ILA LAM Model Solutions
Spring 2025

1. **Learning Objectives:**

2. The candidate will understand and be able to assess issues and concerns common to actuarial models and their development and management.

Learning Outcomes:

(2b) Describe and evaluate the following actuarial modeling best practices:

- Model risk management
- Model validation techniques and methods
- Best practices for assumptions governance
- Application of Actuarial Standards of Practices
- Reliance on expert judgment in actuarial modelling

(2c) Describe, evaluate, and compare implications on modeling organizations, processes, and best practices because of:

- Use of open code and closed code models
- Centralized vs. De-centralized actuarial modeling function

Sources:

LAM-141-19: Case Study: LTC Insurance First Principles Modeling

LAM-142-19: Case Study: LTC Insurance First Principles Modeling: Mortality Assumptions

LAM-143-19: Case Study: LTC Insurance First Principles Modeling: Lapse Assumptions

Commentary on Question:

Commentary listed underneath question component.

Solution:

(a) Critique the following statements.

A. *A model is considered a first principles model only if it breaks down all major assumptions into component pieces.*

B. *When moving from claim cost to first principles, the main challenge is developing the active and disabled mortality.*

1. Continued

Commentary on Question:
This part was generally answered well. Candidates were required to critique the statement and provide valid supporting points to receive full credits.

Statement A
This is incorrect. This is an extreme case of first principles model.

A model can also be considered as first principle model if it is taking the component of claim costs, namely incidence and severity, and bringing them directly into the projection models.
The middle ground definition of first principle model incorporates active and disabled mortality assumptions and using morbidity assumption components based on healthy lives and first situs of care -- due to complexity considerations.

Statement B
This is incorrect or partially correct.
This is one of the key challenges but not the only one.

For example: the use of healthy or total lives for the claim cost model can mean very different things when moving to a first principals model
Morbidity can be another key challenge
Another example: using first situs of care, with all future transfers included in the first situs assumption, will have different considerations than building in transfers within the first principles model

(b) Critique the following approaches used for developing first principles mortality and lapse assumptions for an LTC model.

A. *Developing healthy life and disabled life mortality assumptions independently is the best approach.*

B. *A disadvantage of developing healthy life mortality assumptions and backing into implied disabled life mortality assumptions is that it may not produce results that have a reasonable relationship to the total life mortality assumption.*

C. *An advantage of developing disabled life mortality assumptions and backing into implied healthy life mortality assumptions is that the approach captures each attribute that impacts a policyholder's transition from healthy to disabled status, i.e., incident, utilization, and continuation characteristics. Therefore, if this approach is used, these captured attributes should be preserved.*

1. Continued

D. Given companies generally have a much higher volume of active life data compared to disabled life data, the inability of accurately classifying a termination as a death is limited to a disabled life mortality study.

Commentary on Question:
This part was answered fairly. Candidates were required to critique the statement and provide valid supporting points to receive full marks. A few candidates provided valid explanations without critiquing the statement and therefore received partial credits.

Statement A
This is incorrect.
Not necessarily the best approach. This approach is most consistent with objectives of a first principles model
Companies may have limited historical data for experience studies on this basis

If credibility is limited, should consider if separate assumptions for healthy lives and disabled lives have reasonable relationship to mortality developed on total life basis
If not reasonable, then consider another approach

Statement B
This is incorrect. This is actually one of the Advantages of this approach.

By design and construction, this method will necessarily produce results that have reasonable relationship to total Life assumption.
The disadvantage with this approach sits with the "backed-in" portion as it might produce unexpected or unreasonable patterns.

Statement C
This is incorrect or partially correct.
While it is true that this approach captures all of those attributes, we do NOT want to preserve all attributes due to model complexity and runtime considerations.

May be more efficient to aggregate assumption across some less crucial characteristics while ensuring the important drivers are still being captured.
For companies value simplicity over sophistication, the complexity came with this approach is viewed as a disadvantage.

Statement D
This is incorrect.
This is a problem for active life mortality as well.

1. Continued

For active lives, it is challenging to correctly categorizes termination between active death and lapse.
May want to consider using industry table.

(c) Your company develops healthy life lapse assumptions directly from experience using the GAM-94 mortality table adjusted in aggregate to fit historic experience – i.e., an aggregate mortality scalar has been applied such that total expected deaths are consistent with total actual deaths.

Describe one advantage and one disadvantage of this approach.

Commentary on Question:
This part was not answered well. A few candidates confused the advantages and disadvantages of developing lapse rates with mortality rates and received no credits.

Advantage: this approach is most consistent with objectives of first principles model
Advantage: this approach is healthy life lapse rate can be directly observed

Disadvantage: possible lack of credible experience or miscoding deaths, which can result in incorrect lapses
Disadvantage: added complexity where exposure needs to be split into period of time an individual is healthy vs disabled

(d) You are given a set of experience study data in the Excel spreadsheet.

(i) Calculate the following for each policy year:

- Number of implied lapses
- Mortality rate
- Lapse rate

(ii) Identify issue(s) with the calculated lapse rate.

