Exam ERM-INV

Date: Friday, May 3, 2019
Time: 8:30 a.m. – 12:45 p.m.

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-INV.

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.

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. (*8 points*) CYP is a small Canadian life insurance company. CYP is currently exploring whether it should create its first offshore captive and cede one of its capital intensive products to the captive.

CYP does not have its own actuarial staff, instead relying on a consulting firm to perform the necessary actuarial services.

(a) (*1 point*) Explain why this captive would qualify as an Alternative Risk Transfer (ART) program.

(b) (*3 points*) CYP's CFO has proposed creating an offshore Pure Captive with the following characteristics:

- The captive cannot pursue its own external reinsurance business.
- The offshore location has similar capital requirements but a lower tax rate.
- Two accountants and an administrative assistant will be hired to run the captive from the offshore location.

(i) Explain why a Pure Captive might be preferred over other types of captives for CYP.

(ii) Critique the characteristics of the proposed Pure Captive.

(iii) Describe two additional key actions that need to be completed with respect to establishing the Pure Captive.

(c) (*4 points*) You are employed by the consulting firm that CYP has hired to perform its actuarial services. CYP's CEO has asked you to offer an opinion on whether CYP should retain this business or cede it to a captive.

(i) Evaluate the three key elements that distinguish a captive from a commercial insurer for CYP.

(ii) Recommend whether CYP should use a captive. Justify your answer.

THIS PAGE INTENTIONALLY LEFT BLANK

2. (*9 points*) Orange, an insurance company, writes worldwide property and casualty business with three lines of products. The company is looking to incorporate its risk appetite statement into its business planning.

You are provided the following financial results for business written in 2018 as of December 31, 2018.

Product Line	Premiums Collected	Under writing Profit	Profit Margin	Required Economic Capital*	PV of Required Economic Capital*	PV of After-tax earnings**
Specialty	10	0.9	9%	5	5	1.0
Home owners	30	3.0	10%	20	40	6.0
CAT	60	9.0	15%	150	450	27.0

* Allocated to each risk; no diversification benefit allocated
** Equivalent to risk-adjusted earnings

(a) (*3.5 points*) You are given the following correlation matrix for the three product lines in 2018.

	Specialty	**Homeowners**	**CAT**
Specialty	1.0	0.2	0.2
Homeowners	0.2	1.0	0.2
CAT	0.2	0.2	1.0

(i) Calculate the Risk Adjusted Return on Capital (RAROC) for each product line and the company in total. Show all work.

(ii) Analyze the profitability of the product line with the lowest RAROC.

(b) (*1.5 points*) Orange has developed the following risk appetite statement.

Orange has a long-term aggregate RAROC target of 10%. The company will earn at least 6% RAROC with a probability of 98% in each year.

(i) Assess Orange's compliance with its risk appetite statement.

(ii) Analyze Orange's business mix with respect to the company's RAROC.

2. **Continued**

(c) (*4 points*) There will be no rate increases in 2019. The 2019 business mix plan needs to address the following requirements.

    I.   Collected premiums for each product line must be at least 90% and at most 150% of those in 2018.

    II.   For product lines with sales increase in 2019, collected premiums must be proportional to the collected premiums for those product lines in 2018.

    III.   The required economic capital for the business written in 2019 needs to be lower than the expected available economic capital of $150 million.

Assume the following:

- The diversification between product lines results in a 30% reduction in required capital for business written in 2019.

- The ratio of the required capital to collected premiums in any year for each product line is constant.

(i) Calculate the maximum total premium increase from 2018 to 2019 if Orange aims to maximize overall RAROC, subject to requirements I through III. Show your work.

(ii) Orange has added a requirement that the aggregate RAROC target of 10% needs to be met by the business written in 2019.

    Verify that a total premium increase of $12 million from 2018 to 2019 satisfies this requirement. Show your work.

3. (*10 points*) You are an actuary at ABC Life. Your manager would like your help in applying ALM and Strategic Asset Allocation (SAA) processes at your company.

(a) (*4 points*) ABC Life sells a simple investment product which guarantees payouts at the end of each year for five years. You have been provided the following payouts and annual effective interest rates for this business.

