

# Exam ERM-INV

**Date:** Thursday, November 3, 2022

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## INSTRUCTIONS TO CANDIDATES

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### General Instructions

1. This examination has 8 questions numbered 1 through 8 with a total of 80 points.

The points for each question are indicated at the beginning of the question. Questions 1 and 3 pertain to the Case Study and questions 7 and 8 pertain to the Case Study and/or extension readings.

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.

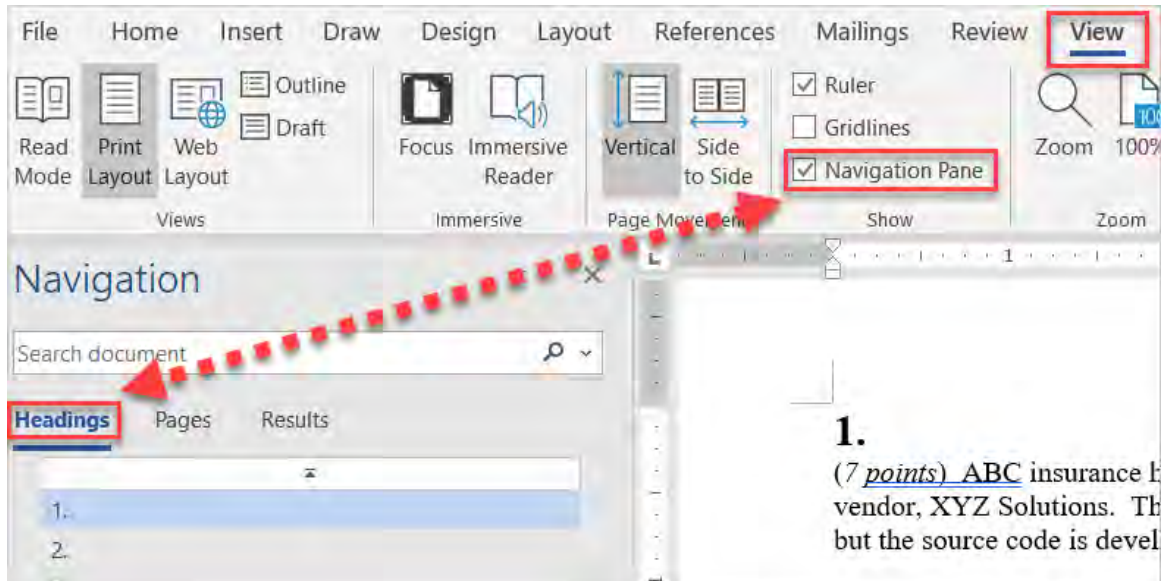
### Written-Answer Instructions

1. Each question part or subpart should be answered either in the Word document or the Excel file as directed. Graders will only look at work in the indicated file.
  - a) In the Word document, answers should be entered in the box marked ANSWER. 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 ^ used to indicate a superscript).
  - b) In the Excel document formulas should be entered. 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) For each question part requiring an answer in Excel, (1) clearly identify the inputs to the calculations, (2) show the necessary interim calculations, adding rows and / or columns, if necessary, and (3) enter the final answer in some or all of the cells highlighted in yellow, as applicable in each circumstance. These cells should contain formulas with links to other calculations in the worksheet. Minimize the use of hard-coded figures and maximize the number of interim steps in the calculations that would demonstrate your line of thinking.
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 files that contain your answers must be uploaded before the five-minute upload period expires.

## Navigation Instructions

Open the Navigation Pane to jump to questions.

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



## **CASE STUDY INSTRUCTIONS**

**The case study will be used as a basis for some examination questions. Be sure to answer the question asked by referring to the case study. For example, when asked for advantages of a particular plan design to a company referenced in the case study, your response should be limited to that company. Other advantages should not be listed, as they are extraneous to the question and will result in no additional credit. Further, if they conflict with the applicable advantages, no credit will be given.**

**Questions 1 and 3 pertain to the Case Study.  
Each question should be answered independently**

**1.**

(11 points) You are an actuary at Lyon working on capital requirements. Improving the economic capital (EC) calculations has been identified as a priority this year.

