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**SOCIETY OF ACTUARIES**  
**Enterprise Risk Management – General Corporate ERM Extension**

# Exam ERM-GC

**Date:** Tuesday, October 31, 2017

**Time:** 8:30 a.m. – 12:45 p.m.

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## INSTRUCTIONS TO CANDIDATES

### General Instructions

1. This examination has a total of 80 points.

This exam consists of 8 questions, numbered 1 through 8.

The points for each question are indicated at the beginning of the question. Questions 7 and 8 pertain to the extension readings and/or the Case Study, which is enclosed inside the front cover of this exam booklet.

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 ERM-GC.
6. Be sure your written-answer envelope is signed because if it is not, your examination will not be graded.

Tournez le cahier d'examen pour la version française.



## **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.**



**\*\*BEGINNING OF EXAMINATION\*\***

- 1.** (6 points) You are an external consultant hired by ABC Life Insurance Company (ABC) to assist with the preparation of the company's first Own Risk and Solvency Assessment (ORSA).

You are provided with the following information regarding ABC:

- It sells term life insurance and variable annuities. All variable annuities have guaranteed benefits.
- It is U.S.-based and issues its products only in the United States.
- The Board of Directors consists of ten members, including the Chief Executive Officer of ABC. The CEO of ABC also acts as the Chairman of the Board.
- The company is a closely held family business and seven board seats are held by family members. Most members on the Board have served more than five years, including the Chairman of the Board.
- The Audit Committee, which reports directly to the Board, has a primary mandate to review the financial statements produced by ABC and to report on public disclosure documents containing financial information pertinent to ABC.
- The primary responsibilities for ABC's Enterprise Risk Management belong to the Audit Committee.

- (a) (3 points) After reviewing what ORSA is intended to achieve, you are prepared to recommend to the Board changes in the corporate structure of ABC.
- (i) Describe three weaknesses of the company's current organizational structure.
  - (ii) Discuss how ABC's corporate structure needs to be modified to satisfy the requirements of ORSA.
- (b) (2 points) To implement ORSA, ABC decided to perform a single stress test combining the following three shocks:
- Equity Shock: Equities down by 5%
  - Interest Shock: Interest rate curve shift down by 1% for all maturities
  - Lapse Shock: Policy lapse / surrender level increase by a factor of 1.1 for all products and all durations.

Critique ABC's approach.

- (c) (1 point) Outline three major additional considerations necessary to comply with the ORSA requirements.

2. (13 points) You are working on a project to calculate VaR using different methodologies. As part of the project, you want to minimize computer runtime because of the extensive calculations for VaR. You assume that the claim distribution is given by the following table of actual insurance claims for the previous 100 months, ordered from smallest to largest.

Claim #	Claim Amount
1-50	100
51-90	150
91	5,100
92	5,200
93	5,300
94	5,400
95	5,500
96	5,600
97	5,700
98	5,800
99	5,900
100	6,000

- (a) (1.5 points) For these insurance claims,
- (i) Calculate the absolute VaR at 95% confidence level. Show your work.
  - (ii) Calculate the relative VaR at 95% confidence level. Show your work.
- (b) (3 points) Instead of calculating VaR from the full distribution of insurance claims, you are investigating a Monte Carlo simulation using the following 10 random numbers between 0 and 1, ordered from smallest to largest:

0.08	0.23	0.26	0.29	0.49	0.65	0.69	0.80	0.91	0.92
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Calculate the following items using direct simulation from the 10 random numbers (i.e., the “naïve” simulation):

- I. Mean
- II. Absolute VaR at 95% confidence level
- III. Relative VaR at 95% confidence level

## 2. Continued

- (c) (6 points) You plan to do a simulation using the importance sampling technique. You are given the change of measure from original equal probabilities to shifted unequal probabilities. Each original scenario has a 1.0% probability of occurrence. To test shifted unequal probabilities, you assume each of the scenarios 1-90 have a 0.1% probability and scenarios 91-100 each have a 9.1% probability of occurrence. The table of shifted probabilities is provided below:

Scenario #	Probability
1-90	0.1%
91-100	9.1%

- (i) Recalculate the simulated insurance claims for each of the 10 random numbers in part (b) using the accumulated shifted unequal probabilities. Show your work.
- (ii) After the shift of the probabilities, VaR needs to be calculated using a shifted confidence level.