(iii) Recommend a solution for the identified issue(s).

Commentary on Question:
This part was generally answered well. Most candidates were able to calculate the rates and provide valid issue and solutions to receive full credits.

1. Continued

(i)
Implied Lapse = Total Terminations - Expected Deaths - Benefit Exhaustion
Mortality Rate = Expected Deaths / Exposure
Lapse Rate = Implied Lapse / Exposure

Implied Lapse	Mortality Rate	Lapse Rate
304.5	1.2%	6.1%
271.5	1.3%	5.8%
234.0	1.4%	5.4%
177.5	1.4%	4.3%
153.0	1.5%	3.9%
117.0	1.6%	3.1%
97.5	1.7%	2.8%
76.0	1.8%	2.3%
43.0	2.2%	1.3%
34.5	2.3%	1.1%
36.5	2.5%	1.3%
35.0	2.6%	1.3%
36.0	2.7%	1.4%
38.0	2.9%	1.5%
138.0	3.1%	2.0%

(ii)
During early durations, lapse rates steadily decline
However, implied lapse rates reach a minimum around duration 10 and then begin to increase, however lapse rates should not be increasing

(iii)
Adjust mortality using durational factors and attained age adjustments or consider more recent industry mortality table

2. Learning Objectives:

1. The candidate will understand, evaluate and use stochastic, generalized linear, multi-state, projection and transition matrix models. The candidate will demonstrate an understanding of their underlying methodologies, strengths, limitations, and applications.

2. The candidate will understand and be able to assess issues and concerns common to actuarial models and their development and management.

Sources:
Reviewing, Validating and Auditing Actuarial Models, Valuation Actuary Symposium, Aug 2015

The Importance of Centralization of Actuarial Modeling Functions, Part 1: Focus on Modularization and Reuse, The Modeling Platform, Nov 2019

Handbook of Fixed Income Securities, Fabozzi, Frank J., 9th Edition, 2021 - Ch. 49: Introduction to Multifactor Risk Models in Fixed Income and Their Applications

Commentary on Question:
Commentary listed underneath question component.

Solution:
(a) List advantages and disadvantages of using an existing actuarial model to develop a model for a new product.

Commentary on Question:
Candidates receive full credit when answering with at least 2 appropriate pros and 2 cons, from the following list.

Pros:
- Easier, most cost-efficient way to initiate model development. Starting from scratch is hardly ever a viable option, both other options (1) copying existing code, and (2) building reusable libraries seem to be easier paths forward
- Centralization of libraries makes code easily extensible to avoid redundant logic
- Utilize existing expertise of the starting model

Cons:
- Copying appears to be the cheaper option because of the divide-and-conquer fallacy – idea that model can be copied and workload can happen in parallel, however copying increases the workload in the long run
- Synchronization of parallel models is challenging due to continual coordination and reconciliation, work is often duplicated
- Any problems or issues with the existing model will carry over to the new model

2. Continued

(b) You are given a set of model output in the Excel spreadsheet.

(i) Perform static validation based on the information provided in the table. Show all work.

(ii) Describe the steps of analyzing static validation results.

(iii) Identify which product and/or metric needs to be investigated based on the static validation results. Justify your answer.

(iv) Propose an investigation approach to identify any potential issues.

Commentary on Question:
Most Candidates performed well on parts (i), (iii) and (iv) but struggled with part (ii).
Part (i), key here is for candidates to compare model to actual output and visualize via a % comparison, to show which metrics are not within threshold.
Part (ii), most credit was awarded when candidates are able to list out the 3 key steps below. Additional credit rewarded when additional detail/examples are provided. Many candidates struggled to provide sufficient detail on how to analyze model output.
Part (iii), candidates that identified Product ξ needing to have policy count drop reviewed, was also rewarded credit.
Part (iv), candidates receive full credits when describing and explaining one of the three approaches. Partial credit was awarded when listing an approach without explanation.

(i) Static Validation = Model / Actual

	Product ξ		
	Extract/Actual (input data)	Model Output	Static Validation
Policy Count	2,598	2,595	99.9%
Face Amount	534,687,985	533,087,956	99.7%
Cash Value	213,875,194	209,625,132	98.0%
Statuary Reserve	254,749,627	252,439,500	99.1%

	Product Ж		
	Extract/Actual (input data)	Model Output	Static Validation
Policy Count	2,598	2,391	92.0%
Face Amount	900,435,789	823,898,747	91.5%
Cash Value	630,305,052	586,183,699	93.0%
Statuary Reserve	700,756,835	637,688,720	91.0%

2. Continued

(ii)

1. Check thresholds
   - Establish reasonable and appropriate thresholds
   - Identify outliers to investigate
2. Validate actuals
   - Ensure that actuals are consistent with reported values, and source data is appropriate (e.g. Statutory Annual Statement)
   - Review the reliability and quality of source data
   - Confirm no errors or omissions in input data
3. Analyze model outputs
   - Validate feed from model output is correct
   - Ensure all new policies and plan codes are captured
   - Review known data adjustments or approximations
   - Review model documentation related to data limitations
   - Review model error log
   - Ensure all plan codes have reasonable balances (e.g. reserve balance/count)
   - Review policy/cell level validations

(iii) The entire Product Ж would require additional investigation as the static validation (Model / Actual or Model / Extract) is off by more than the threshold.

