 bps. Therefore, I think you could flipflop the bond and Treasury with justification. There is nothing in the source material that provides guidance on "normal" credit spread differences vs. term structure rate differentials.*
4. 10-yr Treasury Bond – would fall at this spot on the ranking since the remaining 2 securities below are also 10-year and would both have more credit risk than the Treasury.
5. 10-yr, AA-rated swap – has the same term but lower credit risk than the A-rated MBS
6. 10-yr, A-rated MBS – has the highest credit risk of the 10-yr securities on the list and wiould have the highest yield as a result

## Question 2(b)

**Source: HFIS Ch. 9: U.S. Treasury Securities, HFIS Ch. 62: Interest-Rate Swaps and Swaptions, LPM-164 Ch. 8: Swaps**

 

**Explain four possible reasons the 10-Year swap may have a lower yield-to-maturity than the 10-Year Treasury Bond.**

*I really struggled to come up with 4 reasons based on the syllabus material, and the SOA model solution commentary notes that candidates generally did poorly on this one, so don't feel bad if you struggled too! Swap yields are almost always higher than Treasury yields of the same term because swaps have added risks due to counterparty risk, hedging issues, and the fact that Treasuries are always default-free by their nature. In fact HFIS Ch. 62 states that "Empirically, the swap curve lies above the U.S. Treasury yield-curve and below the on-the-run yield-curve for AA-rated banks." In other words, swap rates are usually higher than Treasuries. LPM-164 Ch. 8 also shows a term structure graph as of 2010 that reinforces this.*

*Fundamentally, this question is asking you to come up with reasons why swap spreads might be negative. Recall from HFIS Ch. 62 that the swap spread for a N-year swap = Swap Rate − N-Year Treasury Yield. The only place in the source reading that specifically addresses negative swap rates is a footnote on p. 248 of LPM-164 Ch. 8 that says "Beginning in late 2008, and up through the date of this writing in early 2012, 30-year swap spreads (and, less frequently, 7- and 10-year swap spreads) have been negative. That is, the yield on 30-year Treasury bonds has been greater than the 30-year swap rate. This is surprising because Treasury yields should be less than private yields." That's all the author says.*

*Therefore, this is the best I could do from the syllabus material that this exam was based on and just general economic knowledge:*

1. The swap rate is based on $\frac{\text{PV Expected Floating Payments}}{\text{PV Notional}}$. Therefore, if the floating payment is based on a short-term rate, and the market expects a relatively flat or even inverted yield curve (implying relatively low future floating payments), the resulting fixed SR could be lower than the current 10-yr Treasury yield.

2. High demand for fixed leg swaps could drive down the yield on the swap

3. If demand for 10-year Treasury bonds falls, due to economic fundamentals that don't affect the swap (e.g. stock market rally that leads to a sell-off of Treasury bonds), it could cause the Treasury yield to rise above the swap yield

4. If hedge costs for the swap are very low, it will result in a lower swap spread, which would increase the chance of the swap yield being lower than a Treasury
    - *I still don't feel great about this answer because hedge costs for the Treasury bond are zero, so even if swap hedge costs are zero, I'm not sure we can argue this would case the swap yield to be lower.*

*The SOA model solution lists a couple of others I wanted to comment on before people ask me about them:*

- *The SOA model solution says that since swaps are marked to market, they have "no default risk." First off, unless both sides of the swap are literally based on Treasury instruments, they would still have some default risk technically (not to mention counterparty default risk) since standalone Treasuries and STRIPS are the only securities in the financial universe that are considered truly default-free. Also, we can't really use "no default risk" as a comparison point by itself in this question because we are comparing directly to a US Treasury bond, which has no default risk. So I don't think that's a good answer.*

 

- *Another point in the SOA model solution mentions that LIBOR is being discontinued and investors might accept a lower SR if they expect LIBOR's replacement to have a lower rate. It is true that LIBOR is being discontinued, but that was not covered in any syllabus readings on the fall 2019 / spring 2020 LPM syllabus that this exam is based on, so I don't think that's a valid answer for exam purposes. I recommend NOT using off-syllabus knowledge to answer future exam questions.*

## Question 2(c)

**Source: MIP Ch. 5, Sections 2–4: Asset Allocation**

**Propose two adjustments to NIN's holdings or strategic asset allocation for each of the following:**

*There were many possible answers using the source readings and general syllabus knowledge. This represents just one possible answer.*

***(i) Achieve a yield of 0.5% above the risk-free rate to support product pricing assumptions***

- Shift some of the 10-year Treasury holdings into the 10-year MBS, which will have higher yield for longer durations
- Shift some of the commercial paper into the municipal bond to increase yield on shorter durations

***(ii) Minimize credit risk, especially default risk***

- Increase Treasury bond holdings
- Use CDS to lower default risk on credit-risky securities whose default risk is similar to the CDS reference entity

***(iii) Minimize interest rate risk by matching asset and liability durations***

*We aren't told what the insurer's liabilities are like in the problem, so we can only make very general statements here.*

- Use swaps to hedge fixed or floating interest payments on the liabilities
- Purchase bonds that have durations similar to the liabilities

***(iv) Maintain sufficient liquidity to make liability payments as they come due***

- Increase commercial paper holdings
- Increase holdings of shorter term Treasuries

 

# Question 3

## Question 3(a)

**Source: LPM-162: Liquidity Risk Management**

**List four objectives of a company's liquidity risk policy.**

*The word "objectives" does not appear in the source reading tested, but it seems that they were looking for general contents of a liquidity risk policy under "Principle 6" in the reading. Any 4 of the following from our DSM should have gotten full credit.*

- Definition of liquidity adequacy in the context of the company's risk philosophy and tolerances
- Degree of reliance on external cash sources vs. self-funding
- Minimum standards to be adequately protected from liquidity risk
  - Describe "cure periods" if standards are not met
- How frequently liquidity adequacy will be measured
- Responsibilities for setting strategy, risk limits, execution reporting, and monitoring functions
- Requirements for liquidity crisis planning

## Question 3(b)

**Source: LPM-162: Liquidity Risk Management, LPM-165 Ch. 3**

**Describe product design features that will mitigate liquidity risk for the new SPUL product.**

SPUL involves a large upfront premium, making it have higher assets backing the product and more of an investment-oriented liability. The key liquidity risk would come from the chance of surrender at times when it is unfavorable to sell assets.

1. Surrender charges would lower the chance of policyholder surrender at an unfavorable time (e.g. if interest rates rise)
2. MVAs would also lower disintermediation risk and liquidity risk by mitigating the risk of having to sell assets to fund surrenders at an unfavorable time
3. Persistency bonuses would lower surrender activity

## Question 3(c)

**Source: LPM-162: Liquidity Risk Management**

**(i) Evaluate the appropriateness of assessing liquidity risk using only the 3 month liquidity stress scenario. Show your work.**

 

*"Show your work" was a key clue that they wanted you to do some math here! "Evaluate" questions do not always require calculations, but they gave you a clue that this one did.*

Looking only at the 3-month scenario is not appropriate

Should compute the liquidity coverage ratio for each scenario at various horizons (7 days, 1 month, etc.)

$$\text{Liquidity coverage ratio} = \frac{\text{Cash Sources}}{\text{Cash Needs}}$$

Cash sources for insurance companies include:

1. Cash inflows from products (premiums, deposits)
2. Asset cash flows (investment income and maturities)

Cash needs driven by cash outflows for insurance companies:

1. Cash outflows from products (benefit payments, withdrawals from surrender)
2. Operating cash outflows

Calculations:

$$\text{3-month LCR} = \frac{15 + 0.25 + 1}{10 + 0 + 4.5} = 112\%$$
$$\text{6-month LCR} = \frac{20 + 0.25 + 1.5}{15 + 0 + 6} = 104\%$$
$$\text{1-year LCR} = \frac{35 + 0.25 + 2}{45 + 0 + 8} = 70\%$$

Therefore, the company should be concerned about liquidity for longer durations because cash needs exceed cash sources

**(ii) Recommend next steps to manage potential liquidity risk for this product based on the output of the stress scenario.**

Recommend investigating the cause of the expected high claims in year 1 to make sure it's not an error. If it's a valid expectation, the company should consider shortening the asset portfolio so that investments will mature around year 1 to provide sufficient funding for expected claims.

