

# Exam ILALAM

**Date:** Thursday, November 4, 2021

## INSTRUCTIONS TO CANDIDATES

### General Instructions

1. This examination has 4 questions numbered 1 through 4 with a total of 40 points.

The points for each question are indicated at the beginning of the question.

2. 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 provided in this document.

### Written-Answer Instructions

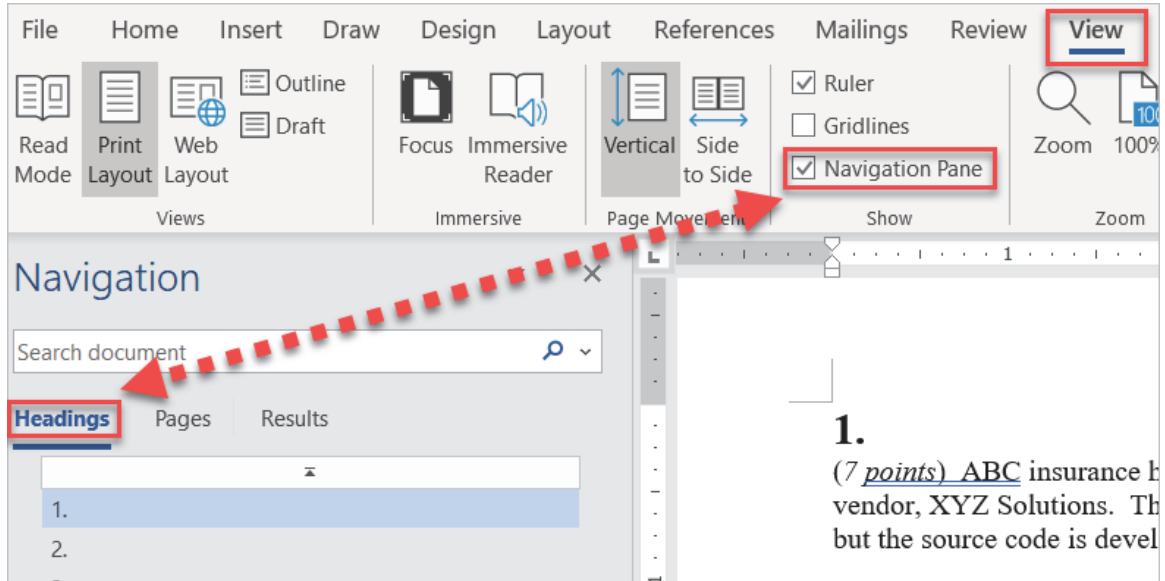
1. Each question part or subpart should be answered either in the Word document or the Excel document as directed within each question. Graders will only look at work in the indicated file.
  - a) In the Word document, answers should be entered in the box marked ANSWER within each question. The box will expand as lines of text are added. There is no need to use special characters or subscripts (though they may be used). For example,  $\beta_1$  can be typed as beta\_1, and  $X^2$  can be typed as x^2.
  - b) In the Excel document formulas should be entered. For example,  $X = \text{component1} + \text{component2}$ . Performing calculations on scratch paper or with a calculator and then entering the answer in the cell will not earn full credit. Formatting of cells or rounding is not required for credit.
  - c) Individual exams may provide additional directions that apply throughout the exam or to individual items.
2. The answer should be confined to the question as set.
3. Prior to uploading your Word and Excel files, each file should be saved and renamed with your five-digit candidate number in the filename.
4. The Word and Excel documents that contain your answers must be uploaded before the five-minute upload period expires.

*Recognized by the Canadian Institute of Actuaries.*

## Navigation Instructions

Open the Navigation Pane to jump to questions.

Press Ctrl+F, or click View > Navigation Pane:



# 1.

(9 points) ABC Life, which sells both life and annuity products, has recently begun developing a stochastic model to address regulatory requirements and their risk analysis needs. ABC has documented the following observations and decisions during development.

