

Exam ILALAM

Date: Thursday, April 30, 2020

Time: 2:00 p.m. – 4:15 p.m.

INSTRUCTIONS TO CANDIDATES

General Instructions

1. This examination has a total of 40 points.

This exam consists of 4 questions, numbered 1 through 4.

The points for each question are indicated at the beginning of the question.
2. Failure to stop writing after time is called will result in the disqualification of your answers or further disciplinary action.
3. While every attempt is made to avoid defective questions, sometimes they do occur. If you believe a question is defective, the supervisor or proctor cannot give you any guidance beyond the instructions on the exam booklet.

Written-Answer Instructions

1. Write your candidate number at the top of each sheet. Your name must not appear.
2. Write on only one side of a sheet. Start each question on a fresh sheet. On each sheet, write the number of the question that you are answering. Do not answer more than one question on a single sheet.
3. The answer should be confined to the question as set.
4. When you are asked to calculate, show all your work including any applicable formulas.
5. When you finish, insert all your written-answer sheets into the Essay Answer Envelope. Be sure to hand in all your answer sheets because they cannot be accepted later. Seal the envelope and write your candidate number in the space provided on the outside of the envelope. Check the appropriate box to indicate Exam ILALAM.
6. Be sure your written-answer envelope is signed because if it is not, your examination will not be graded.

Recognized by the Canadian Institute of Actuaries.

Tournez le cahier d'examen pour la version française.

****BEGINNING OF EXAMINATION****

- 1.** (10 points) BDK Insurance is designing a variable annuity with a Guaranteed Minimum Accumulation Benefit (GMAB). The GMAB is a 3-year annual ratchet based on a managed equity fund.

- (a) (2 points) Describe two methods to model this GMAB guarantee.

Management proposes hedging the GMAB guarantee by purchasing 1-year at-the-money (ATM) S&P500 put options with notional value equal to fund value. The hedge will be rebalanced each year when the ratchet value is calculated.

- (b) (3 points) Evaluate the proposed strategy on the following:
- (i) Risks mitigated
 - (ii) Risks not mitigated
 - (iii) Risks created

1. Continued

BDK decides to sell the new product and use the hedging strategy proposed in part (b). They collect an annual fee equal to 2% of fund value at the beginning of each year. After 3 years, BDK has experienced the following:

Values as of End-Of-Year	Year 0	Year 1	Year 2	Year 3
Fund Unit Price	100	95	105	85
S&P500 Level	1,000	900	1,100	1050
Deposits	10,000	0	0	0
Withdrawals		0	1,000	0
Expenses		100	50	50
1-Year ATM Put Option Price (per 100 notional)	1.0	1.2	0.8	1.4
Cost of Hedging		100	112	x
Hedge Option Payout		1,000	0	y

Surrenders occur at end-of-year.

(c) (5 points) Perform the following:

- (i) Calculate earnings without hedging in year 3.
- (ii) Calculate the hedging gain or loss in year 3.
- (iii) Assess the effectiveness of the hedging strategy.

Show all work.

2. (10 points) CR Life is considering moving to a first principles model for their Long-Term Care (LTC) product. This product is fully underwritten and offers preferred lives a reduced premium for the first 2 years. Benefits are capped at a lifetime maximum.

(a) (1.5 points)

- (i) Define first principles modeling.
- (ii) Describe its advantages.

The following experience data is available:

Year	Beginning of Year Count	Total Decrements	Observed Lapses	Observed Mortality Rate for Disabled Lives
1	1,000	86	35	1.00%
2	914	74	25	1.51%
3	840	64	40	1.69%

- Only healthy lives lapse. Lapses occur at end of year.
- At the beginning of each year 100 lives become disabled.
- Disabled policies cannot recover.
- Deaths occur at mid-year.

(b) (3.5 points) Calculate the lapse rate for each policy year.