The Cash Value for Product ξ is off by 2.0% so requires further investigation.

(iv)

1. Perform static validation on more granular level, e.g., plan code, to identify if certain plan codes have worse static validation than others. Then, investigate the plan codes that has worse validation.
2. Validate the feed from model output is correct, so that the static validation is based on the correct model output.
3. Review model documentation to check if there is known data limitation, e.g., some policies were not modeled due to data issue.

(c) Calculate the idiosyncratic tracking error volatility for each portfolio. Show all work.

Commentary on Question:
Most Candidates did well on this question. Partial credit was given when the formula is correct, but the calculation is done incorrectly.

2. Continued

Total TEV = [(Systemic TEV)^2 + (Idiosyncratic TEV)^2]^(1/2)

Idiosyncratic TEV = SQRT [(Total TEV) ^ 2 - (Systemic TEV)^2]

Idiosyncratic TEV (A) = 9.4

Idiosyncratic TEV (B) = 17.3

(d) Recommend which portfolio your company should invest in. Justify your answer.

Commentary on Question:
Full credit was awarded for listing and elaborating on all four justifications. Most candidates were awarded credit for explaining Portfolio B having higher expected return and a closer duration-match. Partial credit was awarded to candidates that recommended Portfolio A with justification of it having a lower risk profile.

1. Both portfolios are within the risk budget of 25 bps/month. Portfolio A has a lower TEV of 13.6 compared to 22.3 for Portfolio B.
2. Portfolio A has a longer duration than liabilities, whereas Portfolio B's duration matches closer with liability duration.
3. Portfolio B has more securities and is more diversified than portfolio A.
4. While both portfolios' expected return (OAS) are within the target spread range, Portfolio B has a higher return.

Overall, Portfolio B is recommended, because it has a higher expected return, closer duration match, more securities, but is still within the risk tolerance request.

3. Learning Objectives:

3. The candidate will understand the principles of Asset-liability Management ("ALM"), and be able to describe and evaluate various techniques for addressing the mitigation of risk.

4. The candidate will understand the basic design and function of Economic Scenario Generators and Equity Linked Insurance Models.

Learning Outcomes:

(3a) With respect to Asset-Liability Models:

- Describe and apply the fundamental elements of the theory and practice of ALM in an insurance company, including assessing the dangers of mismatched assets and liabilities.
- Describe and demonstrate how ALM can be used to identify and manage product and asset risks, including:
  - Major product risks for which ALM can be a useful tool for their management.
  - Using ALM as a means to manage interest rate risk, equity risk, and risks from optionality.
- Describe how common insurance contracts and variations generate embedded options in an insurer's balance sheet, and assess basic strategies for managing exposures created by such embedded options.
- Describe and apply the basic concepts of cash flow matching, immunization, duration/convexity matching, segmentation.
- Describe and apply Key Rate Durations (KRD) and their use in evaluating interest rate sensitivities of portfolios, including understanding the derivation of KDRs, the profiles of KDRs for selected major asset types, and assessing KRDs in a portfolio context.
- Describe and evaluate the Goldman Sachs' ALM/Strategic Asset Allocation approach for integrating ALM into an enterprise's risk and financial management framework.
- Describe and evaluate ALM modeling considerations in the context of modeling risk aggregation, dependency, correlation of risk drivers and diversification.

(3b) With respect to asset adequacy analysis and cash flow testing, describe and evaluate actuarial practice with respect to:

- Modeling and selecting assets and related assumptions (incl. modeling assets with contingent cash flow risks).
- Handling liability cash flow contingencies and risks.
- Setting up projection model parameters and assumptions.
- Describe how Interest Rate Forwards and Futures and Swaps can be used in ALM, and apply the mathematics in given situations.

3. Continued

(4b) With respect to Equity-Linked models:

- Describe and apply methods for modeling long-term stock returns and certain guarantee liabilities (GMMB, GMDB, GMAB).
- Describe and evaluate the Actuarial and Hedging risk metrics for GMAB and GMDB models.
- Describe and apply methods for modeling Guaranteed annuity options and Guaranteed Minimum Income Benefits (GMIB), and EIA guarantees.

Sources:
LAM-140-19: Asset Adequacy Analysis Practice Note, 2017

LAM-146-19: Ch. 16 of ALM Management of Financial Institutions, Tilman, 2003

LAM-147-19: Ch 2 of ALM Management of Financial Institutions, Tilman, 2003

Commentary on Question:
Commentary listed underneath question component.

Solution:
(a) Critique the following statements related to asset adequacy and capital planning.