Refer to section 2 of the Case Study.

- (a) (1.5 points) SLIC has recently engaged more heavily in the use of interest rate swaps to mitigate interest rate risk. SLIC currently uses Lyon's approach of applying a factor to Corporate assets to account for credit risk in the EC framework.

Annabelle, your actuarial student, asserts the exposure to interest rate swap counterparties constitutes additional credit risk and as a result, SLIC's credit risk profile is now materially different than that of Lyon's Corporate assets. She plans to show that continuing with a factor approach may no longer be appropriate for SLIC.

You are given the following information:

- Annabelle suggests that assessing the counterparty credit risk for interest rate swaps will add complexity.
- Annabelle will draft a communication to alert senior management of the emerging counterparty risk, but she admits the risk's relevance is not obvious until she completes a materiality study.
- Annabelle acknowledges that it will be difficult to explain the change in credit risk to internal stakeholders, since swaps are new to both SLIC and Lyon. However, the associated credit risk is well-documented industry-wide and best practices exist for assessing the risk.

Assess the appropriateness of continuing with the factor approach to determine credit risk for SLIC based on Annabelle's suggested approach. Justify your answer.

ANSWER:

## 1. Continued

- (b) (3 points) You and Annabelle decide to recommend that SLIC move to a more sophisticated approach to calculating EC for interest rate swap credit risk. Annabelle proposes the following:

1. Use a Monte Carlo simulation combined with an appropriate interest rate model to generate interest rates in one year.
2. From the resulting distribution of projected interest rates, determine the VaR(85) of the replacement value of each swap transaction. The replacement value for each swap is the credit exposure.
3. For counterparties with multiple swaps, assume netting applies and is enforceable. Then the potential exposure for that counterparty is the gross loss; that is, the sum of all positive exposures only.
4. The maximum potential exposure is then simply the sum of all individual counterparty exposures.

Critique each of Annabelle's proposed steps.

ANSWER:

- (c) (4 points) Senior management shifts focus to the enterprise assessment of EC, as described in Lyon's recent ORSA report.

Refer to sections 2.11 and 2.12 of the Case Study.

- (i) Discuss an advantage and a disadvantage of Lyon's approach to calculating required EC.

ANSWER:

- (ii) Annabelle suggests that it is reasonable to assume complete independence between all of Lyon's subsidiaries, including Lyon Corporate, under normal business and economic conditions. She proceeds with the independence assumption and calculates a combined required EC of \$2,048,357,000 reflecting the diversification benefit of \$1,288,269,000.

Critique Annabelle's assumption.

ANSWER:

## 1. Continued

- (iii) Marcus, your supervisor, states it is a mistake to use Annabelle's correlation assumption in a stressed business and economic environment.

Explain your supervisor's statement.

ANSWER:

- (iv) Propose two unique modeling solutions that could address the correlation issue. Justify your answer.

ANSWER:

- (d) (2.5 points) You have completed additional analyses and determine the following:

- The changes for the enterprise EC would result in approximately 50% of the diversification effect shown in (c)(ii).
- The changes to the calculation of credit risk could further reduce Lyon's EC by approximately 5% of the diversification effect shown in (c)(ii).

Recommend if Lyon should move forward with each of the changes, based on your answers to (a) through (c) and the additional analyses above. Justify your response.