Year	1	2	3	4	5
Payout (End of Year)	600	200	800	1,000	400
Spot Rate	0.50%	0.80%	1.20%	2.00%	3.00%

ABC Life measures key rate durations at years 1, 2, 3, and 5 using a +0.1% shift and linear interpolation to approximate the shift along the maturity range. Some of the key rate durations are shown below:

Year	Liability Key Rate Duration
1	0.21
2	0.14
3	?
5	1.23

(i) Compare and contrast the use of key rate durations and effective duration for quantifying interest rate risk.

(ii) Verify that the missing key rate duration is 1.44. Show your work.

(iii) Verify, using the effective duration, that the key rate durations have been calculated correctly. Show your work.

3. **Continued**

(b)   (*2 points*) ABC Life evaluates ALM solutions using a "bottom-up" approach and asset-only volatility as their risk measure.

The Chief Investment Officer (CIO) has recommended using surplus volatility as the only risk measure instead because it covers both asset and liabilities.

(i)   Compare and contrast the "bottom-up" and holistic ALM/SAA approaches.

(ii)   Explain how ABC Life's approach would need to change in order to use surplus volatility instead of asset-only volatility as the risk measure.
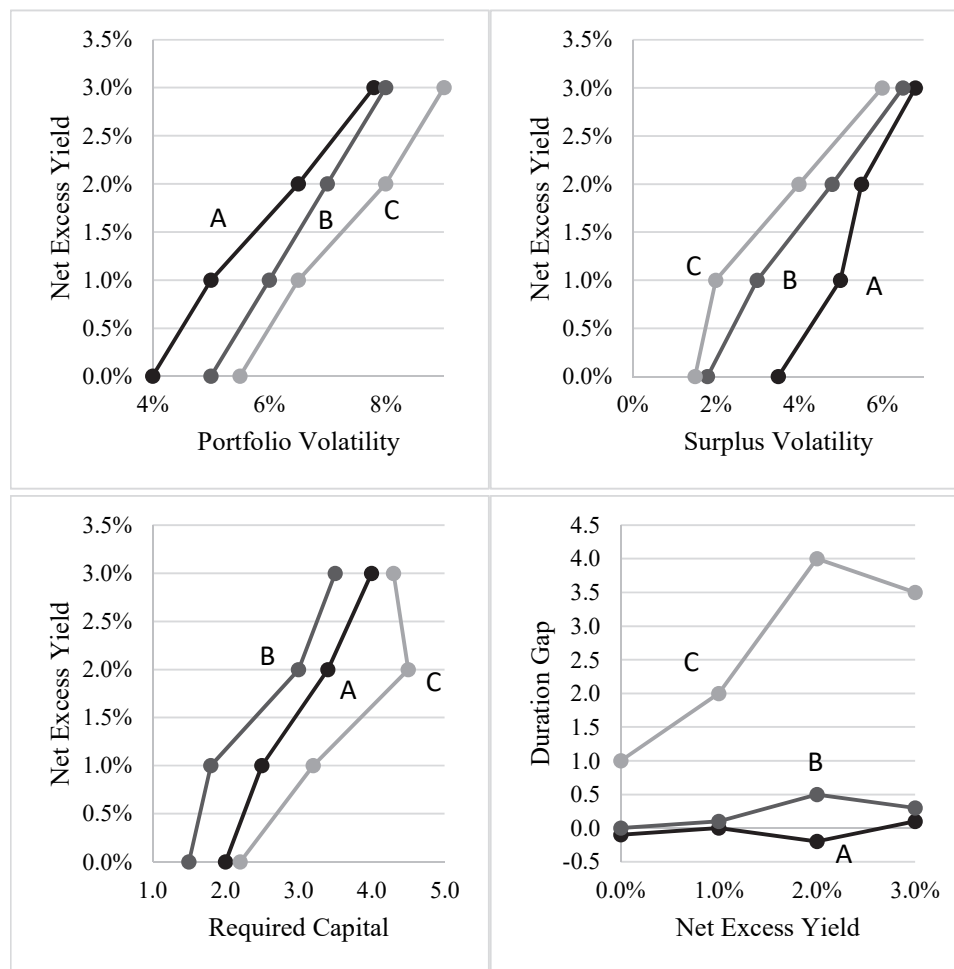
(iii)   Critique the CIO's recommendation.