A. *For products that are not exposed to interest rate risk, insurers are not providing an embedded option to the policyholders.*

B. *We have detailed data of good quality on our historical investment returns. We can set the credited interest rate equal to the average historical investment return minus a margin.*

C. *A gross premiums valuation (GPV) test is appropriate for a level-premium term life product to assess its asset adequacy and duration mismatch in the portfolio.*

D. *The risk capital needed by an insurance company depends on the riskiness of its asset / liability position. Therefore, the goal of asset & liability management is to remove asset / liability risk as much as possible.*

Commentary on Question:
Candidates generally did well on this question by critiquing the statements and providing rationales. For Statement C, some candidates failed to mention that GPV cannot be used to detect duration mismatches.

3. Continued

Statement A:
This statement is false. Protection-type insurance products can also include features that are viewed as embedded options. For instance, the guaranteed premiums feature on LTC policies is a call on the value of future benefit payments.

Statement B:
Historical data isn't always the accurate prediction of the future. There have been cases in the past where companies reached the wrong expectation of the asset yields by looking at the prior interest rates which led to erroneous assumption of future yields.

Statement C:
This statement is partially true. While a GPV may be appropriate in these circumstances for AAT, it cannot detect duration mismatches. GPV does not require the projection of asset cash flows and asset's sensitivity to interest rate is implicitly modeled by varying the liability discount rate.

Statement D:
This statement is partially true. It is true that the risk capital needed by an insurance company depends on the riskiness of its asset / liability position, but a complete elimination of asset / liability risk may amount to a complete elimination of the earnings of the company. As such, insurance company should aim for a partial elimination of the asset / liability risk to help mitigate the exposure & manage the cost of risk capital.

(b) Calculate the present value of the guaranteed minimum benefits for a single policy at issue. Show all work.

Commentary on Question:
Most candidates did well on this question. Some candidates did not convert the management fee to monthly in the AV rollforward and had partial marks deducted.

- M&E fees = 1.5% / 12 * AV at Period Start
- AV at Period End = (AV at Period Start – M&E fees) * Equity Index Change
- GMDB for each period = Max ($110,000 – AV at Period End) * Survivorship to Period Start * Probability of death within period
- GMMB at End of Month 12 = Max ($110,000 – AV at End of Month 12) * Survivorship to End of Month 12

3. Continued

Period (Month)	Simulated Equity Index	AV BOP	M&E Fee	AV EOP	tpx	GMDB	GMMB
0	100	100,000.0		100,000.0	1.0000		
1	92	100,000.0	125.0	91,885.0	0.9985	27.2	
2	96	91,885.0	114.9	95,760.2	0.9970	21.3	
3	102	95,760.2	119.7	101,618.0	0.9955	12.5	
4	128	101,618.0	127.0	127,361.2	0.9940	-	
5	114	127,361.2	159.2	113,289.3	0.9925	-	
6	102	113,289.3	141.6	101,237.4	0.9910	13.0	
7	93	101,237.4	126.5	92,189.3	0.9895	26.5	
8	84	92,189.3	115.2	83,163.7	0.9881	39.8	
9	95	83,163.7	104.0	93,936.6	0.9866	23.8	
10	105	93,936.6	117.4	103,694.9	0.9851	9.3	
11	105	103,694.9	129.6	103,565.2	0.9836	9.5	
12	110	103,565.2	129.5	108,361.3	0.9821	2.4	1,609.4

(c) Critique the use of each scenario in the context of AAT.

(i) 50% reduction in equity performance.

(ii) 3% mortality increase for all projection periods after a recent increase in mortality due to a pandemic.

(iii) A standalone shock of 2% reduction in interest rate, while current interest is 3%.

Commentary on Question:
Most candidates were able to critique the scenario use. However, few of them provided reasonable rationale on how the shocked scenario would have an impact on the product.

3. Continued

(i) This test is appropriate. Reduction equity market return will reduce the return credited on policyholder fund value, and may in turn increase the benefit payment to be made by insurer. It is possible for the tested condition to occur during the testing period so it can be considered moderately adverse. (Alternatively, candidate can suggest that the 50% reduction is too great to be considered a moderate)

(ii) This test is appropriate but is not moderately adverse. Increase in mortality will reduce the benefit payment made by the insurer and also reduce the expense / fee income to the company, so is relevant for policy cash flow risk. However, a 3% increase seems too extreme compared to the current assumption of 0.15% / month, so may not be considered as moderately adverse.

(iii) This test is not appropriate. Change in interest rate will likely impact equity return, so it is not reasonable to perform a standalone interest rate shock without also changing the equity return. A sole change in interest rate will affect only the company's return on asset but not the product cash flows, so this test is not relevant for testing of policy cash flow risk. Given that the current interest rate of 3%, a reduction of 2% may be considered too extreme rather than moderate.

4. Learning Objectives:

4. The candidate will understand the basic design and function of Economic Scenario Generators and Equity Linked Insurance Models.