Also recommend assessing the company's contingent liquidity sources such as:

1. Ability to monetize illiquid assets (e.g. real estate)
2. Uncommitted bank lines of credit
3. Other standby/back-up liquidity lines
4. Ability to issue new product on a guaranteed basis

**(iii) Describe four additional stress scenarios that TEN Life could use to identify liquidity risk.**

*Any 4 of these would do:*

 

1. Disintermediation scenario: Shock interest rates +300 bps
    - Surrenders rise
    - Asset cash flow on callable and prepayable securities falls
    - Asset market values become depressed
2. Catastrophic claims scenario: simulate a catastrophic event
    - Cash needs increase sharply
3. Customer panic scenario: full letter company downgrade
    - Consider impact of falling equity markets, rising credit spreads, and/or catastrophic insurance losses
    - Assume full withdrawals fixed deferred annuities
    - Assume high withdrawals on less sensitive products (WL) but not necessarily full
4. Impaired markets scenario: capital markets become frozen for 3–6 months
    - Impossible to sell assets during this time
5. Impaired markets/panic withdrawal scenario: "run on the book"
    - Very difficult to manage if capital market liquidity has vanished
    - Requires access to other external cash sources

## Question 3(d)

**Source: Interesting Challenges for Insurers**

**Propose two SPUL product design strategies that can help mitigate interest rate risk. Justify your answer.**

1. Reduce minimum guaranteed crediting rate to protect against a very low, prolonged interest rate environment where it would be difficult to earn enough on assets to fund credited interest.
2. Implement an MVA feature to protect the insurer against a rising interest rate scenario that would cause policyholders to surrender while asset values are depressed.

 

# Question 4

## Question 4(a)

**Source: Understanding the Volatility of Experience and Pricing Assumptions in LTCI**

**For each of the following:**

- **Process Risk**
- **Parameter Risk**
- **Economic Scenario Risk**

**(i) Define each risk.**

- Process Risk – the risk that even if we know an event's true probability distribution, we might not know precisely how many times it will occur in limited trials
- Parameter Risk – risk that a probability rate (a parameter) estimated from data samples may not be the true probability (parameter)
- Economic Scenario Risk – risk with unknown future interest rates and other economic variables

**(ii) Describe the causes and contributing factors of each risk specific to long-term care insurance.**

*This was a lot of writing for a 1-pointer!*

- Process Risk:
  1. Probability distributions that drive mortality, morbidity, and lapse
  2. Benefits of the insurance contract
  3. Number of policies
  4. Demographics of the insured population
  5. Length of the reporting period
- Parameter Risk:
  - Sampling risk – result of differences between the sample and the population
    - Most LTCI risk is concentrated at high ages, where there is little historical data
    - Underwriting standard changes and claims adjudication (court rulings) distort experience data
    - Censoring – most policies have been in force for a limited time and haven't reached higher ages
  - Data bias – the risk that the parameters are wrong because they are not trended properly

 

  - Model Misspecification – a misspecified model can hide the true parameter risk

- Economic Scenario Risk
  - LTCI is a long-duration, level premium product with steeply increasing benefits
    * Requires large reserves
    * Relies heavily on investment returns (adds significant interest rate risk)
  - Short-term interest rate risk can be mitigated with asset portfolio management
  - Long-term interest rate risk cannot be diversified away

**(iii) Describe the level of each risk for long-term care insurance. Justify your answer.**

- Process Risk – least serious of the 3 because it can be diversified away over time in the long run with sufficient business volume thanks to the law of large numbers
- Parameter Risk – more serious than process risk because parameter risk cannot be diversified away with time
  - If the policies are priced with the wrong parameter, selling more policies only magnifies the problem
- Economic Scenario Risk – fairly serious because LTCI relies heavily on investment returns to fund future claims

**(iv) Evaluate how each risk is impacted by adding the long-term care rider to a life insurance product.**

- Process Risk – should be reduced because fluctuations in claims reserves account for most process risk in earnings
  - A combo product has more of a natural hedge that dampens claims volatility because if death claims increase, LTCI claims fall (and vice versa)
- Parameter Risk – should also be reduced because of the natural hedge between LTCI and life insurance
  - Misestimating the LTCI parameter is less serious when death claims help dampen exposure to LTCI claims
- Economic Scenario Risk – would increase because combo products have a higher duration than standalone products

## Question 4(b)

**Source: Quantification of Natural Hedges in LTCI Combo Products**

*This solution mirrors the SOA model solution, which was very thorough*

**Evaluate the impact to the overall profitability of Product X if increases were made to the following pricing assumptions:**

**(i) Mortality for disabled lives**

Higher disabled lives mortality usually leads to higher profits. Disabled lives mortality rates act much like a policy lapse, as they end not only the current claim, but the entire policy.

**(ii) Mortality for active lives**

LTC benefits from higher mortality due to lower claims for deaths before disability. Life insurance benefits from lower mortality due to lower claims. If LTC outweighs the life insurance benefit, then increasing active life mortality will increase the profit, and vice versa. Policy design features such as linking benefits to inflation or richer extension of benefit beyond the insurance face amount will increase the weight of LTC benefits.

**(iii) Lapse rates for active lives**

LTC is typically lapse-supported and profits will increase from higher-than-expected lapses. Life insurance is often the opposite (benefits from lower lapses). The effects of increasing lapse rate will vary based on the weights of the life insurance benefit and the LTC benefit.

**(iv) Incidence rates for active lives**

Increasing morbidity incidence rates for active lives will increase payouts on LTC rider, decreasing profit. Disabled life mortality tends to be higher, so higher morbidity will increase mortality and thus increase life insurance payouts, decreasing profits.

## Question 4(c)

*This solution mirrors the SOA model solution, which was very thorough*

**Source: Quantification of Natural Hedges in LTCI Combo Products, Life Insurance Acceleration Riders**

**Critique the following statements:**

**(i) HLC could reduce acquisition expenses and streamline the underwriting process for Product X by only underwriting the life insurance application.**

- Not appropriate
- Although limiting the underwriting to the application may reduce expenses and streamline the process, additional/supplemental underwriting is a critical risk control measure for LTC combo products. The supplemental underwriting typically consists of questions related to the applicant's medical history with respect to the triggers that are used for the acceleration benefit.

**(ii) HLC could increase future sales by allowing life insurance policy holders to add the long-term care rider, without underwriting, while their life insurance policy is inforce.**

- Not appropriate
- Although sales might be higher, one common risk control is limiting the issue ages at which the chronic illness rider can be added, especially at older ages

**(iii) HLC could limit risk for a long-term care rider by adding a restriction that the loss of activities of daily living must be expected to be permanent.**

 

- Appropriate
- In the absence of such as definition an otherwise healthy individual could claim under the rider when there is a situation that involves a temporary loss of ADLs.