(a) (4 points) Critique the following statements:

A. *While the stochastic model will be useful for calculating the average outcome, there is no reliable method for analyzing tail risks given the low probability of them occurring.*

ANSWER:

B. *We will be able to gain a better understanding of our existing single scenario stress test results by comparing with the stochastic distribution of results.*

ANSWER:

C. *We assume a normal distribution for the variables projected by the stochastic model, as the normal distribution is relatively easy to use and therefore less risky than assuming a more complex distribution.*

ANSWER:

D. *10,000 scenarios should be produced each time the model is run, because having more scenarios always provides additional information about the shape of the distribution.*

ANSWER:

**1. Continued**

- E. The model's input parameters are calibrated using the past 2 years of historical experience, about 100 data points in total.*

ANSWER:

- F. During model validation, it is normal to see the stochastic mean being more than double the deterministic best estimate.*

ANSWER:

## 1. Continued

ABC Life sells a disability income rider that pays an additional benefit of 850 in years where a policyholder is disabled. In addition, an expense of 50 will be incurred in the year where a policyholder changes from active to disabled status.

The stochastic model uses a 2-state non-homogeneous Markov Chain to determine disability payments, where State 1 is Active and State 2 is Disabled. Below is the transition probability matrix used:

$$Q = \begin{bmatrix} 0.9 & 0.1 \\ 0.3 & 0.7 \end{bmatrix}$$

A Linear Congruential Generator (LCG) is used within the stochastic model to generate random uniform variables to determine the initial status of each policyholder and has the following parameters:

- Multiplier = 2
- Increment = 5
- Modulus = 11
- Initial Seed = 88

Policyholder  $i$  will start in the Active state if the generated corresponding sequence is less than 0.80.

(b) (5 points)

- (i) (2 points) Calculate the active or disabled status generated by the uniform random number sequence for the first 4 policyholders. Show all work.

*The response for this part is to be provided in the Excel spreadsheet.*

(ii) (3 points) You are also given that:

- The LCG model generated 0.727 for policyholder X at time 0
- Discount rate of 5%
- All cashflows are at the beginning of year

Calculate the time 0 actuarial present value of payments caused by this rider over the next two periods.

*The response for this part is to be provided in the Excel spreadsheet.*

## 2.

(10 points) XYZ Insurance has hired you as a consultant to review aspects of their Modeling function and Assumption Governance Framework.

(a) (2 points) XYZ uses a compliance-based Assumption Governance framework with the main objective of satisfying regulatory requirements.

(i) (1 point) Critique the use of a compliance focused approach to Assumption Governance.

ANSWER:

(ii) (1 point) Recommend an alternative Assumption Governance framework for XYZ and describe the benefits they would realize.

ANSWER:

(b) (4 points) XYZ's modeling function is decentralized into small teams that independently maintain a model for each product. XYZ would like to create a centralized modeling function to improve efficiency, with a specific focus on optimizing new product development.

(i) (2 points) Recommend the approach XYZ should follow when creating their centralized modeling function. Justify your answer.

ANSWER:

(ii) (2 points) Identify the relevant considerations and recommended practices of ASOP 56 that XYZ needs to consider when creating the centralized modeling function. Justify how they apply to XYZ's approach.

ANSWER:

## 2. Continued

- (c) (4 points) XYZ's stochastic modeling group is reviewing their modeling approach for a group of Universal Life policies. You are given the following dataset:

<b>Distance Matrix</b>					
<b>Policy #</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>1</b>	0	1,119	561	30	4,451
<b>2</b>	1,119	0	1,680	1,122	3,336
<b>3</b>	561	1,680	0	558	5,011
<b>4</b>	30	1,122	558	0	4,453
<b>5</b>	4,451	3,336	5,011	4,453	0

<b>Policy #</b>	<b>Plan Code</b>	<b>Face Amount</b>	<b>Account Value</b>	<b>Reserves</b>
<b>1</b>	105	1,500	110	555
<b>2</b>	105	2,000	240	1,111
<b>3</b>	105	5,000	25	250
<b>4</b>	209	1,000	80	555
<b>5</b>	209	5,000	350	2,500

Critique the recommendations made in the report. Justify your answer.

- A. Introducing segment boundaries is not advised as it will increase run time and add more constraints.

ANSWER:

- B. When mapping policies, we start with the pair with the lowest distance (i.e. policy pair #1 and #4) and map to the policy with higher face amount between the pair (i.e. map policy #4 to policy #1).

ANSWER:

## 2. Continued

- C. When there are pairs with similar distance (such as policy pairs #1 and #3 and policy pairs #3 and #4), to avoid bias, the company can use a random number generator to determine which pairs of policies should be mapped first.

ANSWER:

- D. The UL cluster model is calibrated and uses the same weights for account value as the variable annuity cluster model with compression ratio of 50-to-1.