ANSWER:

## 2.

(13 points) EFG Life is a medium-size life insurance company selling traditional whole life policies. You are given the following information:

- EFG is planning to enter the Variable Annuity (VA) market and launch a new VA product this year.
- The guarantees included with the VA product are:
  - Guaranteed minimum accumulation benefit (GMAB): 100% of the initial deposit is returned at maturity
  - Guaranteed minimum death benefit (GMDB): 100% of the initial deposit is paid on death of a policyholder
- Each contract matures after 10 years.
- Policyholders can invest in various equity mutual funds available at contract inception.
- Withdrawals are permitted with a surrender charge of 10% of the account value in the first three years. Afterwards, the surrender charge reduces annually by 2% until it is eliminated.
- Initial deposits at launch total \$30 million.
- A management charge of 200 basis points per year is applied to the account value at the beginning of each year, a portion of which is used to cover the cost of the guarantees.

(a) (7 points) EFG's CRO would like to integrate the VA product into the company Economic Capital (EC) model. You are given the following assumptions:

- The annual mortality rate is assumed to be constant at 0.001
- Renewals, withdrawals, and rollovers are ignored
- The discount rate is 3.00%.

Equity returns are modeled using the distribution described below.

- $S(T) = S(0)e^{\left(\mu - \frac{\sigma^2}{2}\right)T + \sigma\varepsilon\sqrt{T}}$ , where
- $S(0) = 1.0$
- $\mu = 3.00\%$
- $\sigma = 0.3$ , and
- $\varepsilon$  is a random variable from a  $N(0,1)$  distribution.

The EC framework will be based on 100 scenarios of equity returns for the next 10 years. The EC requirement is set as CTE(95) - CTE(0) based on the distribution of losses.

## 2. Continued

95 total simulations have already been run, and the resulting liability calculations are shown on the tab 'Q2(a)(rank)' in the accompanying Excel workbook. Pseudo-random simulated values from the  $U(0,1)$  distribution for the final five scenarios are also available on the tab 'Q2(a)(cash flow)'.

- (i) Describe the process of simulating stock price paths using Monte Carlo methods.

ANSWER:

- (ii) Calculate the required EC for the VA risk. Show your work.

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

- (iii) Critique EFG's approach for modeling EC for VA risk.

ANSWER:

- (b) (3 points) To manage risks associated with VA guarantees, EFG is planning to implement a dynamic hedging program.

- (i) Describe the risks associated with implementing and maintaining dynamic hedging as it relates to the new VA product.

ANSWER:

- (ii) Explain how dynamic hedging could be reflected in EFG's EC framework.

ANSWER:



## 2. Continued

- (c) (3 points) Within two years of the successful product launch, EFG Life grew its assets under management by 500%. Due to this growth, EFG doubled its workforce and implemented a new hedging platform and administrative system to manage the VA business but did not have enough time to properly train the new employees.

EFG had previously identified the following key risks arising from the traditional life insurance business:

- Mortality
- Interest rate
- Credit
- Liquidity

- (i) Evaluate how the success of the new VA product launch should be reflected in the assessment of each of these risks.

ANSWER:

- (ii) Recommend two *key* additional risks that EFG should consider when assessing the newly launched VA block. Justify your recommendation.

ANSWER:

**Questions 1 and 3 pertain to the Case Study.  
Each question should be answered independently**

### **3.**

(11 points) You are an actuary with Caerus Consulting and have been given an assignment to help Lyon Corporation update its ORSA report. Lyon's last ORSA report generated questions from the regulators on the failure to address emerging risks.

Your task is to work with Lyon management to identify and assess relevant emerging risks, and to address them in the next ORSA report. While Lyon does have a new Corporate Risk Committee, you have noted the Committee's relative inexperience with emerging risks.

- (a) (2 points) Rank the appropriateness of the following risk identification techniques for emerging risks. Justify your ranking.
- Individual risk interviews of Lyon's senior management
  - Brainstorming among Lyon's senior management as a group
  - Case studies of other companies and how they dealt with emerging risks

ANSWER:

- (b) (2 points) Lyon's management has decided to focus on climate change as the key emerging risk.

Describe two *key* impacts of climate change on each of Lyon's four subsidiaries.