**(iv) HLC could increase sales by adding a critical illness rider that accelerates a portion of the face amount if the policyholder has a life expectancy of less than 12 months.**

- Not appropriate
- The critical illness rider is being confused with a terminal illness rider in this statement. A critical illness rider pays when meeting the criteria for one or more critical illnesses. A terminal illness rider is one that allows policyholders to accelerate a portion of their face amount when they have a life expectancy of less than X months.

 

# Question 5

## Question 5(a)

**Source: Life Insurance Acceleration Riders**

**Recommend changes to the product design to mitigate risk.**

*This solution mirrors the SOA model solution, which was very thorough*

- Use a supplemental underwriting application rather than using the life insurance application
- Require certification from an approved licensed health care practitioner of whether the policyholder is unable to perform the ADLs instead of a certification from company underwriter.
- Limit the issue ages at which the chronic illness rider can be added (and/or add a cognitive skills test at advanced ages).
- Add additional exclusions on the rider such as mental/nervous disorders, alcoholism, drug addiction, or act of war.
- Limit availability of this rider to certain age groups and/or underwriting classes.
- Require completion of the rider application if the policyholder wants to convert from a term policy without the rider to a permanent policy with the rider.
- Add elimination period/waiting period for the rider.
- Limit the max benefit < 100% of death benefit and/or both the annual and max acceleration amount to some specific dollar amount.
- Define the loss of ADLs as expected to be permanent to reduce the claims.

## Question 5(b)

**Source: Life Insurance Acceleration Riders, Term Conversions – A Reinsurer's Perspective**

- *The SOA model solution does not list the 2nd reading above as a source, but I think it would have been helpful in addressing the first bullet point since it deals specifically with YRT reinsurance for conversions.*

**Explain possible concerns a reinsurer may have with this proposal.**

- Reinsurance method for conversions:
  - If reinsurance is based on point-in-scale YRT rates for conversions in original term block, the reinsurer would want to use 2 possible methods:
    - Increase overall YRT rates
    - Use separate YRT rates for conversions

 

  - Otherwise, the reinsurer would not be adequately compensated for converted policies because converted policies are likely to have higher mortality than what the original point-in-scale rates would indicate

- Risk retention:
  - A reinsurer would probably rather participate in the base policy than let the ceding company fully retain the base policy
  - The reinsurance cost of the chronic illness rider on a term product is much higher and uncertain compared to a base product
    * Much fewer ultimate death claims will result since the coverage period is shorter
    * Life expectancy may be longer than term period
  - The reinsurer can mitigate its risk by participating the base policy and add diversification

- No evidence of insurability required for rider:
  - This will further increase the reinsurer's expected claim cost by allowing anti-selection and adding higher risks to the reinsured pool
  - The reinsurer is likely to want evidence of insurability required to manage claim cost; otherwise the reinsurer will need to charge even higher YRT rate for conversions

## Question 5(c)

**Sources: LPM-107: Experience Assumptions for Individual Life Insurance and Annuities, Credibility Theory Practices**

**(i) Calculate the 95% confidence interval (z = 1.96) of the morbidity rate for company FIV's experience using the Binomial Model.**

Confidence interval for expected morbidity rate $q = E/n$:

$$\frac{E \pm 1.96 \times \sqrt{\text{Var}(E)}}{n}$$

where:

$$\begin{aligned} E &= nq = \text{claims} \\ n &= \text{policy count} \\ \text{Var}(E) &= npq \end{aligned}$$

Calculations:

$$\begin{aligned} n &= 34{,}321 \text{ (given)} \\ E &= nq = 350 \text{ (given)} \\ q &= 350/34{,}321 = 0.010198 \\ npq &= 34{,}321(0.010198)(1 - 0.010198) = 346.44 \end{aligned}$$

Confidence interval:

$$\begin{aligned} 0.010198 &\pm \frac{1.96\sqrt{346.44}}{34{,}321} \\ &\pm 0.00106 \end{aligned}$$

Therefore, the morbidity rate should fall on (0.0091, 0.0113) 95% of the time

**(ii) Calculate the credibility of company FIV's experience according to Limited Fluctuation Theory using an error margin of 0.05.**

*I will first solve this according to the reading tested (Credibility Theory Practices), then I will make some comments about the SOA model solution.*

The general formula for the LFCT credibility factor:

$$Z = \min\left[1, \frac{r\hat{m}}{z\hat{\sigma}}\right]$$

where $\hat{m}$ = count-based A/E ratio

We are given that $r = 0.05$ and $z = 1.96$, so the reading says to use this formula:

$$Z = \min\left[1, \frac{0.05\sqrt{N}}{1.96}\right]$$

where $N$ = actual number of claims observed (given in this problem to be 350)

Therefore,

$$Z = \min\left[1, \frac{0.05\sqrt{350}}{1.96}\right] = 0.47725$$

*In my opinion this is the correct answer if we're to use the source reading tested.*

*However, the SOA model solution commentary describes the above approach as a "common mistake" because it assumes a Poisson approximation to the binomial distribution. They seemed to want you to use the formula differently than the reading presents it. While it may be true that the Z formula above is a Poisson approximation, that point is never mentioned in the reading, and the reading does not give any other formulas for calculating a LFCT Z-factor. The reading does not even mention the Poisson distribution.*

*Even if we make life really hard for ourselves and solve for the general Z formula above using only the Binomial information given in the problem, we will still get to the same place. Let's do that now using the*

*raw notation from the reading:*

$$\begin{aligned}
\hat{m} &= A/E \\
A &= \text{actual claim count} \\
E &= \text{expected claim count based on an industry table} \\
\hat{\sigma}^2 &= A/E^2 = \hat{m}/E \\
\hat{\sigma} &= \sqrt{\hat{m}}/\sqrt{E} \\
z &= \text{standard normal deviate (e.g. 1.96)}
\end{aligned}$$

*In this problem, $A = 350$, but we are not given an industry expectation ($E$). It turns out that won't matter if we work through the proof starting with the general formula for $Z$:*

$$\begin{aligned}
Z &= \min\left[1, \frac{r\hat{m}}{z\hat{\sigma}}\right] \\
&= \min\left[1, \frac{rA/E}{z\sqrt{\hat{m}}/\sqrt{E}}\right] \\
&= \min\left[1, \frac{rA/E}{\frac{z\sqrt{A}/\sqrt{E}}{\sqrt{E}}}\right] \\
&= \min\left[1, \frac{rA/E}{\frac{z\sqrt{A}}{E}}\right] \\
&= \min\left[1, \frac{rA}{z\sqrt{A}}\right] \\
&= \min\left[1, \frac{r\sqrt{A}}{z}\right] \\
&= \min\left[1, \frac{0.05\sqrt{350}}{1.96}\right] \\
&= 0.4772,
\end{aligned}$$

*which is what we got above by just taking the simplified formula in the reading at face value.*