ANSWER:

- E. A small cluster model size is preferred over larger cluster model sizes.

ANSWER:



### 3.

(10 points)

- (a) (3 points) Explain the six core processes of an ERM framework as discussed in the Goldman Sachs' paper *Revisiting the Role of Insurance Company ALM within a Risk Management Framework*.

ANSWER:

- (b) (3 points) PBJ Life is a life insurance company with several lines of business.

You are given the following information on one of PBJ Life's asset segments supporting a single liability payment in Year 19:

		MV (\$million)
<b>Liability</b>	Single payout in Yr 19	100
<b>Assets (Zero Coupon Bonds (ZCB))</b>	5yr ZCB	20
	10yr ZCB	30
	30yr ZCB	50
	Total	100

You are given the following interest rate shock scenarios:

Interest Rate Shock	5yr	10yr	30yr
Scenario 1 (parallel shock)	-50bp	-50bp	-50bp
Scenario 2 (Steepening shock)*	-50bp	-25bp	+150bp

\*Linearly interpolate shock at different terms, if necessary.

- (i) (2 points) For each of the given interest rate shock scenarios, calculate the impact on surplus. Show all work.

*The response for this part is to be provided in the Excel spreadsheet.*

- (ii) (1 point) Critique the following statement:

*"The asset portfolio has the same effective duration as the liability, therefore exposure to interest rate risk is perfectly immunized."*

ANSWER:

### 3. Continued

(c) (4 points) Three of PBJ's major product lines are Non-Participating Single Pay Whole Life Insurance, Fixed Annuities, and Variable Annuities. You are reviewing the use of derivatives to manage risk.

(i) (1 point) Critique the following statement:

*“Since all premium has been paid on the Whole Life product, there are no embedded options in the product from the perspective of the policyholder or the company.”*

ANSWER:

(ii) (1 point) PBJ's Fixed Annuity has the following features:

<b>Current rate of return</b>	3.5%
<b>Guaranteed minimum rate</b>	3.0%
<b>Surrender charge</b>	5% in year 1, grading to 0% in year 6

Critique the following statement:

*“For the fixed annuity product, PBJ only needs to be concerned about the policyholder's embedded options if interest rates fall.”*

ANSWER:

### 3. Continued

- (iii) (2 points) PBJ wants to protect its variable annuity against equity market risk. The primary revenues on this product are M&E fees on the account value, collected at the end of the year. Account values vary directly with the equity market. PBJ purchases one-year S&P Index put options to hedge their equity risk. You are given the following:

Account Value – beginning of year	5,000,000
Hedge Notional Amount	Total AV
M&E charge	2%
Current S&P Index = Strike Price	1800
Premium for each put option	300
Change in S&P Index – end of year	-10%

At the end of the year your colleague argues the cost of the put option was too high and PBJ did not benefit from it. Determine whether the cost of the put option is in excess of the benefit it provides. Justify your answer.

*The response for this part is to be provided in the Excel spreadsheet.*

#### 4.

(11 points) Company QRF uses its own Economic Scenario Generator (ESG) to project real world scenarios for capital stress testing and risk-neutral scenarios to value the stochastic cost of guarantees on Universal Life products with guaranteed minimum crediting rates.

(a) (3 points) Critique the following statements from QRF's Model Risk Management group regarding the ESG model.

A. The real-world scenarios can provide more intuitive results than the risk-neutral scenarios

ANSWER:

B. Correlation between modeled economic and financial market variables are set and held constant at model development.

ANSWER:

C. Spread inputs for a real estate investment trust in our portfolio were not readily available in the market. The actuary estimated the spreads based on fixed income bond spreads from an Oil & Gas bond with the same term-to-maturity.

ANSWER:

D. The model is calibrated using historical data from 2010 to 2019.

ANSWER:

#### 4. Continued

You are given projected reserves under 10 scenarios sets, which used scenario reduction techniques:

Scenario Set #	Reserves with minimum crediting rate guarantee	Reserves without minimum crediting rate guarantee
1	120	100
2	150	135
3	200	150
4	170	150
5	80	45
6	95	60
7	45	45
8	250	200
9	300	250
10	350	300

The closed form solution is 32.1 for the cost of guarantee

(b) (3 points)

(i) Calculate the market-consistent value of the cost of guarantee.