ANSWER:

### 3. Continued

- (c) (3 points) Recommend a risk mitigation strategy, other than reinsurance, for each risk identified in (b). Justify your response.

ANSWER:

- (d) (3 points) Explain how you would incorporate climate change risk into each of the three sections of the ORSA report.

ANSWER:

- (e) (1 point) Identify the subsidiary most likely to be impacted by climate change. Justify your answer.

ANSWER:

## 4.

(9 points) Company XYZ is a small life insurance company that has been selling Life and Annuity products for the past 20 years.

Detailed information on each product is given below:

- Traditional Life Insurance
  - Level term period of either 20 or 30 years
  - 25% YRT reinsurance
  - Gross reserves of \$50 million, with most policies issued between 2016 and 2018
- Universal Life
  - Designed to accumulate high cash surrender values relative to the death benefit
  - 3% guaranteed minimum crediting rate
  - Gross reserves of \$250 million, with most policies issued between 2005 and 2007
- Fixed Deferred Annuity
  - Flexible premium with a guaranteed crediting rate of 2%
  - Gross reserves of \$150 million
- Variable Annuity
  - Return of Premium Guaranteed Minimum Death Benefit (ROP GMDB), reduced dollar for dollar by withdrawals.
  - Optional Guaranteed Minimum Withdrawal Benefit (GMWB) guarantees the contract holder the ability to withdraw 5% of the benefit base per year for life. An annual fee of 1% is charged on the benefit base.
  - Gross reserves of \$10 million, split equally between policies with GMWB and policies without GMWB.

All mortality and lapse assumptions are based on industry studies, modified by internal experience factors.

In past years, XYZ has relied on external consultants to conduct its scenario and stress testing. XYZ has recently invested in new modeling software with stochastic capabilities, and senior management has expressed interest in bringing its modeling in-house to assist with capital allocation decisions. As the Chief Actuary at XYZ, you are in charge of evaluating XYZ's new modeling capabilities.

#### 4. Continued

You have identified the following three major risk types as relevant to XYZ's current product portfolio:

- Underwriting/Insurance Risk
- Credit/Asset Risk
- Market Risk

(a) (3 points) XYZ currently has limited capacity to implement stochastic scenario testing and plans to apply stochastic modeling for a single product at this time.

(i) Assess, for each product, which risk type would be best suited for stochastic modeling.

ANSWER:

(ii) Recommend which product should be selected for stochastic modeling. Justify your response.

ANSWER:

(b) (1.5 points) XYZ is considering the following four aggregation approaches for calculating Economic Capital:

- Fixed diversification percentage
- Correlation matrix based on its own experience
- Correlation matrix based on industry experience
- Copulas. The software that XYZ has licensed can model copulas, although XYZ has done limited testing of that capability.

Recommend an aggregation technique appropriate for XYZ. Justify your response.

ANSWER:

#### 4. Continued

(c) (2.5 points) At the quarterly meeting of XYZ senior managers, the topic of scenario and stress testing in the internal models was discussed. The following items were specifically mentioned by the CEO:

- Because our ERM department serves as our company's first line of defense, our CRO and her team should be responsible for developing the scenarios and stresses.
- We will rely on the ERM team to explain the results.
- Our risks are siloed enough that we should not have to worry about dependencies.
- These results should be provided shortly after quarter-end reporting if we are to use them in our planning processes.

Critique each of the CEO's statements.

ANSWER:

(d) (2 points) In past cycles, XYZ has leveraged stress tests promulgated by regulators to demonstrate the strength of the business.

Explain why adopting an internal model could be viewed favorably by regulators.