3. Continued

(c) (*4 points*) You are assessing three different risk minimization approaches:

1. Minimize economic surplus risk while relaxing the asset-liability duration gap.
2. Minimize asset-only risk while constraining the asset-liability duration gap.
3. Minimize economic surplus risk while constraining the asset-liability duration gap.

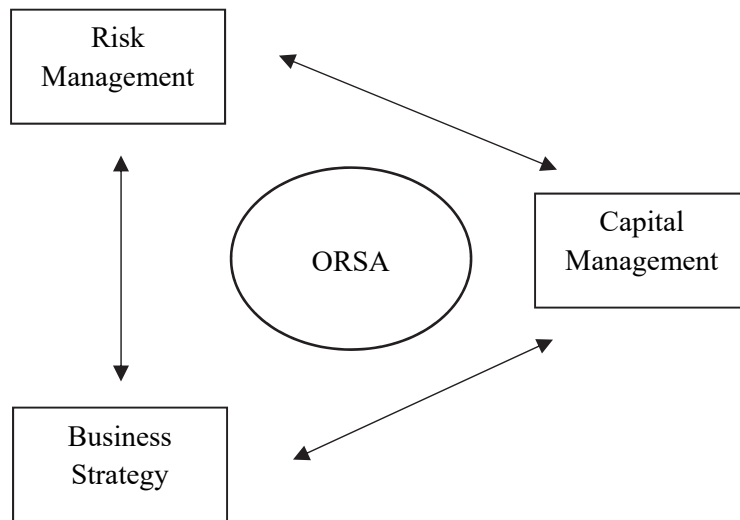The following efficient frontier results have been provided.

(i) Match labels A, B, and C to the approaches listed above. Justify your answer.

(ii) Recommend which approach to use. Justify your answer.

THIS PAGE INTENTIONALLY LEFT BLANK

4. (*12 points*) You are an ERM actuary working at XYZ, a life insurance company. XYZ envisions an international expansion into one of three new regions. Your task is to assist the Board of Directors (BoD) with implementing ERM best practices in evaluating these strategic options.

    (a)   (*1 point*) XYZ's CRO is proposing that XYZ use the ORSA framework, as shown below, to assist the BoD in evaluating each strategic option and its underlying risks:

        Assess the appropriateness of the CRO's proposal.

4. **Continued**

(b)   (*3 points*) You have identified some specific external threats and opportunities. The following list summarizes some of the key challenges:

- <u>Existing and potential customer challenges</u>
  - Facing new challenges: longevity risk and changing traditional family patterns and needs.

- <u>High-tech challenges</u>
  - Artificial intelligence and technological advances in insurance (InsuranceTech) are on the horizon.
  - Big data and predictive modeling are opportunities, but new regulations about individual privacy rights are unknown.

- <u>Financial challenges</u>
  - Internationally, long-term interest rates are low by historical standards.
  - New internationally-enforced capital regulations are in effect as a result of the 2008 financial crisis.

- <u>Competitive challenges</u>
  - Intense international competition from online insurance companies.

- <u>Other challenges</u>
  - Environmental climate changes and their impact on investments.
  - The long-term sustainability of social governmental programs.
  - Demographic changes and migration patterns are unknown.

The CRO proposes that you use the PESTEL method to perform a preliminary strategic risk identification analysis.

(i)   Describe advantages and disadvantages of the PESTEL method for XYZ.

(ii)   Identify, using the PESTEL method, the strategic risks that XYZ may face.

(iii)   Propose an alternative risk identification method that may improve XYZ's assessment. Justify your response.