Sources:

LAM-148-19: Introduction to Economic Scenario Generators - Selecting and Specifying ESGs

Economic Scenario Generators: A Practical Guide, 2016, Ch. 1, 2, 4.1, 5, 6, 9, 10, 11.1 & 11.3

LAM-139-19: Simulation of a Guaranteed Minimum Annuity Benefit, Freedman, 2019; Excel Model - Stochastic Simulation of a GMAB Option (Accompanies Simulation of a GMAB)

Investment Guarantees, Hardy, Mary, 2003 - Ch. 2: Modeling Long-Term Stock Returns

Commentary on Question:

This question focuses on the understanding of concepts and theories related Economic Scenario Generators, and tests candidates' knowledge on real world scenarios and risk neutral scenarios.

In general, candidates performed better on parts A, C, E and F, while B and D proved to be challenging.

Solution:

(a) Critique each of the following statements:

A. *According to Jensen's inequality, a single scenario representing the average market condition is used in pricing and valuation of VA.*

B. *Feynman-Kac theorem prohibits the use of risk neutral scenarios that are not mean reverting because such scenarios do not look real.*

C. *Real world and risk neutral scenarios are selected based on different use cases. Since economic capital focuses on extreme tail events which may not exist in real life, risk neutral scenarios are always used. For strategic asset allocations, real world scenarios are used since cash flow pricing is not the primary consideration.*

D. *Risk neutral scenarios must always be used directly for calculating market prices.*

E. *In order to improve the efficiency of the ESG calibration process, the cascade structure is used.*

4. Continued

F. Management decides to perform deterministic stress testing using a scenario generated by the ESG.

Commentary on Question:
Overall, candidates answered well. Candidates who did not explicitly state true/false, etc received partial marks. Those who only stated true/false etc without any explanations received no marks

A. False
- Guarantee price and reserves are a non-linear function of market conditions.
- Based on Jensen's Inequality, expected price / reserves cannot be calculated using the average market condition. Evaluating only the expected scenario will likely result in underestimating the reserve or the price.
- Full-on stochastic projections should be done, instead of using a single expected scenario.

B. False
The Feynman-Kac theorem is a math trick that provides a convenient solution to derivative pricing. The risk-neutral scenarios generated to satisfy this theorem are meant to look unreal instead of looking like market variables.

C. Partially True
- It is true that RN and RW scenarios are utilized for different purposes. It is also true that SAA analysis is performed using real-world scenarios as cash flow pricing is not the primary consideration.
- However, both market-consistent and real-world representations are important in developing economic capital calculations. Certain economic capital definitions require the calculation of market values at a future point in time, Tx. The scenarios used for traveling to Tx may be real-world representations that are not market consistent. However, within this path, the scenarios used to determine the market values at Tx may be market consistent.

D. False
ESGs are typically chosen so that the prices of key assets like treasury bonds, equities and corporate bonds are available in closed form. When the prices of key assets are available in closed form, these prices can be simulated off the real-world dynamics, and risk-neutral scenarios are not required.

E. True
A cascade structure is a model framework design whereby each subsequent variable in the cascade structure depends only on prior values of the variable and the values of variables that lie above them on the cascade structure. Therefore, using this approach will increase the efficiency of ESG.

4. Continued

F. False
ESG is intended to generate multiple scenarios that result in a distribution for testing rather than choosing one single scenario

(b) Calculate the price of the GMAB using Black-Scholes formula. Show all work.

Commentary on Question:
The goal of the question is for the candidate to apply Black-Scholes formula on GMAB.

Only a few students were able to calculate the correct Notional amount but most of the candidates correctly applied Black-Scholes formula based on their incorrect Strike Price. Credits were awarded by steps; points were not deducted for correct formula but wrong results because of the incorrect input from the previous step.

Set the current fund level to 1,000

Strike price
= Current Fund level * Guarantee / Initial Premium*(1- M&E fees- Rider Fees)^ Term (years)
= 1,000*600,000/(500,000*(1-2%-2%)^30
=4,084

Notional
= Initial Premium/ Current Fund level*(1-Lapse rate)^ Term (years)
= 500,000/1,000*(1-5%)^30
=107.32

d1
=(LN(Current Fund level /Strike price)+(Risk-Free Rate+0.5* Volatility ^2)*Term)/(Volatility *SQRT(Term))
=(LN(1000/4084)+(0.05+0.5*0.1^2)*30)/(0.1*SQRT(30))
=0.444

d2=d1- Volatility *SQRT(Term))
= 0.444-0.1*SQRT(30)
=-0.104

Put ($1)
= Strike Price *EXP(Term*Risk Free rate)* NORMSDIST(-d2)-Current Fund Level*NORMSDIST(-d1)
=4084*EXP(-30*0.05)*NORMSDIST(-0.104)-1000*NORMSDIST(-0.444)
=164.7

4. Continued

Price of the GMAB =Put($1)* Notional
=164.7*107.32
=17,676

(c) Discuss two key challenges when setting the implied market volatility assumption for option pricing.

Commentary on Question:
This question test candidate's understanding of option pricing. The candidates did poorly in this question. A common answer is only stating that the volatility should not be constant.

The implied market volatility is calculated from market prices at some instant in time. The options embedded in equity-linked contracts have effective maturity far longer than traded options. Market volatility varies with term to maturity in general, so in the absence of very long-term traded options, it is not possible to state confidently what would be an appropriate volatility assumption based on current market conditions.