ANSWER:

## 5.

(5 points) You are an actuary, recently hired by QRY as part of the new corporate level ERM function. QRY is a stock-based holding company that owns the following subsidiaries:

<b>Company</b>	<b>Description, including existing risk management</b>	<b>Challenges</b>
Hollywood Life	A life insurance company, providing individual whole life coverage to wealthy clients, with 20% quota share reinsurance with a highly rated reinsurer for all policies. The company has a very conservative investment policy, holding only Treasuries and investment grade corporate bonds. The Asset-Liability Management team produces quarterly duration analysis and requires rebalancing whenever liability durations exceed asset durations by more than 1.0.	Profit margins have been quite low, so the company has started to add private placements and oil and gas investments to increase yield.
California HomeGuard	A California-based property and casualty company which provides home and property coverage to California residents only. No reinsurance exists for this subsidiary; it is informally assumed that the holding company provides adequate protection if required.	The company has been profitable until recently when wildfires generated unexpected levels of claims.
HealthGuard	A health insurer, with a relatively young customer demographic. Prior to 2020, profits from this subsidiary provided a regular dividend to QRY. Because customers are young, no reinsurance is in place.	COVID-19 experience has led to increased liabilities and claims expenses, and no dividend was paid to QRY in 2020 or 2021.

Using its accumulated retained earnings, QRY is planning to invest in a fourth subsidiary and is considering multiple options.

You have been asked to consider the importance of liquidity risk to QRY and its subsidiaries.

## 5. Continued

(a) (3 points)

(i) Describe the two types of liquidity risk.

ANSWER:

(ii) Evaluate how the current operations and planned activities expose QRY to each type of liquidity risk.

ANSWER:

(b) (2 points)

(i) Evaluate existing risk management techniques for liquidity risk for QRY and its subsidiaries based on the information provided above.

ANSWER:

(ii) Recommend improvements to liquidity risk management for QRY and its subsidiaries, including both changes to existing risk management techniques and new approaches. Justify your response.

ANSWER:



## 6.

(11 points) ABC is an insurance company specializing in auto and property insurance. ABC's risk management team is evaluating the risk of the company's two lines of business.

- (a) (3 points) A normal distribution is used to estimate the annual claim loss for each line of business below. The risk tolerance is set to the maximum annual claim loss for each line that management is willing to accept. ABC management defines the aggregate risk tolerance for the company as the sum of risk tolerances for each line of business.

Annual Claim Losses			
Line of Business	Mean (\$ million)	Standard Deviation (\$ million)	Risk Tolerance (\$ million)
Auto	200	20	210
Property	40	5	45

- (i) Calculate the probability that annual claim losses are above the risk tolerance for each line of business. Show your work.

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

- (ii) Calculate the probability that at least one of the lines of business losses is above the risk tolerance using the Clayton Copula function for the dependence below using the tab 'Q6(a)(i)(ii)' in the accompanying Excel workbook. Show your work.

$$C(u_1, u_2) = (u_1^{-2} + u_2^{-2} - 1)^{-1/2}$$

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

- (iii) Recommend two risk management actions to lower the aggregate risk of the portfolio. Justify your response.

ANSWER:

## 6. Continued

- (b) (6 points) A stochastic model was used to create 10,000 simulations of ABC's annual losses by line of business. The table in the accompanying Excel workbook, tab 'Q6(b)(i)(ii)(iii)', shows the 100 highest total simulated losses (in \$ millions). The company uses Risk-Adjusted Return on Risk-Adjusted Capital (RARORAC) and Economic Value Added (EVA) in analyzing its results.

Assume the following:

- The total required risk capital for ABC is \$200 million and the opportunity cost is 8%.
  - The projected risk-adjusted return is \$5 million for Auto and \$4 million for Property.
  - The projected net income is equal to projected risk-adjusted return for each line of business.
- (i) Calculate the amount of risk capital to assign to each line of business using a Co-TVaR capital allocation approach at the 99.6 percentile. Show your work.

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

- (ii) Calculate RARORAC for each line of business. Show your work.

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

- (iii) Calculate EVA for each line of business. Show your work.