Question 4 continued on the next page

4. **Continued**

(c)   (*2 points*) A colleague outlined a series of qualitative scenarios in order to assess the impact of three of the threats and opportunities identified. The analysis is summarized below:

Strategic Decision	Threats / Opportunities		
	Artificial Intelligence	**InsuranceTech**	**Climate Change**
European Expansion	Little impact in the short-term	High potential positive impact in the short-term	Will generate opportunities
Asian Expansion	Potential for a medium threat in the longer term	High potential negative impact medium term	Will impact capitalization and risk
African Expansion	Little impact in the short-term	Highly negative in the short-term	Negative impact: already happening

Describe four shortcomings of the assessment methodology used for this analysis.

4. **Continued**

(d) (*6 points*) XYZ's ERM group estimated the amount of required economic capital for the threat associated with climate change, which the BoD considers the current primary threat.

You are provided the following financial information (in $ million):

XYZ's Balance Sheet, economic basis

Assets		Liabilities and Equity	
Long-Term Traded Securities	400	Long-Term Insurance Liabilities	75
Non-Traded Investments	150	Long-Term Financial Debt Instruments	25
Non-Traditional Investments	50		
Total Assets	600	Available Capital	500

XYZ's equity on an accounting basis is 200.
Tax rate is equal to 0%.

Climate change threat data

Expansion	Revenue	Costs	Expected Losses	Available Economic Capital	Required Economic Capital
European	15	5	1	100	54
Asian	60	10	5	120	127
African	5	15	5	75	9

(i) Compare and contrast the following performance measures in terms of their use in strategic decision making. Justify your analysis by performing appropriate calculations.

- ROE
- RAROC
- RARORAC

(ii) Recommend to the Board which strategic expansion should be pursued based on your financial analysis. Justify your recommendation.

5. (*13 points*) You work in the warranty department for Pleasant Air, a heater manufacturer with a current market that is limited to only two cities: NorthPole and SouthPole.

You want to determine the amount of capital needed in order to support the warranties on Pleasant Air's products. For the warranties, Pleasant Air would use liquid assets equal to the 96% daily absolute VaR of the warranty costs. Warranty claims are dependent on the weather experienced each day.

You are given the following information:

Weather Type	Probability	Aggregate Daily Claims Distribution	
		NorthPole	**SouthPole**
Non-Extreme	95%	U($0, $1,000)*	U($0, $2,000)
Extreme	5%	U($3,000, $5,000)	U($4,000, $7,000)

        * U indicates a uniform distribution

(a) (*3 points*) VaR is calculated independently for NorthPole and SouthPole. It is your task to aggregate VaR at the enterprise level.

    (i) Determine the 96% daily absolute VaR of aggregate claims for each city. Show your work.

    (ii) Determine the theoretical range of the aggregate 96% daily absolute VaR based on the VarCovar method. Show your work.

    (iii) Assume claim amounts in NorthPole and SouthPole have a correlation of $\rho = 0.8$.

        Determine the 96% daily VaR of aggregate claims for both cities combined using the VarCovar method.

    (iv) Discuss the appropriateness of the VarCovar method for calculating enterprise capital.

5. **Continued**

(b)   (*5 points*) Your manager asks you to perform a simulation exercise to estimate warranty claims for NorthPole and SouthPole. He suggests using Monte Carlo simulation with correlated uniform random variables for this task.

(i)   Explain how you would apply Cholesky factorization to address your manager's request.

(ii)   Calculate the Cholesky factors using the correlation coefficient from part (a). Show your work.

You have partially populated the following table using the Cholesky factors from part (b)(ii). Z1 and Z2 represent random draws from a N(0,1) distribution. Your manager said to initially induce correlation on these variables, producing Z3 and Z4, before translating them to U(0,1) variables.

Claim Amount Simulation from 1,000 replications
Ordered from lowest aggregate claims to highest aggregate claims

Simulation Number	Z1	Z2	Z3	Z4	U1 = F(Z3) is U(0,1)	U2 = F(Z4) is U(0,1)	Aggregate NorthPole Claims from U1	Aggregate SouthPole Claims from U2	Total Aggregate Claims
959	1.08	1.99	1.08	2.06	0.86	0.98	905	5,800	6,705
960	1.52	1.39							
961	0.13	3.53	0.13	2.22	0.55	0.99	579	6,400	6,979

(iii) Determine the absolute VaR using your manager's suggested method by completing the above table. Show your work.