Another problem is that the market statistics do not give the whole story. Market valuations are not based on true probability measure, but on risk-neutral measure. In analyzing future cash flows under the equity-linked contracts, it will also be important to have a model of the true unadjusted probability measure.

A third difficulty is the volatility of the implied volatility. Movements in implied volatility are common in practice. It is not satisfactory to determine long-term strategies for the actuarial management of equity-linked liabilities on assumptions that may be deemed incorrect one day later.

5. Learning Objectives:

2. The candidate will understand and be able to assess issues and concerns common to actuarial models and their development and management.

3. The candidate will understand the principles of Asset-liability Management ("ALM"), and be able to describe and evaluate various techniques for addressing the mitigation of risk.

Learning Outcomes:

(2b) Describe and evaluate the following actuarial modeling best practices:

- Model risk management
- Model validation techniques and methods
- Best practices for assumptions governance
- Application of Actuarial Standards of Practices
- Reliance on expert judgment in actuarial modelling

(3a) With respect to Asset-Liability Models:

- Describe and apply the fundamental elements of the theory and practice of ALM in an insurance company, including assessing the dangers of mismatched assets and liabilities.
- Describe and demonstrate how ALM can be used to identify and manage product and asset risks, including:
  - Major product risks for which ALM can be a useful tool for their management.
  - Using ALM as a means to manage interest rate risk, equity risk, and risks from optionality.
- Describe how common insurance contracts and variations generate embedded options in an insurer's balance sheet, and assess basic strategies for managing exposures created by such embedded options.
- Describe and apply the basic concepts of cash flow matching, immunization, duration/convexity matching, segmentation.
- Describe and apply Key Rate Durations (KRD) and their use in evaluating interest rate sensitivities of portfolios, including understanding the derivation of KDRs, the profiles of KDRs for selected major asset types, and assessing KRDs in a portfolio context.
- Describe and evaluate the Goldman Sachs' ALM/Strategic Asset Allocation approach for integrating ALM into an enterprise's risk and financial management framework.
- Describe and evaluate ALM modeling considerations in the context of modeling risk aggregation, dependency, correlation of risk drivers and diversification.

5. Continued

Sources:
Managing Investment Portfolios, Maginn, John L. and Tuttle, Donald L., 3rd Edition, 2007 - Ch. 6: Fixed-Income Portfolio Management (sections 1-5)

LAM-146-19: Ch. 16 of ALM Management of Financial Institutions, Tilman, 2003

LAM-117-14: Key Rate Durations: Measures of Interest Rate Risk

LAM-131-19: Ch. 22 of Life Insurance Accounting, Asset/Liability Management

Commentary on Question:
Commentary listed underneath question component.

Solution:
(a) Explain how this product design exposes the company to investment risk.

Commentary on Question:
Candidates did generally well identifying the basic concepts of investment risk and identifying specific design elements that expose the company. Full credit was awaded to candidates for pointing out that the product design required investment returns to fund the policyholder liability. Candidates that explained other risks such as disintermediation risk, reinvestment risk and interest rate risk also received full credit.

This FDA product includes a savings element, whereby the ultimate benefits provided to policyholder reflect the accumulation of interest of some portion of the premiums. As the insurer is responsible for investing the assets backing reserves, the insurer's profitability is dependent on the ability of its investment to fund the benefits promised to the policyholder. Additional risks that apply to this product design include disintermediation risk, reinvestment risk, and interest rate risk.

(b) Describe two embedded options inherent in this product design.

Commentary on Question:
Candidates did very well identifying 2 embedded options. Some candidates received partial credit for listing options but failing to provide description or incorrectly identifying the type of embedded option

5. Continued

Candidates must have 2 out of the following options for full credit:

- The GMIR is an interest rate floor.
- Additional premium deposit is a call on The value of future annuity payments.
- Surrender at account value minus charge is a put on The value of The policy.
- Right to convert the policy from a fixed-rate to a floating rate is an interest rate swap (from insurer perspective)

(c) Discuss the impact of a significant increase in interest rates on the profitability of this product from the perspective of both the liability and the supporting asset portfolio. Assume the supporting asset portfolio is fully invested in fixed income.

Commentary on Question:
Almost all candidates identified that the market value of the fixed asset portfolio would decrease under a high interest rate environment and that higher lapse experience was likely to occur. Some candidates struggled to identify the impact of high interest rates on the profitability of the product

From liability perspective:

- Value of the Liabilities (ie. surrender on account value less surrender charge) remain constant.
- Companies may not be able to raise credited rates enough or soon enough to retain policyholders due to annual declaration of credited rates
- Policyholders are incentivized to surrender to seek more attractive credited rates elsewhere.

From asset perspective:

- The market values of existing fixed-income securities are reduced.
- As policyholders are more likely to request withdrawals, ABC will be forced to liquidate assets at depressed values to fund the surrender values of departing policyholders, resulting in financial loss.

(d)

(i) Select the most suitable benchmark index. Justify your answer.