*The key difference in the SOA model solution is that they set $\hat{m} = 350$, which is the claim count. That's definitely not how the reading defines $\hat{m}$ since it's clear the reading treats $\hat{m}$ as a mortality rate or multiple because it uses it in the credibility-weighted mortality estimate formula like so:*

$$Z\hat{m} + (1 - Z)a$$

*However, I believe the rationale of the person who wrote the SOA model solution was to treat that term more generally as a mean that corresponded the variance in the denominator. This lead them to:*

$$\begin{aligned}
Z &= \min\left[1, \frac{0.05(350)}{1.96\sqrt{346.43}}\right] \\
&= 0.4797,
\end{aligned}$$

 

*which incidentally is extremely close to what we got using the reading's formula as-is. This approach may very well be valid, but it's not supported with any explanation in the source materials. It also gives an extremely similar result to what we got using the reading's formula as-is. Morever, part (ii) never explicitly said to use the binomial distribution in this way. So it's surprising that they described the former approach as a "mistake." I'm not sure what else to say, but I would recommend sticking with the source material for future problems.*

**(iii) Recommend an incidence rate to use for company FIV's chronic illness rider.**

The credibility-blended rate is:

$$Z\hat{m} + (1 - Z)a$$

where $\hat{m}$ = incidence rate estimate from part (i) and $a$ = industry rate (given to be 0.005)

Therefore, recommend using an incidence rate estimate of:

$$0.47725(0.010198) + (1 - 0.47725)(0.005) = 0.007481$$

 

# Question 6

## Question 6(a)

**Source: VA Guaranteed Living Benefits Utilization**

**(i) List the considerations for policyholders taking withdrawals.**

Most important: Age and source of funding (qualified or nonqualified)

- No variations in age before age 70
- 2/3 of VAs are funded with qualified money (e.g. 401(k), IRAs, etc.)
  - After age 70, withdrawal utilization increases with age
- Nonqualified contracts: age and contract duration mainly drive withdrawals
- Less significant factors: size, deferral incentives, distribution channel, in-the-moneyness

**(ii) Evaluate the appropriateness of using the given experience from the existing block as the proposed assumptions on the new GLWB rider.**

Not appropriate. The existing block was sold to blue collar workers, who are a different demographic/market than the high net worth retirees being targeted by the new rider.

- The average age of a GLWBs ower is 63 (mostly Baby Boomers age 49–67)
  - Blue collar workers are younger (in working years)
- Highest withdrawal activity occurs with qualified plans for ages 70+
  - Therefore, withdrawal experience will likely differ
- Younger owners more likely to add premium than older owners
  - Typical GLWB owners rarely add premium after year 2
- Surrender rates are very low for older GLWB owners
  - Under age 60 are more likely to surrender
- Younger owners are more likely to exceed maximum allowed withdrawal benefit
- VAs with higher contract values are less likely to take withdrawals that significantly exceed the benefit maximum

## Question 6(b)

**Source: LPM-156: The Impact of Stochastic Volatility**

**Evaluate the impact of each of the following scenarios on the value of the GLWB rider:**

**(i) Favorable stock market return**

- GLWB delta $< 0$

 

- If the VA has equity funds, an increase in the value of equity funds will lower the value of the GLWB (makes it less ITM). The GLWB is more ITM when the VA account value falls because the benefit base is more likely to exceed the AV, forcing the insurer to pay withdrawals that are not funded by the AV.

**(ii) Decreasing interest rate**

- The GLWB also has a negative rho, so falling interest rates result in higher option values, increasing the value of the GLWB. For VAs that have allocations to bond funds, falling interest rates will lead to a rise in those AVs, making the GLWB less ITM. The net impact will depend on the extent of the interest rate drop and amount of allocation to bond funds.

**(iii) Increasing equity volatility**

- Vega > 0
- Increasing volatility increases the value of the GLWB because the GLWB is a one-side option, so increases in volatility magnify the equity downside possibility.

**(iv) Increasing surrender rates**

- Increasing surrender rates will decrease the value of the GLWBs in total because there will be fewer contracts in force to collect payouts. When a contract is surrendered, future guaranteed withdrawals are forfeited.

## Question 6(c)

**Source: LPM-156: The Impact of Stochastic Volatility**

**The company is considering the following dynamic hedging strategies:**

- **No hedging**
- **Delta hedging**
- **Delta and Vega hedging**

**(i) Define each hedging strategy.**

- No hedging – All guarantee fees are simply invested in the money market account (no replicating portfolio used)
- Delta hedging – Take a position in the underlying to immunize the portfolio against small changes in the underlying's level
- Delta and Vega hedging – Incorporates the use of the straddle option to neutralize the portfolio's exposure to changes in the underlying's volatility

**(ii) Compare the use of the Black-Scholes and Heston models for determining the fair value of the guarantee.**

1. Black-Scholes – assumes deterministic (constant) volatility based on Brownian motion
2. Heston – assumes market is driven by 2 stochastic processes: the underlying stock price $S(t)$ and its instantaneous variance $V(t)$

 

    - Assumes stochastic volatility (more realistic)

3. Both result in similar fair guaranteed withdrawal rates

**(iii) Evaluate how each hedging strategy is affected by the choice of Black Scholes or Heston models for valuing the guarantee.**

- No hedging – choice of BS vs. Heston is irrelevant
- Delta hedging – Any kind of delta hedging greatly reduces risk
  - BS and Heston are similar: hedging model choice not that important
  - However, choice of data-generating model is very important
    - Heston DG model shows much higher risk after delta hedge
    - Insurer's risk depends on whether true volatility is deterministic or stochastic
- Delta and Vega hedging – The delta-vega Heston hedge model results in the least risk
  - Also adds complexity
  - BS requires a modified vega to compensate for the fact that BS uses constant volatility but we are trying to use it to hedge changing volatility
  - It is a judgment call as to whether the incremental cost of adding a vega hedge with straddles is worth the additional reduction in risk
  - A unique vega hedging strategy does not exist
  - Over-hedging can increase risk even more than if there is no vega hedge at all

 

# Question 7

## Question 7(a)

**Source: Earnings Emergence Insurance Accounting**

**Calculate the pre-tax earnings during the first two years under the above methodologies. Show all work.**

*The source reading itself does not provide explicit reserve formulas for any accounting standards it covers. However, our video lesson does contain the necessary formulas you would have needed to do the calculations in this part.*

*We can also deduce a general formula for pre-tax earnings from the basic pre-tax solvency earnings formula in LPM-149 (even though it's not cited as a source):*

$$\text{PreTaxEarnings}_t = \underbrace{\text{ProdCashFlow}_t + \text{InvIncome}_t}_{\text{Given in the problem}} - \text{ResIncr}_t$$

*The key difference between each of the 3 accounting regimes is simply the change in reserve*

US GAAP

- Method: FAS 60 net level premium reserve
- Assumptions = best estimate plus PAD (locked in at issue)
- Deferrable acquisition costs are capitalized and amortized using a DAC asset

FAS 60 reserve formula: PVFB + PV(Exp) − PV(Net Prems) − DAC

- Reserve Type D is the best match for the FAS 60 net premium reserve because it's based on best estimates with PADs on all pertinent assumptions
- DAC Type H is the best match for the FAS 60 DAC since it's only based on first year commission
  - *The only other choice was DAC Type G, which included all first year expenses. These 2 choices were a bit squishy because we weren't really told much about the nature of the product's expense profile. DAC should only include deferrable expenses. If we assume there are some non-deferrable expenses in year one (very likely), then that rules out Type G. Of course, by picking Type H, we're also assuming there are no renewal commissions because if there is a renewal commission, the only first year commissions in excess of the renewal commission would be deferrable.*

 

