

Exam ERM-INV

Date: Wednesday, May 5, 2021

INSTRUCTIONS TO CANDIDATES

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 4, 5, and 6 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

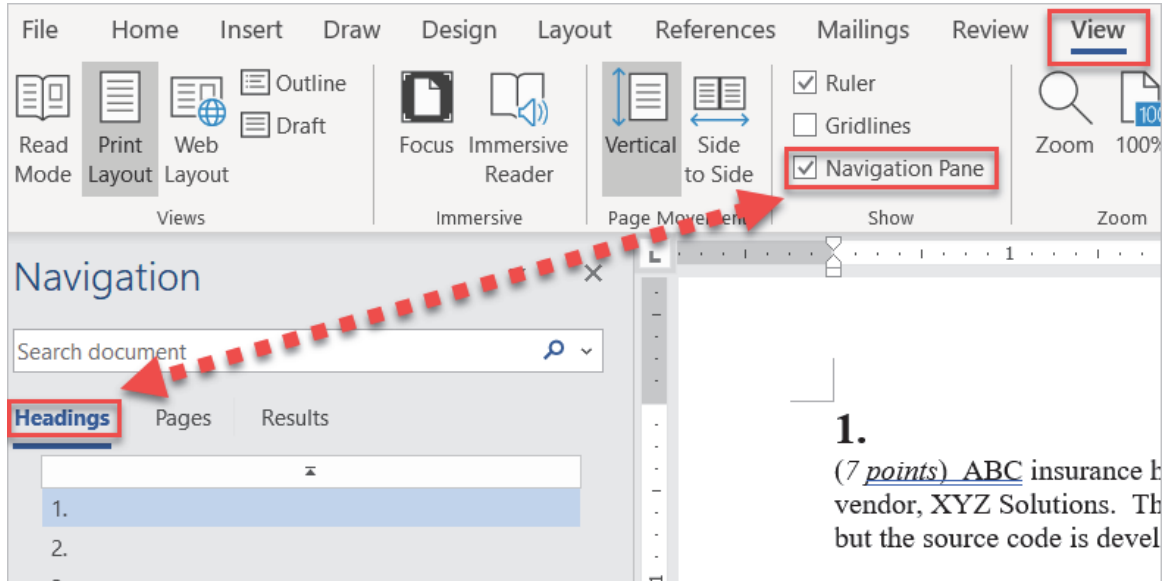
1. Each question part or subpart should be answered either in the Word document or the Excel file as directed. Graders will only look at work in the indicated file.
 - a) In the Word document, answers should be entered in the box marked ANSWER. The box will expand as lines of text are added. There is no need to use special characters or subscripts (though they may be used). For example, β_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 time 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:



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.

1.

(10 points) ABC Re (ABC) is an international reinsurance company with business units in North America, Europe, and Asia.

ABC is considering outsourcing the development and maintenance of its operational systems to DEF, an external company that specializes in developing and customizing platforms for financial institutions. DEF is located in Bermuda.

You are hired as a risk management consultant by ABC's Vice President of Strategy Planning (VP).

You are given the following information:

- Currently, direct insurers send their data and financials to ABC according to a pre-arranged schedule.
- Premium, claim, inforce, and termination data from ABC's clients are in various formats and handled separately through several of ABC's existing systems which are not capable of handling large volumes of data.
- DEF will incorporate new technologies, make use of big data, and develop a system that can unify the functionalities of all of ABC's existing legacy systems in all geographies.
- DEF will be responsible for maintaining the newly developed system after it is delivered to ABC.
- If DEF is hired, the planned timeline for the development and transition is two years.
- There is disagreement amongst ABC's senior management whether to undertake this project.

(a) (3 points) The VP is concerned that hiring DEF will increase ABC's operational risk.

(i) Explain why each of the following operational risks could increase.

- People Risk
- Reputational Risk

ANSWER:

(ii) Explain how the new system could improve data quality.

ANSWER:

1. Continued

- (b) (3 points) If DEF is hired, the VP will organize a steering committee consisting of key internal stakeholders.
- (i) List and explain the steps that need to be taken by the steering committee to ensure an effective development process for the new system.

ANSWER:

- (ii) Propose three review and testing procedures that ABC can adopt to validate the new system.

ANSWER:

- (c) (3 points) You are asked to design and implement an internal control framework for ABC to effectively manage the risk of hiring DEF and implementing the new system.

Recommend four controls to be adopted in your design. Justify your answer.

ANSWER:

- (d) (1 point) Recommend whether ABC should proceed with the proposal. Justify your response.

ANSWER:

2.

(11 points) ERM Life is concerned about the impact of a potential pandemic on its mortality and liquidity risks.

In order to mitigate mortality risk, ERM Life is considering the use of either traditional or alternative risk transfer means.