Calculate the absolute VaR at 95% using the recalculated insurance claims in (i) and a shifted confidence level of 50%. Show your work.

The simulated insurance claims from shifted unequal probabilities need to be modified by reflecting the likelihood ratios. The following are the likelihood ratios for the ten simulated insurance claims from (i) (simulated claim 1 was generated using the random number 0.08):

Simulated Claim	Likelihood Ratio
1	10.00
2-10	0.11

- (iii) Calculate the claims based on the importance sampling method for each of the simulated insurance claims from (i). Show your work.
- (iv) Calculate the relative VaR at 95% confidence level using the importance sampling method. Show your work.
- (d) (2.5 points) After the calculations, you are ready to inspect the results based on the various approaches.

Analyze the results produced in your calculations of VaR using naïve simulation and importance sampling. Include the reasoning behind the results they produce.

**3.** (12 points) Bank MC is a fast growing derivatives dealer in an emerging market. MC currently does not have a formal derivatives credit risk management function. You are the leader of the derivatives products team in MC. MC currently has no netting or collateral agreements.

(a) (2 points) In derivatives activity, there are three important stakeholders:

- Dealers
- End-Users
- Supervisors

(i) Provide two examples of each stakeholder.

(ii) Compare and contrast the roles of each stakeholder with respect to derivatives risk management.

(b) (2 points) The CFO decided that the finance department would control the overall credit risk exposure and the company's risk appetite. The CFO asked you to add the responsibility of derivatives credit risk management into your existing team as an additional function.

(i) Describe the responsibilities of a derivatives credit risk management function.

(ii) Identify three areas of concern in regard to the CFO's decisions. Justify your response.



### 3. Continued

- (c) (5 points) You receive only the following reports for monitoring the derivatives credit risk.

Quarterly report – all counterparties – current derivatives portfolio (MV/MtM in \$M)

Counterparty	Credit Exposure	Products					
		1	2	3	4	5	6
A	\$ 61.2	\$ 29.1	\$ 18.9	\$ 13.2	\$ (5.2)	\$ (12.1)	\$ -
B	\$ 295.8	\$ 84.5	\$ 133.7	\$ 77.6	\$ (89.2)	\$ (98.3)	\$ (100.5)
C	\$ 75.3	\$ 62.1	\$ 13.2	\$ -	\$ -	\$ (25.2)	\$ -
Other small counterparties	\$ 275.2	\$ 120.2	\$ 65.7	\$ 89.3	\$ (71.2)	\$ (131.2)	\$ (24.2)
Total	\$ 707.5						

Weekly report – new derivatives transactions only (MtM in \$M)

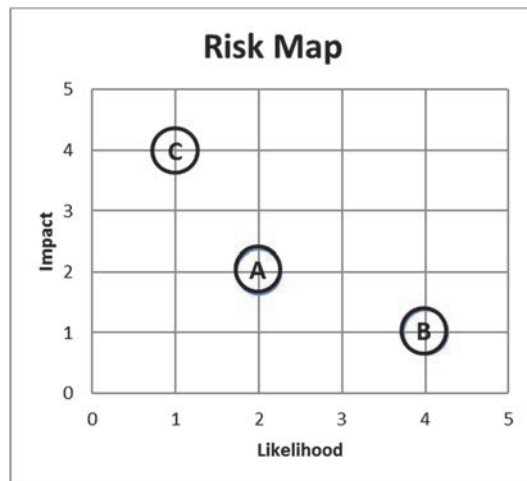
Counterparty		Products					
		1	2	3	4	5	6
A		\$ 1.1	\$ -	\$ 2.2	\$ (1.5)	\$ -	\$ -
B		\$ 8.4	\$ 2.3	\$ 25.0	\$ (2.9)	\$ (11.3)	\$ (13.2)
C		\$ 7.8	\$ -	\$ -	\$ -	\$ (2.1)	\$ -

- (i) Describe three areas of concern in regard to Bank MC's reporting process and current counterparty exposure.
- (ii) Recommend a risk mitigation strategy for each of the concerns identified in (i).
- (iii) MC wants to evaluate the impact of entering into a bilateral netting agreement with Counterparty B.