US GAAP Calculations:

$$\begin{aligned}
\text{ResIncr}_1 &= (1239 - 3536) - (0 - 0) = -2297 \\
\text{PreTaxEarnings}_1 &= -2775 + (-111) - (-2297) = -589 \\
\text{ResIncr}_2 &= (2195 - 3189) - (1239 - 3536) = 1303 \\
\text{PreTaxEarnings}_2 &= 1757 + 161 - 1303 = 615
\end{aligned}$$

CALM

- CALM liability = current carrying value of assets required to satisfy the company's liabilities under a worst case interest rate scenario
  - Approximated by PV'ing liability cash using a discount rate tied to worse case scenario
  - Discount rates are based on asset yields tied to a prescribed scenario
- Assumptions = best estimates plus margins for adverse deviation (MfADs)

*As noted above, there is no explicit formula given in the source reading for the CALM reserve, but hopefully if you had used our video lesson, you knew to use a gross premium valuation*

CALM reserve formula: PVFB + PV(Exp) − PV(Gross Prems)

- Reserve Type C is the best match because it involves a gross premium valuation based on padded assumptions and a worst-case scenario

CALM Calculations:

$$\begin{aligned}
\text{ResIncr}_1 &= -4607 - 0 = -4607 \\
\text{PreTaxEarnings}_1 &= -2775 + (-111) - (-4607) = 1721 \\
\text{ResIncr}_2 &= -3048 - (-4607) = 1559 \\
\text{PreTaxEarnings}_2 &= 1757 + 161 - 1559 = 359
\end{aligned}$$

Solvency II Earnings

*Keep in mind, as the reading notes, Solvency II "earnings" are not a real thing since Solvency II is a capital standard and is entirely balance sheet focused. There is no concept of an income statement under the actual Solvency II regulation. However, the reading presents Solvency II more generally as a type of market-consistent framework so you can get a sense of how earnings might emerge under a market-consistent income statement approach.*

- Approximated with 2 components:
  1. Best estimate liability = PV best estimate liability cash flows
     - Discount rate = risk-free rate + 50 bps "matching adjustment" spread
  2. Risk margin based on the same CoC method as the IFRS risk adjustment

Solvency II "reserve" formula: PVFB + PV(Exp) − PV(Gross Prems) + Risk Margin

 

- Reserve Type B is the best match
- We also need the risk margin given under "other items"

Solvency II calculations:

$$\begin{aligned}
\text{ResIncr}_1 &= (-6719 + 1830) - 0 = -4889 \\
\text{PreTaxEarnings}_1 &= -2775 + (-111) - (-4889) = 2003 \\
\text{ResIncr}_2 &= (-5026 + 1668) - (-4889) = 1531 \\
\text{PreTaxEarnings}_2 &= 1757 + 161 - 1531 = 387
\end{aligned}$$

## Question 7(b)

**Source: Earnings Emergence Insurance Accounting**

**Predict how earnings will change for years 4 and 5 under each of the three accounting methodologies in part (a) using the revised best-estimate assumption.**

- FAS 60 US GAAP
  - Assumptions are locked in from issue, so there is no way to revise the reserve assumptions
  - Therefore, there will be no impact on reserve changes in years 4 and 5 and hence no impact on earnings from this change
- CALM
  - CALM liability is based on current assumptions, so if best estimate mortality is increased, the reserve will increase
  - This will cause larger reserve increases in years 4–5, which will lower earnings
- Solvency II
  - Like CALM, Solvency II uses current assumptions, so the earnings impact would be the same directionally as CALM

*The SOA model solution also mentions that the Solvency II impact would be larger because it uses a lower discount rate. All else equal, that's a true statement. However, the reserve margins are quite different between CALM and Solvency II, and technically CALM is also based on a full asset-liability projection. The CALM GPV is really calibrated to reproduce the results of the full asset-liability run. Put simply, there are a lot of moving parts and ripple effects, so I don't think we can say with certainty that Solvency II would lead to higher reserve increases than CALM (or vice versa). I don't think that statement was necessary for full credit anyway.*

 

# Question 8

## Question 8(a)

**List the three categories of motivations behind customized reinsurance.**

**Source: LPM-160: Strategic Reinsurance and Insurance**

1. Structured protection and risk transfer
    - Increases efficiency of insurance programs
    - Makes it easier to insure difficult-to-insure risks
    - Increases capacity for catastrophic risks (most difficult for smaller carriers)
2. Corporate-finance driven (financial focus)
    - Releases trapped or redundant capital and/or increases ROE
    - Optimizes capital structure to achieve a broader set of financial objectives
    - Can be substituted for traditional capital and reduce the cost of paid-in capital by reducing volatility
3. Enabling strategy and growth (emphasizes dynamic benefits of reinsurance)
    - Creates partnership between insurer and reinsurer
    - Multi-year solutions align reinsurance with the client's long-term strategic plans

## Question 8(b)

**Source: LPM-160: Strategic Reinsurance and Insurance**

**Recommend a reinsurance solution for each company's insurance objective. Justify your recommendations.**

*LPM-160 contains a number of sidebars (24 total!) with extremely specific examples of customized reinsurance solutions. Answering this question correctly required matching the details given in the problem to the details in those examples. However, even if you did not achieve the super human feat of committing those granular details to memory, I think you could have also done pretty well on these with general knowledge from the Tiller book chapters. I'm showing the SOA model solution answers below with some additional comments.*

- Company A – Catastrophic reinsurance would be a good solution. Cat reinsurance provides protection against low frequency and high severity risks, this prevents negative surprises. The capital requirements are then lowered, with a one-time price associated to transfer the risk.
    - *This answer matches the example on p. 30 of the study note, which uses the phrase "adverse development cover attaching above the acquired reserves," but I think recommend cat coverage is saying something similar.*

 

- Company B – Mod-Co or coinsurance are both good options here. Coinsurance will lower the capital requirements, which then increases the insurers solvency ratio. With new regulations that may require a higher solvency ratio, the lower required capital results in a higher ratio.
  - *This solution loosely matches the example on p. 21 of the study note, which doesn't mention coinsurance or modco by name, but those definitely make sense here.*
- Company C – 100% quota share coinsurance will provide full risk transfer. This will increase surplus, providing capital relief and improving ROE. This will stabilize earnings for inforce business.
  - *This matches the top example on p. 19*
- Company D – Modified Coinsurance, this allows capital to free up and the ceding company can still retain assets in their control to improve ROE. This covers all existing business, allowing the company to maintain both traditional life business and venture into products with lower capital requirements and higher returns.
  - *This loosely matches the bottom example on p. 19, which does not mention modco, but that's a reasonable recommendation, too.*

## Question 8(c)

**Source: Tiller Ch. 9: Risk Transfer Considerations**

**Determine whether a ceding company can recognize a reinsurance reserve credit for its statutory reserves for each of the situations below, assuming all other conditions for a reinsurance reserve credit are met. Justify your response.**

*This question was testing your knowledge of the 11 conditions listed under the Life and Health Reinsurance Agreement Model Regulation that prevent a ceding company from taking a reinsurance reserve credit.*

**(i) The ceding company is required to recapture all its business at policy year 10.**

- No credit allowed if ceding company is required to recapture or terminate all or part of the reinsurance under contract by a specific date

**(ii) The ceding company receives an experience refund, if the reinsured block is profitable.**

- Credit allowed. The model reg does not prohibit use of experience refunds to transfer profits back to the ceding company. Presence of experience refunds do not necessarily indicate lack of risk transfer.