While the simulated random variables have a correlation of $\rho = 0.8$, the simulated claim amounts are correlated with $\rho = 0.7$. Your manager suggests the correlation discrepancy may be due to the choice of dependency measure and recommends using Spearman's rho.

(iv)   Explain your manager's feedback.

Question 5 continued on the next page.

5. Continued

(c)   (*3 points*) After rerunning the analysis in part (b) using Spearman's rho, your manager explains that this method is equivalent to simulation using a Gaussian copula. You are evaluating the following options:

- Monte Carlo Simulation using a Gaussian Copula
- Monte Carlo Simulation using an Archimedean Copula
- Copula methods should not be used

(i)   Describe the pros and cons of the two copulas listed.

(ii)   Identify three key considerations for determining the most appropriate option.

(d)   (*2 points*) Pleasant Air is expanding to several additional locations and you need to determine the best way to estimate the VaR for the entire company.

Describe one key advantage and one key disadvantage for each of the following methods as they pertain to Pleasant Air's analysis:

I.   VarCovar
II.   Simulation using Cholesky factorization / Gaussian Copula
III.   Simulation using Archimedean copula

THIS PAGE INTENTIONALLY LEFT BLANK

6. (*8 points*) You have recently been hired as CRO for PQR, an insurance company started by a hedge fund, in country XEN. Even though PQR has no business yet, you want to develop the risk management function for the company to comply with rating agency and regulatory capital requirements. Standard & Poor's (S&P) Rating Services will be assessing the ERM framework of PQR.

PQR has already hired several actuaries with strong life insurance background. PQR will utilize the parent hedge fund as the investment advisor.

PQR's CEO has identified several blocks of business available for purchase. The CEO is exploring using the U.S. Risk Based Capital (RBC) framework to evaluate each block.

A consultant provided the following data regarding the blocks of business available for purchase. Due to confidentiality agreements, the consultant was unable to disclose any additional information about Blocks A, B, or C.

RBC Components and Purchase Price by block, in $ thousand

RBC Component	Block A	Block B	Block C
C0	0	0	0
C1	380	1,060	120
C2	440	40	650
C3	310	300	150
C4	80	40	110

	Block A	Block B	Block C
Authorized Control Level	820	1,360	710

	Block A	Block B	Block C
Purchase Price	3,500	1,500	3,200

	Block A	Block B	Block C
RBC Ratio			

(a) (*3 points*) The CEO has asked you to evaluate the three blocks. PQR has $5 million of seed money available for the acquisition and capital support.

    (i)   Describe the risks associated with each RBC component identified above.

    (ii)   PQR evaluates each block separately. For example, when evaluating block A, blocks B and C are ignored.

            Populate the missing RBC Ratio values in the table. Show all work.

    (iii)   Evaluate the pros and cons of each block for PQR.

6. Continued

(b) (*5 points*) Several years have passed and you are provided the following facts about PQR's current Enterprise Risk Management (ERM) program.

- Main sources of material risks are identified and monitored.
- Risk appetite framework is directly linked with risk limits.
- Model limitations are documented and understood within the organization.
- Key risk exposures are managed within specific risk tolerances.
- A formal and comprehensive risk limit system exists and is enforced.
- Risks are managed within the business units.
- A strict model governance process has been implemented.
- The Board of Directors' participation in the ERM process is infrequent.
- Material risks are modeled both deterministically and stochastically.
- Model results are used to support senior business leaders in making decisions.

(i) You anticipate that PQR's Emerging Risk Management and Strategic Risk Management subfactors will be scored as Negative by S&P.

Assess each of the remaining three ERM score subfactors for PQR. Justify your answer.

(ii) Determine PQR's expected overall ERM score. Justify your answer.

(iii) Recommend two improvements to PQR's ERM program to increase the overall ERM score to the next level. Justify your recommendation.

7. (*10 points*) Refer to Max Hawke's November 27, 2018 memo in Section 3.9.2 of the Case Study.

As one of SLIC's investment actuaries, you have been tasked with assessing the risk of the new fund's portfolio.