Calculate the impact of this agreement, from MC's perspective, on the counterparty credit default risk for both MC and Counterparty B using the provided weekly data. Show your work.

- (iv) Recommend additional steps Bank MC should take to help monitor and mitigate its current counterparty exposure.
- (d) (3 points) The CFO has approached you about the management of market risk within your department. Your team currently uses a dynamic hedge on option-based derivatives.
- (i) Describe advantages and disadvantages of using dynamic hedging versus static hedging on option-based derivatives.
- (ii) Describe the risks associated with the dynamic hedging of MC's market risk.

4. (9 points) Health Insurance Company (HIC) uses risk maps to assess its risks and identify key risks. Below is the risk map used by HIC for three of its key risks. HIC's risk tolerance level is 99.3% for each risk.



The following key risks are shown in the risk map above:

- A. Inappropriate investment of assets
- B. Cyberattack
- C. Severe epidemic

(a) (2 points)

- (i) List advantages and disadvantages of using a risk map.
- (ii) Rank the risks. Justify your answer.

#### 4. Continued

- (b) (3 points) To evaluate severe epidemic risk, the following annual aggregated loss probability distribution table for losses caused by epidemics is used. The table was developed using hard data and soft data from both internal and external sources.

Annual Aggregate Loss	Probability
\$1,000	20.5%
\$10,000	60.0%
\$100,000	18.0%
\$10,000,000	0.8%
\$20,000,000	0.7%

- (i) Calculate the aggregated expected loss and aggregated unexpected loss. Show your work.
- (ii) Your manager has recommended that only hard data be used when developing the annual aggregated loss probability distribution table.

Critique your manager's statement.

*Question 4 continued on the next page.*

#### 4. Continued

(c) (4 points) You are given the following information.

- The company aggregates the three risks using three methods with the risk value populated for two of them.

Method	Aggregate Risk Value
Correlation Matrix	
Copula	\$13,607,900
Scenario-based	\$17,533,829

- The correlation matrix among the three risks is given in the table below.
- Aggregated Unexpected Loss for inappropriate investment of assets is \$8,000,000.
- Aggregated Unexpected Loss for a cyberattack is \$5,500,000.

Risks Correlation Matrix			
	A	B	C
A	1.00		
B	0.20	1.00	
C	0.02	0.01	1.00

- (i) Calculate the aggregate unexpected loss using the correlation matrix. Show your work.
- (ii) Recommend a method for aggregating the three risks. Justify your response.
- (iii) The maximum risk capital you are prepared in any given year for aggregate unexpected risk loss of the three risks is \$20,000,000.

Determine whether the current risk capital meets HIC's risk tolerance level.

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5. (12 points) You are the pricing actuary for MH Life Reassurance. MH pricing guidelines require a minimum Return on Capital (ROC) of 20%. Capital is established at the VaR (95%) level.

You are provided the following annual loss distributions determined by cedents relating to different reinsurance opportunities of underlying annual group life insurance business. Both cedents are concerned with their tail risks.

Treaty	Cedent A		Cedent B	
	Probability	Loss	Probability	Loss
Annual Loss Distribution	5%	-	5%	-
	5%	1.5	10%	33.0
	80%	2.0	50%	36.0
	5%	2.5	10%	38.0
	5%	15.0	10%	44.0
			10%	46.0
			5%	49.0

- (a) (2.5 points) Consider each of the following deficiencies of VaR:

- Bricolage
- Historical Data and Observation Period
- Agency Risk

For each of the deficiencies identified above:

- (i) Define the deficiency.
- (ii) Explain whether or not the deficiency is relevant in the context of the MH pricing exercise.
- (b) (3 points) Your manager wants you to calculate premiums for the two reinsurance opportunities, and tells you to use the following simplified formula for profit:

$$\text{Profit} = \text{Premiums} - E(\text{Loss})$$

- (i) Demonstrate that the VaR (95%) for both options is 12.45.
- (ii) Demonstrate that the minimum premiums which satisfy MH's pricing objectives are 5 for Cedent A and 39 for Cedent B.

## 5. Continued

- (c) (1.5 points) Propose two conditions to be introduced to MH pricing guidelines which would complement the ROC based pricing hurdle.
- (d) (1 point) MH can enter only one of the two reinsurance treaties.

Explain whether MH should be indifferent between these two treaties from a capital perspective. Justify your response.