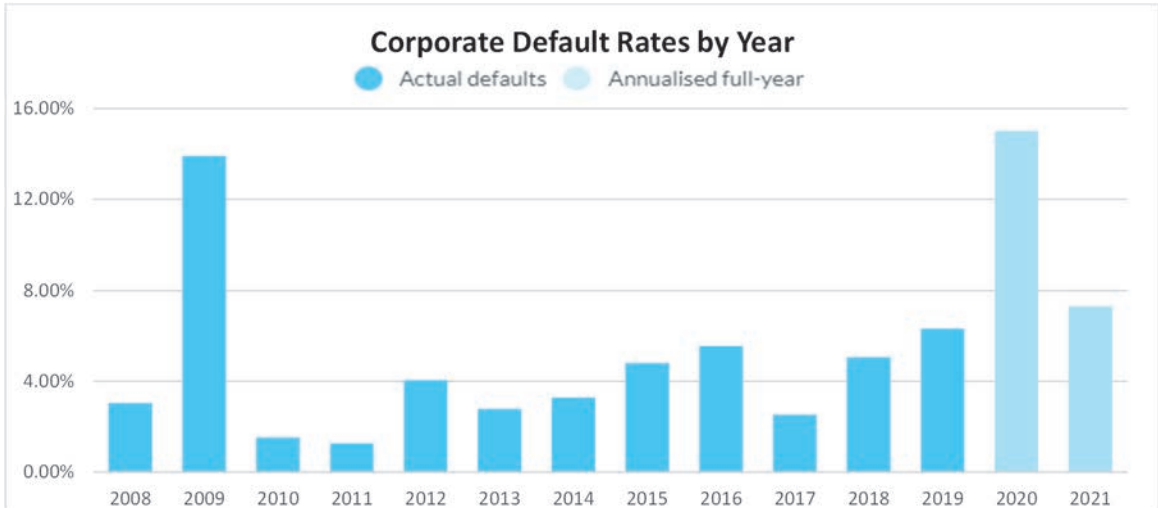
*The response for this part is to be provided in the Excel spreadsheet.*

(ii) Using a quantitative measure, analyze the appropriateness of the scenario reduction techniques. Recommend changes if needed.

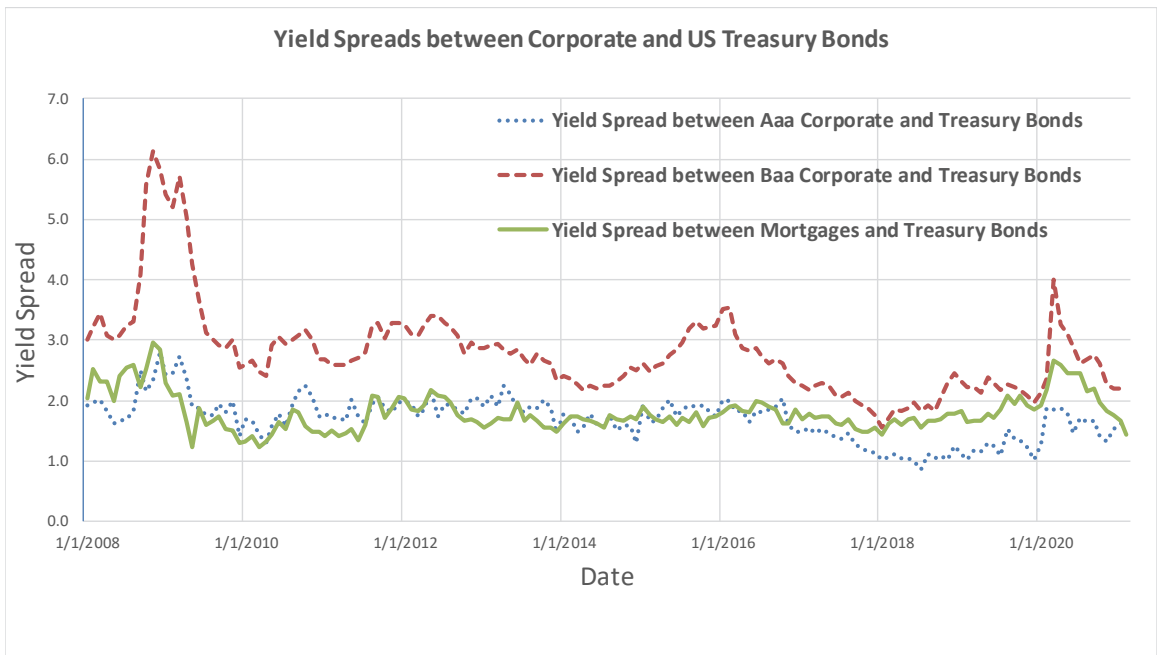
*The response for this part is to be provided in the Excel spreadsheet.*

## 4. Continued

You provided your actuarial student the following charts to analyze impacts on the ESG parameters.