(ii) Recommend either a pure bond indexing strategy or an enhanced indexing strategy. Justify your answer.

Commentary on Question:
Most candidates received full credit on part (i). For part (ii), many candidates were unable to identify the differences between pure bond indexing and enhanced indexing which often led to unsupported recommendations that did not receive full credit. No credit was given for the recommendation of pure bond indexing, which is unsupported by source material

5. Continued

(i) Pick Index Y. ABC utilizes its asset portfolio to meet FDA liabilities, so stability and dependability of income are of primary concern. A longer portfolio is less risky in terms of income risk than a shorter portfolio. In addition, the FDA product has an accumulation period of 10 years, which is considered relatively long-term. As such, Index Y is a better choice than Index Z. Index X is not suitable since it invests in below-investment-grade debts and is not dependable.

(ii) Pure bond indexing (or full replication): This approach attempts to duplicate the index by owning all the bonds in the index in the same percentage as the index. Full replication is relatively difficult and expensive to implement compared to the other strategies.
Enhanced indexing (either by matching primary risk factors or by small risk factor mismatches): This approach uses a sampling approach to match the primary index risk factors (or match the duration only) to achieve a higher return than full replication. The construction and maintenance costs are lower than full replication. This approach tracks the index less closely than under full replication.

Given resource and budget constraints, enhanced indexing is recommended. The type of enhanced indexing (primary risk factor matching or small risk factor mismatch) can be determined based on desired level of portfolio return and the resource availability.

(e) Construct a portfolio of zero coupon bonds to match the key-rate durations. Assume a portfolio value of 100,000. Show all work.

Commentary on Question:
Most candidates were able to calculate the correct weights of each bond, but many candidates made the mistake of grossing up the dollars in each bond rather than holding a cash position. Full credit required that candidately accurately identified the cash position.

Step 1: Calculate the weight of each bond equal to the duration / term
Step 2: Calculate the dollar amount invested in each bond equal to the market value x the weight from step 1
Step 3: Identify the cash position, equal to the market value - sum of the dollar amounts in step 2
See detailed excel solution

(f) Calculate the tracking risk of your asset portfolio against the benchmark index. Show all work.

5. Continued

Commentary on Question:
Almost all candidates received credit by calculating active return, but many lost points for incorrect calculation of the sample standard deviation.

Step 1: Calculate the active return for each period equal to the asset portfolio return – benchmark return
Step 2: Calculate (AR – Average AR)^2
Step 3: Calculate the tracking risk as the sample standard deviation of results. (Square Root (sum of step 2 / 9))
See detailed excel solution

6. Learning Objectives:

5. The candidate will understand the role of the Investment Actuary and the Portfolio Management Process in the Life Insurance company context, as well as the common forms of Fixed income securities and their uses, and the methods and processes used for evaluating portfolio performance and asset allocation.

Learning Outcomes:

(5b) Describe and evaluate how a company's objectives, needs and constraints affect investment strategy and portfolio construction (including capital, funding objectives, risk appetite and risk return tradeoff, tax and accounting, accounting considerations, and constraints such as regulation, rating agency ratings and liquidity.

(5e) Describe and assess Alternative Investment Portfolios (including real estate) in the context of an insurance company portfolio.

(5f) Describe and apply methods and processes for evaluating portfolio performance, including performance attribution, sources of earnings analysis on investment income, benchmarks, metrics, and risk adjusted performance appraisals (including total return vs reported earnings).

(5i) Describe the attributes of US Treasuries, Agency Debt Securities, Municipal bonds, Corporate bonds, Private Money Market securities, Floating Rate Agreements, Agency Mortgage Backed securities, Agency Collateralized Mortgage securities, Interest Rate Swaps and Swaptions, Credit Derivatives and High Yield Bonds, and the markets they are traded in.

Sources:

Managing Investment Portfolios, Maginn, John L. and Tuttle, Donald L., 3rd Edition, 2007 - Ch. 5: Asset Allocation (sections 2-4)

LAM-158-F23: Managing Liquidity Risk, Industry Practices and Recommendations for CROs, CRO Forum, 2019

LAM-153-23: Managing your Advisor: A Guide to Getting the Most Out of the Portfolio Management Process

Managing Investment Portfolios, Maginn, John L. and Tuttle, Donald L., 3rd Edition, 2007 - Ch. 3: Managing Institutional Investor Portfolios (section 4.1)

LAM-151-23: High-Yield Bond Market Primer

LAM-XXX-24: Profiles of Alternative Assets in Life Insurance Landscape

6. Continued

Commentary on Question:
Most candidates did well in parts a & b, but many candidates struggled in part c because they didn't get the unit right.

Some candidates failed to state whether the statements were correct or incorrect in part d.

Solution:

(a) Critique the company's decision to use a single asset portfolio.

Commentary on Question:
The main point of the question is for the candidate to understand the possible issues with merging the portfolio and recommend the to keep the 3 portfolios separate. Candidates are expected to support this conclusion based on comparing product characteristics.

The insurance company should not manage the assets as a single portfolio. Instead they should create three separate portfolios because each product has different features.