- (e) (4 points) You have been informed that the minimum required premium for Cedent B was considered too expensive by the cedent and exceeded the direct premium assessed by Cedent B. You are asked to evaluate the following options aimed at reducing the reinsurance premium:

- I. MH reinsures 75% of the entire underlying risk using a Quota Share treaty.
- II. MH reinsures 100% of the entire underlying risk subject to a maximum payout of \$36.55.
- III. MH provides stop-loss coverage which attaches at \$36.55.

- (i) Provide a loss distribution reflecting each of I, II and III from MH's perspective.
- (ii) Explain using qualitative arguments why options I and II are unlikely to be attractive reinsurance structures for the cedent.
- (iii) Provide qualitative and quantitative arguments supporting option III.

6. (8 points) NewCo is an insurance company that recently sold its first structured settlement policy which provides the policyholder payments for the next five years, as shown below.

Year	1	2	3	4	5
Payout (\$ thousand)	100	210	530	220	110

NewCo's actuary, Brian, provides you with the following information:

- The reserves as of today are \$1.1 million.
- The assets backing the reserves have not yet been purchased but NewCo is targeting a duration of 3 with a value of \$1.1 million.
- The net single premium from the policy, after all commissions and expenses were paid, was \$1.1 million.

The company's objective is to fully immunize its surplus against changes in interest rates.

Brian wants to test the balance sheet under different interest rate scenarios and provides the following information:

Year	Liability Key Rate Duration	Scenario 1: Level	Scenario 2: Steepness	Scenario 3: Curvature
1	0.09	+10 bps	+0 bps	-20 bps
2	0.36	+10 bps	+0 bps	+1 bps
3	1.36	+10 bps	+0 bps	+20 bps
4	0.73	+10 bps	+25 bps	+34 bps
5	0.46	+10 bps	+35 bps	+60 bps

- (a) (2 points) Construct a replicating portfolio using cash and zero-coupon bonds that immunizes against any yield curve shift. Show your work.

The product was priced assuming half of the assets are invested in 2-year zero coupon bonds and the other half are invested in 4-year zero coupon bonds. Your actuarial student has suggested using the same assets for investments and the yield curve shift in scenario 3 to estimate the asset value.

- (b) (3 points)
- Calculate the change in surplus (equity) under scenario 3 using the actuarial student's approach. Show your work.
  - Provide a qualitative description of the change in surplus under Scenarios 1 and 2.



**6. Continued**

(c) (3 points)

- (i) Describe the advantages and disadvantages of your actuarial student's suggestion with respect to the portfolio determined in (a).
- (ii) Determine whether the suggestion satisfies NewCo's objective. Show your work.
- (iii) Recommend whether the company should accept the suggestion.

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

**7.** (9 points)

- (a) (2.5 points) You are reviewing Patrick Lyon's Corporate ERM Department memo in section 2.6 of the case study.
- (i) Assess to what extent the Corporate ERM Department framework he lays out meets the three lines of defense risk management framework. Justify your response.
  - (ii) Assess how Patrick Lyon's memo is evidence of a robust risk management culture with respect to the responsibilities of senior management and the Board of Directors.

One of the first initiatives of the Lyon Corporate ERM Department is to assess the current incentive compensation plans at the subsidiary companies.

- (b) (2.5 points)
- (i) Describe four principles to be followed in designing an effective incentive compensation plan.
  - (ii) Evaluate how AHA's proposed Contingent Compensation Plan for brokers aligns with each of the four principles.

## 7. Continued

- (c) (2.5 points) You have been made aware of the following situation that occurred at AHA:

Jimmy Pike, a senior broker for AHA, worked hard to sign up a large institutional client. This sale could potentially double his book of business. Jimmy received a report from the new business department showing that this would be a profitable case for AHA. Shortly before his meeting to sign the contract with the client, Jimmy found an error in the analysis. Specifically, he noticed that certain administrative expenses had been understated by a factor of 10. He could see that correcting the error would likely make the case unprofitable. However, he proceeded to sign the contract with the client anyway.