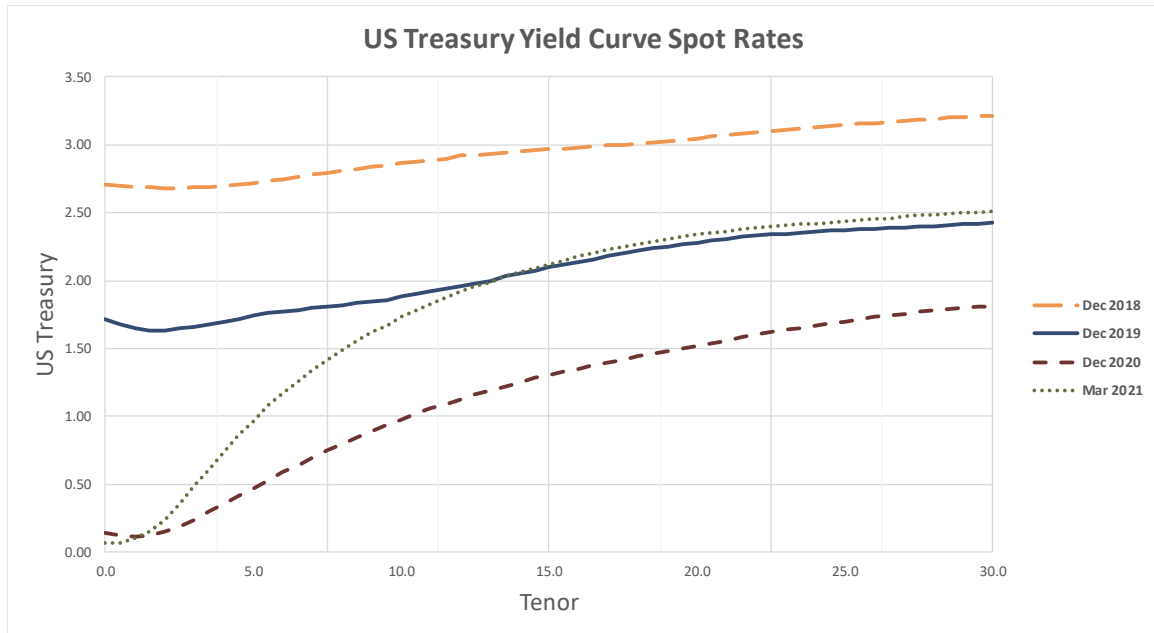


Corporate defaults are expected to decline in 2021 after a sharp rise in 2020. Forecasts project that the default rate will peak at 7.3% in March 2021, and then decline to 4.7% by December.



## 4. Continued

The COVID-19 outbreak has led to significant financial market disruption that has resulted in a marked increase in corporate bond spreads. By March 2021 Corporate spreads have completely recovered and are back to pre-pandemic levels.



(c) (5 points) Your student compiled the following list of observations and considerations. Assess each of the findings.

A. Probabilities of default will rise with general economic conditions as evidenced in 2009 and 2020.

ANSWER:

B. Widening corporate spreads will always track realized default rates.

ANSWER:

C. Corporate spreads gross of defaults fluctuated more because of 2008 and 2020 recessions.

ANSWER:

#### 4. Continued

- D. Baa rated corporate spreads are much more volatile than the Aaa rated bonds as economic condition changes.

ANSWER:

- E. Based on the yield curve from different periods, it is safe to assume interest rates can be floored at 0.

ANSWER:

- F. We experienced inverted yield curve from Dec 2019 to Dec 2020 because all points on the yield curve have decreased.

ANSWER:

- G. Choosing a 10 year look back period for the study is reasonable as it would capture the COVID-19 impact, and therefore produces reasonable stylized facts.

ANSWER:

**\*\*END OF EXAMINATION\*\***