You begin your analysis by modeling portfolio risk using the beta model. Your analyst obtains the following information:

- Portfolio beta: 1.25
- Annual volatility of the S&P 500 market index: 24%

(a)   (*2 points*)

    (i)   Calculate the portfolio volatility. Show your work.

    (ii)   Calculate the portfolio VaR at 97.5%. Show your work.

Hawke states the following:

> "I'd like you to design a portfolio insurance strategy using European put options on the S&P 500 index. The strategy should protect the value of the portfolio from declining below $36 million over the next year. Note that the Board has mandated that the cost of implementing any hedging strategy must not exceed 5% of the initial portfolio value."

Your analyst retrieves the following prices for one-year put option contracts, given the current S&P 500 index value of $1,000:

Strike price ($)	850	875	900	925	950	975	1,000
Contract price ($)	2,565	3,260	3,954	4,888	5,750	6,860	7,962

- Each put option has a contract size of 100 times the S&P 500 index.
- The annual risk-free rate is 2.9%.
- Assume the index and portfolio are non-dividend paying.

(b)   (*4 points*) Assess whether the cost of implementing the hedge complies with the Board's mandate.

7. **Continued**

You consider the following three alternatives for reducing the cost of the hedging strategy:

      I.   Purchase deeper out-of-the-money put options

      II.   Sell deeper out-of-the-money put options to finance the purchase of the put options

      III.   Sell out-of-the-money call options to finance the purchase of the put options

(c)   (*4 points*)

     (i)   Evaluate each of the alternatives in terms of both cost and hedge effectiveness.

     (ii)   Recommend one of the alternatives. Justify your answer.

8. (*10 points*) SLIC has been struggling to achieve substantial investment returns in the current low interest rate environment. In response to this, CIO Max Hawke has decided to move $50 million of assets to a portfolio manager, ABC Group, which specializes in active management of large-cap U.S. equities. ABC Group uses the S&P 500 as its benchmark.

Five years later, the following annualized returns from both ABC Group and the S&P 500 Index are observed:

Year	ABC Group Return	S&P 500 Index Return
1	8.5%	6.0%
2	-4.1%	-2.2%
3	5.3%	1.4%
4	12.0%	9.4%
5	1.8%	-3.1%

(a)   (*3 points*) Estimate the one-year VaR (95%) of the tracking error based on the 5 year data sample, assuming the tracking error is normally distributed.

Hawke is considering allocating investments to two more managers that actively manage large-cap U.S. equities and use the S&P 500 as their benchmark. Compared to ABC Group:

- JS Capital has <u>lower</u> tolerance for deviations from the policy mix
- FL Funds has <u>higher</u> tolerance for deviations from the policy mix.

Hawke makes the following statements in a meeting:

I.   "Allocating funds to JS Capital and FL Funds will cause the policy-mix risk of the overall fund to increase."

II.   "If funds are allocated to JS Capital and FL Funds, I would expect the fund's active-management VaR to be significantly larger than the fund's policy-mix VaR. This follows from the fact that actively-managed portfolios are riskier than passively-managed portfolios."

III.   "The fund's total VaR may not be equal to the sum of the policy-mix VaR and active-management VaR."

(b)   (*3 points*) Assess each of Hawke's statements. Justify your answer.

8. Continued

To gain extra investment return from its fixed-income portfolio, SLIC has re-allocated a portion of its holdings in government bonds to below-investment-grade corporate bonds. The new portfolio is comprised of two issuers:

Issuer	Exposure (in millions)
A	$15
B	$5

The covariance matrix of the bond returns:

Issuer	A	B
A	25%	12%
B	12%	16%

(c) (*2 points*) Calculate the standard deviation for the new portfolio in percentage terms. Show your work.

Hawke is concerned about the credit risk of this portfolio, particularly in the event of extreme market scenarios. He is interested in quantifying the risk of corporate bond defaults using a copula-based framework.

(d) (*1 point*) Identify the main shortcoming of using a Gaussian copula framework for modeling credit risk in extreme market scenarios.

(e) (*1 point*) Recommend an alternative copula model that overcomes the shortcoming identified in (d). Justify your answer.

END OF EXAMINATION

USE THIS PAGE FOR YOUR SCRATCH WORK