- (i) Categorize the type of operational risk illustrated in the case above. Justify your response.
- (ii) Explain how AHA's current risk management philosophy, as highlighted in AHA's Report to Corporate and their broker compensation plan, may contribute to this type of risk.
- (iii) Recommend changes AHA should make to mitigate this type of risk.
- (d) (1.5 points) You are considering the unique compensation structure of AHA's potential acquisition target, Columbia Health, as an alternative example of a health insurance company approach to compensation.

Evaluate the pros and cons of Columbia's compensation structure from the perspective of risk to Columbia.

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

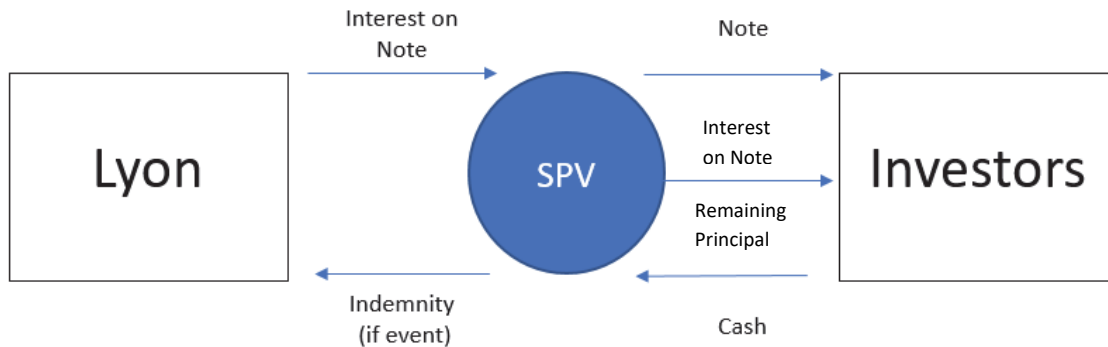
- 8.** (11 points) You are an actuary within Lyon’s Corporate ERM Department, and have been following the much-publicized emergence of cybersecurity risk at corporations. You are reviewing Lyon’s current cybersecurity risk management practices for potential improvement to meet this increasing threat.
- (a) (1 point) Contrast, from Lyon’s perspective, two ways in which cybersecurity risk differs from the risks associated with the Personal Auto line of business.
  - (b) (1 point) Compare and contrast management of cybersecurity risk through internal mitigation versus risk transfer.
  - (c) (4.5 points) With respect to internal risk mitigation, you intend to follow the five critical attributes of effective cybersecurity risk management, as follows:
    - I. An Effective Framework
    - II. End-to-End Scope
    - III. Thorough Risk Assessment and Threat Modeling
    - IV. Proactive Incident Response Planning
    - V. Dedicated Cybersecurity Resources

For each attribute, I through V:

- (i) Describe the objective of the attribute.
- (ii) Identify one gap in Lyon’s current cybersecurity risk management processes as outlined in section 2.6.2.3 of the Case Study.
- (iii) Recommend a remediation action to address the gap identified in (ii).

## 8. Continued

- (d) (2.5 points) Lyon wants to consider transferring the risk that remains following the implementation of the DataShield software. One approach to transfer this risk would be to sponsor a catastrophe bond. The note will be issued to investors who will receive interest payments in exchange for providing protection from all losses relating to cybersecurity risk up to the principal of the notes.



For the above financial structure:

- (i) Explain how investors could be exposed to adverse selection.
  - (ii) Explain how investors could be exposed to moral hazard.
  - (iii) Recommend two specific features that should be included in the structure to remediate the issues identified in (i) and (ii).
- (e) (2 points) Upon reviewing Lyon’s current cybersecurity risk management process, you have identified several gaps when measured against the critical attributes of effective cybersecurity risk management. You ultimately develop a comprehensive cybersecurity risk strategy, which, in addition to the DataShield software already purchased, includes both additional hiring and buying protection through various risk transfer mechanisms.

However, as you present your plan to the Board of Directors, Tomas Lyon III interrupts you.

He says: “I don’t want to use additional shareholder capital to pay for more cybersecurity protection. It seems like we have done enough as it is. Spending all this money will hurt our earnings this quarter. Furthermore, a large cybersecurity event is so rare that even without all these expenditures, Kelly Ratings gives us an A- rating. I think your additional programs are unnecessary.”

Critique Tomas Lyon’s statement and propose a suitable response.

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

**USE THIS PAGE FOR YOUR SCRATCH WORK**

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