**(iii) The ceding company receives the settlement amount every 30 days.**

- Credit allowed. The model reg does not allow credit if settlements are less frequent than quarterly.

**(iv) The ceding company pays back some of the losses, if the business is unprofitable.**

- No credit allowed if ceding company must repay reinsurer for losses under the agreement

 

# Question 9

## Question 9(a)

**Source: LPM-153: Life in-force Management**

**(i) Identify reasons policyholders might lapse.**

- Consumer-specific drivers:
  - Needs change (new stage of life)
  - Premiums lower on other products
  - Lack of interaction between insurer and customer
  - Advisors encouraging policy switching
- Market-specific drivers:
  - High unemployment, falling income
  - Spike in interest rates

**(ii) Explain ways ABC Life can improve policyholder persistency.**

- Premium holidays to help with temporary affordability
- Offer discounts to match better offers
- Offer exchanges or alternative products if needs have changed
- Offer a more gradual premium transition to the ART period to reduce shock lapses

## Question 9(b)

**Source: Experience Study Calculations, LPM-107: Experience Assumptions for Individual Life Insurance and Annuities**

**Calculate**

**(i) The mortality rates for policy years 8-10 using grouped exposure methodology.**

Using the Balducci Hypothesis, the mortality rate at age $x$ is $q_x = d_x/E_x$, where

$$E_x = \ell_x - \frac{1}{2}w_x \text{ for grouped calculations}$$

*The problem provides values in terms of policy years rather than ages and uses "x" as the policy year index. However, the calculations work the same.*

 

Calculations:

$$E_8 = 929 - 55/2 = 901.5$$
$$E_9 = 862 - 50/2 = 837$$
$$E_{10} = 797 - 40/2 = 777$$
$$q_8 = 12/901.5 = 0.0133$$
$$q_9 = 15/837 = 0.0179$$
$$q_{10} = 10/777 = 0.0129$$

**(ii) The lapse rates for policy years 8-10 using grouped exposure methodology.**

Same formula as part (i), but reverse the role of deaths and lapses:

$$E_x^w = \ell_x - \frac{1}{2}d_x$$
$$q_x^w = w_x / E_x^w$$

Calculations:

$$E_8^w = 929 - 12/2 = 923$$
$$E_9^w = 862 - 15/2 = 854.5$$
$$E_{10}^w = 797 - 10/2 = 792$$
$$q_8^w = 55/923 = 0.0596$$
$$q_9^w = 50/854.5 = 0.0585$$
$$q_{10}^w = (600 + 40)/792 = 0.8081$$

*The SOA model solution commentary notes that a common mistake was calculating the exposure incorrectly for this part, and the SOA model solution seems to have made this mistake as well. While the SOA model solution does not show its lapse exposure calculation, the lapse rates shown are based on the mortality exposure in part (i). For example, it shows 6.10% for year 8, which is* 55/901.5*. This is not correct. If you are studying lapse rates, you simply assume non-lapse terminations like death occur mid-year on average just like you assume lapses occur mid-year in a mortality study. In a lapse study, lapses get a full year of exposure just like deaths get a full year of exposure in a mortality study. This is covered in both source readings noted above as well as our course materials.*

**(iii) The actual to expected ratios for mortality in policy years 8-10.**

Actual mortality rates were calculated in part (i). Expected mortality is given in the problem to be 0.0130 for years 8–10.

$$\text{Year 8 A/E} = 0.0133/0.0130 = 102\%$$
$$\text{Year 9 A/E} = 0.0179/0.0130 = 138\%$$
$$\text{Year 10 A/E} = 0.0129/0.0130 = 99\%$$

**(iv) The actual to expected ratios for lapses in policy years 8-10.**

 

Actual lapse rates were calculated in part (ii). Expected lapses are given by year in the problem.

$$\text{Year 8 A/E} = 0.0596/0.05 = 119\%$$
$$\text{Year 9 A/E} = 0.0585/0.06 = 98\%$$
$$\text{Year 10 A/E} = 0.8081/0.30 = 269\%$$

*These A/E ratios differ from those shown in the SOA model solution due to the error noted in part (ii).*

## Question 9(c)

**Sources: Evolving Strategies to Improve Inforce Post-Level Term Profitability, Post Level Term Experience Results**

**(i) Evaluate the appropriateness of ABC's post-level term pricing assumptions.**

- Inappropriate because ABC's lapse rate and mortality assumed is too low
- Post-level shock lapses can be 70% in year 11, so ABC's lapse assumption looks too low at 50%
- Post-level mortality can be 300% of the level period, while ABC is assuming only 123% of level period mortality in year 11

**(ii) Propose two ways to improve ABC's post-level term profitability. Justify your answers.**

*Any 2 of these 3 would have gotten full credit*

1. The Simplified Re-Underwriting Approach
   - Optional questionnaire determines PLT rate class (e.g. SM/NS)
   - If decline survey: default to original YRT ceiling
   - Advantages:
     - Greater sense of fairness to policyholders and regulators
     - Lowers selective lapsation
     - Insured gets lower rate and insurer has more confidence in rates
2. The Graded Approach
   - PLT premiums increase at a smaller increment intially (e.g. 5 years) before reaching YRT scale
   - Advantages:
     - Makes initial PLT rates more attractive (lower lapses)
     - Insurer can still increase to YRT ceiling
     - Avoids underwriting
     - Low administrative cost

 

  - Early experience suggests it works as intended

3. The Class Continuation Approach
   - Maintain level term class structure into PLT period
   - Develop separate YRT scales by class
   - All YRT scales converge to an ultimate scale (original YRT scale)
   - Advantages:
     - May be "the fairest approach" since it uses original underwriting
     - YRT scale encourages/discourages lapses based on class
     - Permanent insurance experience could be used for classes

 

# Question 10

## Question 10(a)

**Source: MIP Ch. 5, Sections 2–4: Asset Allocation**

**(i) Recommend a portfolio for XYZ based on risk-adjusted expected returns.**

$U_m$ = risk-adjusted expected return for asset mix $m$

$$\begin{aligned} U_m &= E(R_m) - 0.005 R_A \sigma_m^2 \\ E(R_m) &= \text{expected return of asset mix} \\ R_A &= \text{value of risk aversion} = 4 \\ \sigma_m &= \text{standard deviation of asset mix} \end{aligned}$$

As risk aversion $R_A$ and/or $\sigma$ increases, utility falls due to the higher "risk penalty"

- I.e. the more risk averse the investor, the higher the expected return must be for a given level of risk ($\sigma$) to achieve a desired risk-adjusted expected return

Therefore, all else equal, an investor will prefer a portfolio with the highest risk-adjusted return

Calculations:

$$\begin{aligned} U_A &= 9.25 - 0.005(4)(19^2) = 2.03 \\ U_B &= 8.50 - 0.005(4)(15^2) = 4.00 \\ U_C &= 6.00 - 0.005(4)(10^2) = 4.00 \end{aligned}$$

Either portfolio B or C would be preferred since they have the highest risk-adjusted returns

*The SOA model solution commentary says that for part (i) some candidates incorrectly used a risk threshold of 0.5% instead of the 5% required by XYZ. It's likely they meant to say this about part (ii) instead of part (i) since the company's 5% risk threshold is used in the safety-first criterion. It does not impact the risk-adjusted expected return calculation in part (i) at all. The 0.005 used in the $U_m$ formula always the same. It's just a "hard coded" factor in the formula.*