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

- (iv) Recommend two risk mitigation actions for the company given the RARORAC and EVA for each line of business. Justify your response.

ANSWER:

## 6. Continued

- (c) (2 points) ABC executives target a 20% growth in auto insurance sales.

A new bonus structure is being introduced to incentivize sales growth over a one-year horizon. You discover that the executive bonus structure is heavily tied to sales growth but does not consider risk.

- (i) Explain what risk governance issues are created by this bonus structure.

ANSWER:

- (ii) Recommend two additions to the executive bonus structure to mitigate the risk governance issues you identified in (i). Justify your response.

ANSWER:

**Questions 7 and 8 pertain to the Case Study and/or extension readings.  
Each question should be answered independently.**

**7.**

(10 points) GSI, an insurance company, is developing a fixed annuity product with three-year minimum guaranteed crediting rates. GSI invested \$50 million in corporate bonds to support the liability.

The corporate bond portfolio consists of 1-year, 2-year and 3-year annual coupon bonds bought at par with weights of 10%, 10% and 80%, respectively. You are given the following information.

	Expected Cash Flow (Per \$100 Par Value)			
Year	1-Year Bond	2-Year Bond	3-Year Bond	Discount Factor
1	\$103	\$4	\$5	0.9709
2		\$104	\$5	0.9242
3			\$105	0.8621

You are also given the correlation matrix of zero coupon bond returns and undiversified individual VaRs for different maturity terms.

Correlation Matrix				
Term	1 Year	2 Year	3 Year	Undiversified Individual 1 Year Horizon VaR (95%)
1 Year	1	0.9	0.8	3.40%
2 Year	0.9	1	0.92	3.90%
3 Year	0.8	0.92	1	4.20%

- (a) (5 points) Calculate the diversified 1 year horizon VaR (95%) of the bond portfolio using the cash flow mapping approach. Show your work.

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

## 7. Continued

The Chief Actuary has suggested increasing investment return by allocating \$6 million from the bond portfolio to equity while keeping the bond allocation proportions unchanged. You are given the following information.

- Per \$ risk exposure for equity is 0.15.
- Per \$ risk exposure for bond should be based on part (a).
- The correlation between the equity and bond portfolios is 0.1.
- The total risk budget is \$2 million.

- (b) (3 points) Calculate the value to be reallocated between the equity and corporate bond portfolios to achieve a total risk budget of \$2 million. Show your work.

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

- (c) (2 points) Evaluate the Chief Actuary's recommendation.

ANSWER:

*Questions 7 and 8 pertain to the Case Study and/or extension readings.  
Each question should be answered independently.*

**8.**

(10 points) Refer to the February 16, 2022 memo from Max Hawke related to Aivilo's defined benefit pension plan (Case Study section 4.14). Assume the risk-free rate is 5%.

- (a) (1 point) Describe two factors that the plan must consider from a completion portfolio perspective when using hedging assets.

ANSWER:

- (b) (2 points) Compare and contrast using zero coupon bonds vs. using zero coupon interest rate swaps to match the plan's liabilities.

ANSWER:

- (c) (1 point) Describe the cash flows at time zero and at the end of five years:

- (i) Using zero coupon bonds

ANSWER:

- (ii) Using zero coupon interest rate swaps

ANSWER:

- (d) (2 points) Demonstrate that both methods protect against risk if the risk-free rate falls by 1% immediately. Show your work.

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

- (e) (1 point) Recommend which method to use. Justify your recommendation.

ANSWER:

## 8. Continued

(f) (3 points) Max is considering using a callable bond with an embedded call option from the issuer to support the pension plan.

- The bond has a current market value of \$1.1 million.
- The embedded call option matures in one year and has a strike of \$1.5 million.
- The volatility of the call option is assumed to be 10%.

(i) Calculate the value of the option. Show your work.

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

(ii) Describe the benefits and risks of using a callable bond with embedded call option to support the pension plan.

ANSWER:

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