(a) (2 points) ERM Life is considering the use of reinsurance to address its concerns with catastrophic mortality claims. The following reinsurance alternatives have been offered to ERM Life:

- 50% pro-rata reinsurance
- Per risk excess of loss reinsurance
- Per occurrence excess loss reinsurance
- Aggregate excess of loss reinsurance

Assess the suitability of each of these alternatives to mitigate ERM Life's catastrophe risk exposure.

ANSWER:

(b) (4 points) ERM Life is also considering the following alternative risk transfer approaches to cover catastrophic mortality claims:

- Issuing a catastrophe bond sold through a dedicated Special Purpose Vehicle (SPV)
- Participating in a self-insurance pool
- Setting up its own captive

(i) Describe each approach.

ANSWER:

(ii) Analyze the appropriateness of each approach to mitigate ERM Life's catastrophic mortality risk.

ANSWER:

2. Continued

ERM Life has agreed to a reinsurance treaty. The treaty will cost ERM Life a first-year premium of \$10 million to be paid one week from today. ERM Life will pay for this premium by liquidating some equity shares of its asset portfolio. ERM Life owns 100,000 shares of Stock Company with a market price of \$103.00 per share as of today.

ERM Life is considering two options:

- 1st option: Liquidate 100,000 shares immediately
- 2nd option: Liquidate 20,000 shares each of the next five trading days

(c) (0.5 points) Describe the asset liquidity impact of each option.

ANSWER:

(d) (4.5 points) It has been suggested that ERM Life use liquidity-adjusted VaR (LVaR) to inform its decision on how to pay the reinsurance premium. You are given the following information for the liquidation options:

- Price impact of the 1st option: \$257,500
- Price impact of the 2nd option: \$51,500
- Asset portfolio VaR for 2nd option: \$361,623

(i) Recommend which liquidation option ERM Life should implement in order to pay the reinsurance premium. Justify your answer.

ANSWER:

(ii) Describe other aspects of asset and liability liquidity risks that ERM Life should consider when entering into this transaction.

ANSWER:

(iii) Describe two other relevant risks that ERM Life should consider when entering into this transaction.

ANSWER:

3.

(8 points) You work on the credit risk management team at a large insurance company. Your team's responsibilities include analyzing credit risks of the company's fixed income portfolio.

(a) (2 points) There are several modeling approaches used for estimating default probabilities, including:

- Merton's model
- KMV Moody's
- Models incorporating bond prices

(i) Compare and contrast the structure and use of reduced-form models and structural models.

ANSWER:

(ii) Identify whether each of these models is a reduced-form model or a structural model. Justify your response.

ANSWER:

(b) (1 point) Using bond prices, the credit spread of a bond can be calculated and used to estimate the expected credit loss. Thus, your colleague claims that if bond A has higher spread than bond B, bond A must have higher probability of default than bond B.

Explain whether your colleague's statement is correct.

ANSWER:

3. Continued

(c) (5 points) Your team has been working on a project using simulations to estimate tail credit loss of the company's portfolio. You use copulas in the simulations to capture the dependencies between credit losses on bonds in the portfolio. You are given the following information:

- The time horizon is one year.
- The returns of each bond issuer's asset portfolio are simulated assuming they follow a lognormal random walk.
- A correlation matrix of the returns of the bond issuers' assets.
- The following have already been estimated for each bond issuer: the growth rate of the asset value, the volatility of the asset value, default threshold, exposure, and loss given default.

(i) Describe the steps to simulate the asset values of the bond issuers and to calculate credit loss of your company's portfolio using a Gaussian Copula. You do not need to give any formulas.

ANSWER:

(ii) Your other choice of copula is Student's t.

Describe how the simulation process would need to change in order to incorporate a Student's t copula into the simulation. You do not need to give any formula.

ANSWER:

(iii) You run two simulations, each generating 10,000 samples – one using a Gaussian copula and the other using a Student's t copula. You then calculate the credit loss at the 99th percentile from each simulation.

Compare the VaR(99) results you would expect between the two simulations. Justify your answer.

ANSWER:

3. Continued

- (iv) Recommend which copula should be implemented. Justify your recommendation.

ANSWER:

**Questions 4 through 6 pertain to the Case Study.
Each question should be answered independently**

4.

(10 points) Refer to Sections 1.8 and 1.9 of the Case Study.

In anticipation of future consumer behavior, Giant Auto Motors (GAM) has decided to enter the battery electric vehicle (BEV) market. Caerus has been hired by GAM to help develop risk metrics for this venture.

GAM has identified companies A and B as potential suppliers of the parts needed for its BEVs. If the chosen supplier becomes insolvent, disruptions in the supply chain could lead to production issues. GAM wants to pick the company that is least likely to default over the next five years.

Both companies are large borrowers and heavily traded on the stock market. Your boss wants to use the Merton model to determine the default probabilities.