*The calculations shown in the SOA model solution for part (i) are correct. As we explain in the course, you can use a 0.5 factor if you format the return and $\sigma$ as a decimal. For example:*

$$U_A = 0.0925 - 0.5(4)(0.19^2) = 0.0203 = 2.03\%$$

**(ii) Recommend a portfolio for XYZ based on Roy's safety-first criterion.**

Roy's safety-first ratio ("SFRatio") – the oldest shortfall risk criterion

$$\text{SFRatio} = \frac{E(R_P) - R_L}{\sigma_P}$$

where $R_L$ = minimum threshold return that the investor insists on meeting

- Given to be 5% in the problem

The "safety-first optimal portfolio" maximizes the SFRatio

- I.e. choose the portfolio with the highest SFRatio

Calculations:

$$\text{SFRatio}_A = \frac{9.25 - 5.00}{19} = 22.4\%$$
$$\text{SFRatio}_B = \frac{8.50 - 5.00}{15} = 23.3\%$$
$$\text{SFRatio}_C = \frac{6.00 - 5.00}{10} = 10.0\%$$

Portfolio B would be the best recommendation based on Roy's safety-first criterion

## Question 10(b)

**Source: MIP Ch. 5, Sections 2–4: Asset Allocation, MIP Ch. 8, Section 3: Real Estate**

**(i) List two advantages and two disadvantages of direct equity real estate investing.**

*You only needed 2 of each for full credit*

Advantages:

1. Tax subsidies – deductible mortgage interest, property taxes, etc.
2. Leverage – mortgages allow real estate borrowers to use more financial leverage than with other securities investing
3. More direct control over property compared to the typical stock investment
4. Geographic diversification – low correlations across different regions
5. Relatively low return volatility compared to stocks

Disadvantages:

1. Can result in large concentrations (not easy to divide into smaller pieces)
2. High information cost due to uniqueness of each property
3. High commissions paid to brokers
4. High operating and maintenance costs (administration, leasing, repairs, management expertise)
5. Risk of neighborhood deterioration
6. Political risk – tax deductions could go away

 

**(ii) Recommend whether real estate investments should be added to the portfolio selected using Roy's safety-first criterion. Show all work.**

According to MIP Ch. 5, a new asset class $N$ should be added to portfolio $P$ if:

$$\text{SharpeRatio}_N > \text{SharpeRatio}_P \times \text{Corr}(R_N, R_P)$$

Since the Sharpe ratio is simply Roy's safety-first ratio using the risk-free rate instead of the threshold return, we can generalize this to:

$$\text{SFRatio}_N > \text{SFRatio}_P \times \text{Corr}(R_N, R_P)$$

$\text{SFRatio}_P = 0.233$ from our optimal portfolio in part (ii) and the correlation is given to be 0.70 in the problem

Calculations:

$$\begin{aligned}\text{SFRatio}_{\text{RE}} &= \frac{8.20 - 5.00}{7.5} = 0.427 \\ &> 0.233(0.70) = 0.163\end{aligned}$$

Therefore RE should be added to the portfolio

*The SOA model solution gets the calculation right but mixes up the Sharpe ratio formula with Roy's safety-first ratio. The Sharpe ratio is a special case of Roy where the risk threshold = risk-free rate. We are not given the risk-free rate in the problem, so we can't use the Sharpe ratio. The problem itself tells us to use Roy anyway.*

## Question 10(c)

**Source: MIP Ch. 6, Sections 1–5: Fixed Income Portfolio Management**

**Evaluate whether the following portfolio returns meet XYZ's target tracking risk of 1%. Justify your response.**

Tracking risk = standard deviation of the portfolio's active return over a series of time periods ($t = 1, 2, \ldots, T$)

$$\text{TR} = \sqrt{\frac{1}{T-1}\sum_{t=1}^{T}(\text{AR}_t - \overline{\text{AR}})^2}$$

where

- $T$ = total number of time periods (or final time period)
- $\text{AR}_t$ = active return for period $t$ = $\text{PortfolioReturn}_t - \text{BenchmarkReturn}_t$
- $\overline{\text{AR}}$ = average AR for all time periods

Calculations:

$$
\begin{aligned}
AR_1 &= 9.50 - 9.25 = 0.25 \\
AR_2 &= 6.45 - 6.10 = 0.35 \\
AR_3 &= 2.85 - 3.30 = -0.45 \\
\overline{AR} &= \frac{0.25 + 0.35 - 0.45}{3} = 0.05 \\
TR &= \sqrt{\frac{1}{3-1}\left[(0.25 - 0.05)^2 + (0.35 - 0.05)^2 + (-0.45 - 0.05)^2\right]} \\
&= 0.4\%
\end{aligned}
$$

Since the tracking risk is less than 1%, it meets the company's objective

 

# Question 11

*This was a fairly straightforward verbal question but required committing some very fine details to memory. The SOA model solution is generally very good, so my response below is very similar except where noted.*

## Question 11(a)

**Source: LPM-165 Ch. 1: Term Insurance, LPM-107: Experience Assumptions for Individual Life Insurance and Annuities**

**Assess how the following should be factored into adjusting the existing experience in order to derive the new pricing lapse assumption:**

**(i) KLA Life has moved from a captive agent distribution to a brokerage-based model with more sophisticated, older clients and larger coverage amounts.**

- Overall, brokerage-based business will have higher lapse rates compared to captive agents due to their greater ability to shop policies
- Higher lapse rates at renewals are expected from more sophisticated clients.
- Sophisticated term buyers often need large amounts of insurance for brief periods and have the potential to lapse early compared with normal purchasers of term insurance.

**(ii) To encourage new sales, the new RT10 product will have lower initial premiums and higher renewal premiums.**

- Lower initial premium rates will encourage lower early duration lapses as it is less likely that insureds will be able to find better rates elsewhere
- Lower initial premium rates and higher renewal premiums will increase the renewal premium jump compared to what is embedded in KLA's lapse experience, therefore higher lapses at renewal should be expected

**(iii) KLA Life now has stricter underwriting rules with fewer substandard issues than in the past and the addition of a super-preferred class.**

- Super-preferred class will have higher shock/renewal lapses as they have a better chance of qualifying for a better deal at renewal.
- Super-preferred class will have lower initial premiums than is embedded in KLA's lapse experience and lower early duration lapses should be expected.
- Slightly substandard lives are more likely to lapse and seek a better deal.
- Fewer substandard issues going forward will reduce the expectation of deteriorating lives continuing coverage post renewal, therefore lapse experience at renewal should increase.

 

## Question 11(b)

**Source: Report on the Conversion Experience Study for the Level Premium Term Plans, Post Level Term Experience Results**

**Explain how each of the following might affect the year 11 lapse assumption:**

*This was a very tricky question because the problem is asking specifically about the year 11 lapse assumption. Year 11 is the first year in the post-level period. The most pronounced shock lapse impact happens at EOY 10. I'm not sure if the question writer was thinking "year 10" when they wrote year 11, but either way it makes answering these sub-questions very difficult because the effects after year 10 are very subtle and nuanced in the graphics that appear in this reading. Don't feel bad if you struggled on this part. The first time I answered this one on my own, I was definitely thinking about the initial shock lapse, not the first year after the initial shock lapse.*

**(i) A shift in the gender mix of the business from (50% male and 50% female) to (60% male and 40% female).**

*The SOA model solution notes that either of these 2 answers would have been acceptable here:*

1. Males tend to have a higher year 11 lapse assumption than females, therefore a shift in the proportion of males from 50% to 60% will have the effect of increasing year 11 lapses.