There is a mix of open and closed blocks - UL and Term are closed, FIA is open.

The duration of liabilities vary significantly by products. UL is very long duration. Term is medium duration. FIA is short duration.

(b) Assess the liquidity risk inherent in the three products assuming a significant increase in interest rates.

Commentary on Question:
Candidates are expected to understand the interest rate sensitivity of different products/product designs and their impact on liquidity.

Term Insurance:
Term is not sensitive to interest rate changes. This product has no change in cashflow and limited liquidity exposure in the increased rate environment.

Universal Life:
The key here is to understand that the decision on lapse for UL will depend on whether the competitor crediting rate for newly issued products is higher or lower than ABC's 5% guarantee. If the competitor crediting rate is higher than lapses are likely to occur and there will be liquidity risk exposure.

Fixed Index Annuity:

The market value adjustment along with the surrender charges decrease the incentive for policyholders to surrender. Therefore, FIA cashflows' sensitivity to interest rate changes is limited. This product has limited liquidity exposure.

(c)

(i) Calculate the utility for each portfolio to support the persistency bonus. Show all work.

(ii) Calculate Roy's safety-first criterion for each portfolio. Show all work.

(iii) Recommend which portfolio the ALM team should use to support the persistency bonus feature. Justify your response.

Commentary on Question:
Candidates need to recognize that 5% is not the required return. The required return is the 5% of the face amount. Therefore, the return is 500,000/12,000,000.

It's important for the candidate to pick a portfolio with the best utility and safety-first ratio in part (iii).

(i)
Utility = E(Rm) – 0.005*Ra*Var

A = 4% - 0.005*6*2%^2 = 4%
B = 10% - 0.005*6*20%^2 = 9.88%
C = 7% - 0.005*6*10%^2 = 6.97%

(ii)
Safety-First Ratio = (E(Rp)-RL)/SD
RL = 500,000/12,000,000 = 0.0417

A = (4% - 0.0417)/2% = -0.08
B = (10% - 0.0417)/20% = 0.29
C = (7% - 0.0417)/10% = 0.28

(iii)
Portfolio B has a better Utility and is safety-first optimal. Therefore, to support the product feature, this is the portfolio recommended.

6. Continued

(d) Critique the following statements:

A. A below investment grade bond will have higher interest rate sensitivity compared to an investment grade bond with equal face value and term structure.

B. Collateralized Loan Obligations (CLOs) often offer more predictable cashflows compared to other types of collateralized securities.

C. CLOs can be used to meet various levels of credit risk taking through a tranche structure giving companies the flexibility to target certain levels of yield based on credit risk appetite.

D. Including CLOs in a portfolio will provide a hedge against inflation, particularly if they are floating rate.

E. To avoid taking on higher credit or liquidity risk, a CLO investment strategy should focus on middle market rather than broadly syndicated CLOs.

Commentary on Question:
For below investment grade bonds / junk bonds, candidate must understand the links between higher coupon leading to higher duration which translates to increased interest rate sensitivity. If the candidate does not explain the thought process to their conclusion, then no credit is awarded. The thought process is more important than the conclusion being right.

For CLOs, candidate should agree CLOs are more predictable than many other collateralized securities and note reasons such as those listed in the model solution. Description on how the tranche structure carries different risk and yield should be provided for part C. For part D, the candidate should agree that floating rates can hedge inflation. For part E, the candidate should disagree with the statement and explain why middle market CLOs are considered to have higher credit (default) risk and liquidity risk (partial credit if only addressing one of these two risks in their answer). Note Ch. 30 of the Fabozzi textbook also discusses CLOs, which candidates may appropriately reference when critiquing statements (particularly statement i), though LO#5-25 addresses the topics in these statements more directly.

Statement A
Candidate understands that below investment grade bonds (aka junk bonds) have higher coupons than otherwise similar investment grade bonds due to the higher risk associated with junk bonds. They should comment that the higher coupons received in junk bonds will increase duration, thus increasing interest rate sensitivity compared to investment-grade bonds.

6. Continued

Statement B
This statement is correct. CLOs are considered to have more predictable cash flows than many other collateralized securities, given consistent interest payments associated with the securities, along with covenants and coverage tests.

Statement C
This statement is correct. CLOs are typically broken out into tranche structures. The lower credit risk underlying loans (lower default probability) are in senior tranches and generally offer lower yields, while the riskier underlying loans are in mezzanine and junior tranches with higher yields.

Statement D
This statement is correct. Floating rate CLOs can serve as a hedge against inflation. Candidate may also discuss the fact that floating rate CLOs carry lower duration compared to fixed rate CLOs.

Statement E
"This statement is incorrect. Middle market CLOs have historically had a higher default rate than broadly syndicated loans, as the underlying loans are tied to smaller companies which may carry higher credit risk than the larger companies in broadly syndicated loans. Middle market CLOs are also considered less liquid, as difficulty in finding buyers for the smaller, less-known loans during a stressed market environment can result in longer waiting periods to sell and/or sell at fair market prices.