The Merton model and the financial data for both firms as of December 31, 2020 are shown below.

$$\Pr(X_T \leq B) = \Phi \left(\frac{\ln \left(\frac{B}{X_0} \right) - \left(r_x - \frac{\sigma_x^2}{2} \right) T}{\sigma_x \sqrt{T}} \right)$$

Company	Total Asset Value (in millions)	Expected Growth Rate	Volatility of Growth Rate	Total Amount of Company's Borrowing (in millions)	Time of Lump Sum Payment of Company's Debt
A	\$5,000	5%	35%	\$1,000	5 years from today
B	\$8,000	7%	25%	\$2,000	5 years from today

4. Continued

(a) (4 points)

- (i) Assess the appropriateness of using the Merton model to measure the solvency of companies A and B.

ANSWER:

- (ii) Propose one alternative method GAM could use to measure the solvency of its supplier. Justify your proposal.

ANSWER:

- (iii) Demonstrate that Company B is preferable to Company A, as of December 31, 2020, using the Merton model. Show all work.

ANSWER:

4. Continued

(b) (4 points) GAM's management is concerned with the cost of lithium which heavily influences the price of the batteries and, therefore, the overall production cost of BEVs. Caerus has determined that lithium prices can be described using geometric Brownian motion.

(i) Describe a process for using Monte Carlo simulation to calculate VaR(99) for lithium prices over the next n years.

ANSWER:

(ii) Explain how the volatility of battery prices could be mitigated using:

- A forward contract on lithium
- A futures contract on lithium

ANSWER:

(iii) Recommend whether GAM should use a forward or a futures contract for lithium to hedge against battery price volatility. Justify your recommendation.

ANSWER:

4. Continued

(c) (2 points) In response to the board meeting described in section 1.9 of the Case Study, your team has been asked to perform scenario analysis regarding GAM's strategy.

(i) Explain why using a synthetic scenario for the analysis would be more beneficial than a historical scenario in this situation.

ANSWER:

(ii) Design a company-specific synthetic stress scenario that could be applied to the situation where GAM remains in the PCV market. Support your answer using evidence from the Case Study.

ANSWER:

**Questions 4 through 6 pertain to the Case Study.
Each question should be answered independently**

5.

(12 points) You work as a consultant with Caerus and have been assigned to the Energetix account. Refer to section 1.11 of the Case Study.

You have been asked to develop a strategy to address emerging risks in the energy industry and to establish a risk appetite statement for specific emerging risks.

- (a) (3 points) Your initial task requires assessing key emerging risks that are relevant to Energetix.
- (i) Describe the process of environmental scanning as part of an emerging risk review.

ANSWER:

- (ii) Explain how a balanced environmental scanning approach could be used by Energetix to assess the potential emerging risks related to:
- Regulatory change
 - Cybersecurity threats

ANSWER:

5. Continued

(b) (4 points) You plan to coordinate scenario planning for key risks across Energetix's various subsidiaries. Caerus has identified key risk factors related to the Energy Utility Industry, and you have elaborated major themes that characterize plausible developments as follows:

1. Regulatory changes related to the environment and the potential impact of global climate change
2. Operational activities that impact the reputation or financial condition of the company.

(i) Describe a relevant scenario, specific to Energetix, for each theme.

ANSWER:

(ii) Outline the remaining steps in the scenario planning process.

ANSWER:

(iii) Provide a relevant example for each step identified in (ii) using one of your scenarios from (i).

ANSWER:

5. Continued

- (c) (5 points) The Energetix Board has developed a new qualitative risk appetite statement for cybersecurity risk as follows:

“Any material damage to Energetix’s reputation or interruption of business from a cybersecurity event is unacceptable.”

The Energetix CRO wants more specific limits and has asked you to help establish a quantitative risk appetite statement for cybersecurity risk.

- (i) Identify the challenges with translating a qualitative statement into a quantitative one for cybersecurity risk.

ANSWER:

- (ii) Energetix initially proposes a quantitative risk appetite statement, as follows:

“The company cannot lose more than 20 percent of value in a cybersecurity event.”

Propose a modification to the above statement incorporating each of the following:

- Energetix’s current balance sheet and income statement
- Historical experience in data breaches and operational failures.

Explain your reasoning.

ANSWER:

- (iii) Recommend two enhancements that Energetix could implement to support compliance with the cybersecurity risk appetite statement that you proposed in (ii). Justify your response.

ANSWER:

**Questions 4 through 6 pertain to the Case Study.
Each question should be answered independently**

6.

(9 points) Giant Auto Motors (GAM) has set the following as its strategic objectives. Refer to section 1.9 of the Case Study.