2. Sex on its own is not a determinant of higher/lower lapses, but that lapses are more closely related to premium jump and age, were given full marks

*The graphic shown in the reading on p. 27 shows pretty clearly that males have a higher initial shock lapse in year 10 compared to females. The year 11 bars are nearly equal. Males seem to have very slightly higher year 11 lapses than females. The good news is that if you simply remembered that the year 10 shock lapse was higher for males, you probably would have "accidentally" got this one right. Yay! It's likely they accepted answer No. 2 above because the year 11 bars are nearly equal.*

**(ii) A shortening of the grace period from 3 months to 2 months.**

*The SOA model solution says they accepted 2 possible answers. This one was probably the most straightforward to get right if you understood the grace period adjustment concept:*

- If KLA Life considers the date of lapse to include the grace period, then a shortening of the grace period from 3 months to 2 months will not alter the number of lapses in year 11 but will shift the shock lapse from the end of month 3 to the end of month 2.

- If KLA Life considers the date of lapse to be the end of the paid premium period, then shortening the grace period from 3 months to 2 months will not have an impact of year 11 lapses as all non-payment of premium at the start of year 11 will be considered year 10 lapses.

**(iii) A shift to monthly premium mode from annual premium mode.**

Monthly mode lapses are slightly higher than annual mode lapses in year 11. Therefore, year 11 lapses should increase as a result of this change.

 

*This was probably the most difficult of all to get right. For year 10, there is a clear pattern on p. 30 of the reading that shows that shock lapse rates tend to fall as premium payment frequency increases. Annual mode has the highest shock lapses; monthly has the lowest. So if you were thinking about the initial shock lapse, you would have said shock lapses should decrease as a result of this change.*

*However, the pattern specific to year 11 is different. Monthly mode lapses are slightly higher than annual mode lapses in year 11. I think it would have been very difficult to memorize year-specific patterns in the post-level period for premium mode, especially because the patterns after year 10 don't appear to be very pronounced or interesting compared to the impact in year 10.*

## Question 11(c)

**Source: LPM-107: Experience Assumptions for Individual Life Insurance and Annuities, LPM-151: Understanding Post-Level Experience**

**(i) Explain how lapse assumptions can impact the mortality assumption during the post level term period.**

If excess healthy lives lapse, it can create anti-selection

Healthy lives are more likely to lapse than unhealthy lives, especially when faced with high renewal premiums

Healthy lives are more likely to lapse than unhealthy lives, especially when faced with high renewal premiums

The mortality of the remaining group begins to increase by the "conservation of deaths" principle:

$$q_{[x]+t} = w^{AS} q_{[x+r]+t-r} + (1 - w^{AS}) q^{AS}_{[x]+t}$$

This says that total mortality at a given duration, $q_{[x]+t}$, is weighted average of the mortality of 2 groups:

1. Mortality of the "select" lives that lapse in duration $r$ to buy a new policy: $q_{[x+r]+t-r}$
2. Mortality of the lives that stay with the original policy: $q^{AS}_{[x]+t}$

The "weight" is $w^{AS}$, which is the portion of policies that lapse to buy a new policy in duration $r$, we would expect their mortality to be less than group as a whole—because they qualify for select rates, which are lower

If healthier lives are leaving, the remaining group's mortality must increase to maintain the equality

If healthier lives are leaving, the remaining group's mortality must increase

Therefore, the more healthy lives that lapse, the higher the remaining inforce's mortality will be

**(ii) Determine the mortality rate for persisting policyholders. Show all work.**

*I think the most difficult aspect of this problem was reading the small table given and making sure you identified each value given. If you were able to do that successfully, it was simply a matter of plugging*

*values into the standard formula given in LPM-107 that we also illustrate in our video lesson.*

*The formula shown in part (i) assumes $r$ is the duration at which the shock lapses occur. This is how the LPM-107 study note presents it. However, $r$ does not appear in the notation in the problem. Implicitly, the problem is assuming the shock lapse occurs at duration $r = t$. That lets us simplify the formula to:*

$$\begin{aligned} q_{[x]+t} &= w^{AS} q_{[x+r]+t-r} + (1 - w^{AS}) q^{AS}_{[x]+t} \\ &= w^{AS} q_{[x+t]} + (1 - w^{AS}) q^{AS}_{[x]+t} \end{aligned}$$

We are given:

- 40% = Total lapse rate for the original group of policies originally issued at age $[x]$
  - *This is essentially the shock lapse observed*
- 4% = lapse rate for select lives issued a new policy at age $[x + t]$
  - *This is like a base level of lapses*
- 90% = percent of extra lapses at duration $t$ that are select

Therefore:

$$\begin{aligned} w^{AS} &= 0.90(40\% - 4\%) = 32.4\% \\ 0.003 &= 0.324(0.001) + (1 - 0.324) q^{AS}_{[x]+t} \\ q^{AS}_{[x]+t} &= 0.00396 \end{aligned}$$

*The SOA model solution says they also accepted an alternative approach, which resembles the method in LPM-151:*

$$\begin{aligned} q^{\text{norm}} &= q^{\text{sel}} \times w^{\text{eff}} + q^{\text{norm}} \times (w^{\text{non-eff}} + w^{\text{base}}) + q^{\text{pers}} \times (1 - w) \\ q^{\text{sel}} &= \text{select issue age mortality} \\ q^{\text{norm}} &= \text{normal, point-in-scale mortality} \\ q^{\text{pers}} &= \text{mortality of persisters remaining in force} \\ w &= \text{total lapse rate at the time of the shock lapse} \\ w^{\text{base}} &= \text{normal base lapse rate in absence of shock lapse} \\ w^{\text{shock}} &= w - w^{\text{base}} \\ w^{\text{eff}} &= \text{“effective reverters” = Effectiveness Rate} \times w^{\text{shock}} \\ w^{\text{non-eff}} &= \text{non-effective reverters} = w^{\text{shock}} - w^{\text{eff}} \end{aligned}$$

 

Our inputs are:

$$\begin{aligned} q^{\text{sel}} &= 0.001 \text{ (given)} \\ q^{\text{norm}} &= 0.003 \text{ (given)} \\ w &= 0.40 \text{ (given)} \\ w^{\text{base}} &= 0.04 \text{ (given)} \\ w^{\text{shock}} &= 0.40 - 0.04 = 0.36 \\ w^{\text{eff}} &= 0.90(0.36) = 0.324 \\ w^{\text{non-eff}} &= 0.36 - 0.324 = 0.036 \end{aligned}$$

This lets us solve for $q^{\text{pers}}$:

$$\begin{aligned} 0.003 &= 0.001 \times 0.324 + 0.003 \times (0.036 + 0.04) + q^{\text{pers}} \times (1 - 0.40) \\ q^{\text{pers}} &= 0.00408 \end{aligned}$$

*This mortality rate is higher because it assumes non-selective and normal lapses have the same mortality as the overall group. This concentrates the higher residual mortality in a smaller portion of the group (only 60%). With the LPM-107 approach, 67.6% of the group absorbs the higher residual rate (so it's spread over a greater portion of the group). These 2 methods give fairly different answers, but since both are on syllabus, both are acceptable approaches.*

 