2. Continued

Due to low credibility, CR Life decides not to use assumptions based on observed data. Instead, they use industry mortality tables to calculate the expected number of deaths and derive an implied lapse rate as follows:

Year	Total Decrements	Expected Deaths (Based on GAM94 Industry Table with Mortality Improvement)	Implied Lapses	Implied Lapse Rate
1	86	25	61	6.18%
2	74	25	49	5.44%
3	64	24	40	4.83%
4+	46	24	22	2.88%

(c) (5 points)

- (i) Evaluate the use of an implied lapse assumption for this product.
- (ii) Recommend actions to improve the quality of the lapse assumption.

Justify your answer.

3. (10 points) Company XYZ is a new life insurer developing their first product. It is an innovative form of life insurance that will offer several new features. You are responsible for creating the actuarial model used for rate setting and cash flow projections.
- (a) (3 points) Recommend if XYZ should implement an open or closed model system based on the following considerations:
- (i) Governance and Control Environment
 - (ii) Model Efficiency
 - (iii) Model Flexibility
- (b) (5 points) While building the model, you have made the following decisions:
- The model uses simplifications in the code to improve runtime.
 - Internal and external data sources are combined for model input.
 - The model uses an innovative approach uncommon in the industry.
 - Sensitivity and stress testing were performed and reveal large changes in model outcomes under spikes to interest rates.
 - The model does not use statistical techniques.

Draft an outline of the Model Development Documentation based on these decisions using the structure described in *Model Risk Mitigation and Cost Reduction Through Effective Documentation*.

3. Continued

- (c) (2 points) The risk department requires all new models to undergo model validation before they are used. The analyst responsible for the validation schedules a meeting to review the validation plan.

Critique the following statements made by the analyst during this meeting.

- A. *Only positive testing will be conducted in which valid input parameters will be tested to ensure valid output is produced.*
- B. *Materiality of input parameters should be validated through sensitivity testing.*
- C. *The reporting and use of the output generated by the model is out of scope of the validation.*
- D. *Validation of raw input data is not necessary as it should be covered under validations of those particular source systems.*

4. (10 points) ABC Life sells a product with the following features:

- 3 year coverage period
- Annual Premium paid at the beginning of each year if a policy is *Active*
- Annual Benefit of 100, paid at the end of each year if a policy is *Disabled*
- Paid Premiums are refunded when a policyholder *Dies*

Let $Q^{(i,j)}$ be the transition probability matrix with the following states:

- State #1 for *Active*
- State #2 for *Lapsed*
- State #3 for *Disabled*
- State #4 for *Deceased*

$$Q^{(i,j)} = \begin{bmatrix} 0.9 & 0.05 & 0.04 & 0.01 \\ 0 & 1 & 0 & 0 \\ 0.3 & 0 & 0.6 & 0.1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

- (a) (5 points) Calculate the annual premium using the Equivalence Principle, assuming an annual interest rate of 10% and transitions occur at end of year. Show all work.

ABC offers a discount to policyholders if they are willing to undergo a credit check.

- (b) (2 points) Contrast the benefits and limitations of using a Linear versus Generalized Linear Model to calculate the policyholder discount.

4. Continued

- (c) (1 point) Determine which of the normal and gamma variance functions is the most appropriate choice for this GLM.
- (d) (2 points) You are given the following formula which was derived using the Generalized Linear Model concept:

$$\ln(\text{Avg Claim}) = 7.0 + 0.03 * \text{Issue Age} - 0.3 * \text{Credit Score} - 0.1 * \text{Gender}$$

Where:

$$\text{Credit Score} = \begin{cases} 0, & \text{No Credit Check} \\ 1, & \text{Strong Credit} \\ -1, & \text{Bad Credit} \end{cases}$$

$$\text{Gender} = \begin{cases} 1, & \text{Male} \\ 0, & \text{Female} \end{cases}$$

Average claim is expressed in thousands.

- (i) Define and identify the link function.
- (ii) Calculate the discount a 25-year-old male with a strong credit score would receive assuming the equivalence principle. Show all work.

****END OF EXAMINATION****

USE THIS PAGE FOR YOUR SCRATCH WORK