Objective	Key metric	Risk
Expand GAM's 10% ownership in current JV in China to at least 40%	Current Market Share of JV	Regulatory Changes limiting JV
Be able to produce its own BEV automotive batteries within one year	Number of batteries purchased each month should be < 90% of prior month's purchased batteries	Ability to obtain material for batteries
Become the top provider of BEV automotive batteries in China in five years	% of BEVs vs PCVs	Having the skillset in-house for continued battery improvements

GAM asked Caerus Consulting to evaluate GAM's objectives.

(a) (4 points)

- (i) Evaluate whether these objectives are the appropriate *key* strategic objectives for GAM.

ANSWER:

- (ii) Assess if the listed key metrics are suitable for measuring progress towards the stated objectives.

ANSWER:

6. Continued

(b) (3 points)

- (i) Evaluate whether the risks identified are appropriate for the corresponding objectives.

ANSWER:

- (ii) Assess if the risks identified are *key* risks for GAM. Justify your response.

ANSWER:

(c) (2 points) The following controls are suggested for the risks associated with achieving the stated objectives:

- Audit the entire production process of batteries quarterly
- Test each battery to ensure it meets the guidelines needed for all global markets in which GAM participates
- Have each order for component parts be double-checked for accuracy

Assess the effectiveness of the proposed controls for each risk when implementing a risk-based controls approach. Justify your answer.

ANSWER:

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

7.

(9 points) You are a risk manager in the investment department of an insurance company. Your company has a block of 1,000 variable annuity contracts with GMDB. The guaranteed death benefit per policy is \$5,000 and the current account value is \$5,000.

The investment committee advised hedging the delta and gamma risk for the GMDB using out-of-the-money (OTM) call options and OTM put options. One option contract is based on 100 shares.

You found the following at-the-money (ATM) and OTM data from the market.

	Strike price	Option price	Delta	Gamma
ATM put	50	1.4	-0.56	0.12
OTM call	60	0.08	0.04	0.02
OTM put	40	0.01	-0.01	0.005

(a) (0.5 point)

Explain why the hedging strategy needs to include options rather than only a position in the underlying stock.

ANSWER:

(b) (3.5 points)

(i) Explain how gamma neutrality enhances hedging effectiveness of the portfolio against the underlying price changes.

ANSWER:

(ii) Determine the number of the OTM option contracts to trade to ensure the delta-gamma neutrality of the hedge.

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

(iii) Calculate the cost of the trade.

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

7. Continued

(c) (3 points)

- (i) (1 point) Describe how the delta and gamma of each option will change when the stock price drops.

ANSWER:

- (ii) (2 points) Describe how the delta and gamma of each option will change when the volatility increases.

ANSWER:

Your manager wants to limit the portfolio downside risk. You are asked to construct portfolio insurance using index futures to protect the portfolio.

(d) (2 points)

- (i) Explain the advantages of using synthetic put options.

ANSWER:

- (ii) Explain why trading index futures contracts are preferred to trading the underlying stocks in the portfolio.

ANSWER:

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

8.

(11 points) Refer to Case Study Section 4.

Michelle Ryoto has been newly appointed as the Chief Risk Officer (CRO) of SLIC, reporting to R. Tomas Lyon III, CEO. Michelle is creating and leading an independent Enterprise Risk Management (ERM) department within SLIC.

- (a) (1.5 points) Describe the three key components for managing risk in a solid risk management program, from *Managing Investment Portfolios Chapter 9*.

ANSWER:

Michelle stated: “The risk models in SLIC have been well developed mathematically and the risk reporting and management processes have been standardized and automated. With this consistent approach, we do not need a large ERM department within SLIC.”

- (b) (1.5 points) Critique Michelle’s statement using principles of effective risk management.

ANSWER:

8. Continued

SLIC is considering investing in three zero-coupon bonds, each with 1 year to maturity and maturity values of 100. Trader X has decided to invest equally in Bonds A and B, whereas Trader Y has decided to invest equally in Bonds B and C. You are given:

Bond	Price	Risk Free Rate	Recovery	Probability of Default
A	96.0	2%	40%	3.6%
B	97.0	2%	30%	1.6%
C	97.5	2%	15%	0.7%

Assume defaults are independent.

(c) (6 points)

(i) Calculate Present Value of Expected Credit Loss (PVECL) for each bond.

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

(ii) Calculate Expected Portfolio Loss for each trader's portfolio.

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

(iii) Calculate Variance of Expected Losses for each trader's portfolio.

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

(iv) Critique the assumption of default independence.

ANSWER:

8. Continued

Every yearend, bond traders in SLIC are compensated by the annual bonus according to the below formula:

Trader's Bonus = Trader's Base salary x Fixed Bonus % x (1-Expected Portfolio Loss %)

(d) (2 points)

(i) Critique this compensation design for bond traders.

ANSWER:

(ii) Recommend a change to the current compensation design. Justify your answer.

ANSWER:

****END OF EXAMINATION****