SOCIETY OF ACTUARIES

QFI Investment Risk Management Exam

Exam QFIIRM

Date: Friday, May 2, 2025

INSTRUCTIONS TO CANDIDATES

General Instructions

1. This examination has 10 questions numbered 1 through 10 with a total of 60 points.

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

2. While every attempt is made to avoid defective questions, sometimes they do occur. If you believe a question is defective, the supervisor or proctor cannot give you any guidance beyond the instructions provided in this document.

Written-Answer Instructions

1. Each question part or subpart should be answered either in the Word document or the Excel 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) Individual exams may provide additional directions that apply throughout the exam or to individual items.

2. The answer should be confined to the question as set.

3. Prior to uploading your Word and Excel files, each file should be saved and renamed with your five-digit candidate number in the filename.

4. The Word and Excel files that contain your answers must be uploaded before time expires.

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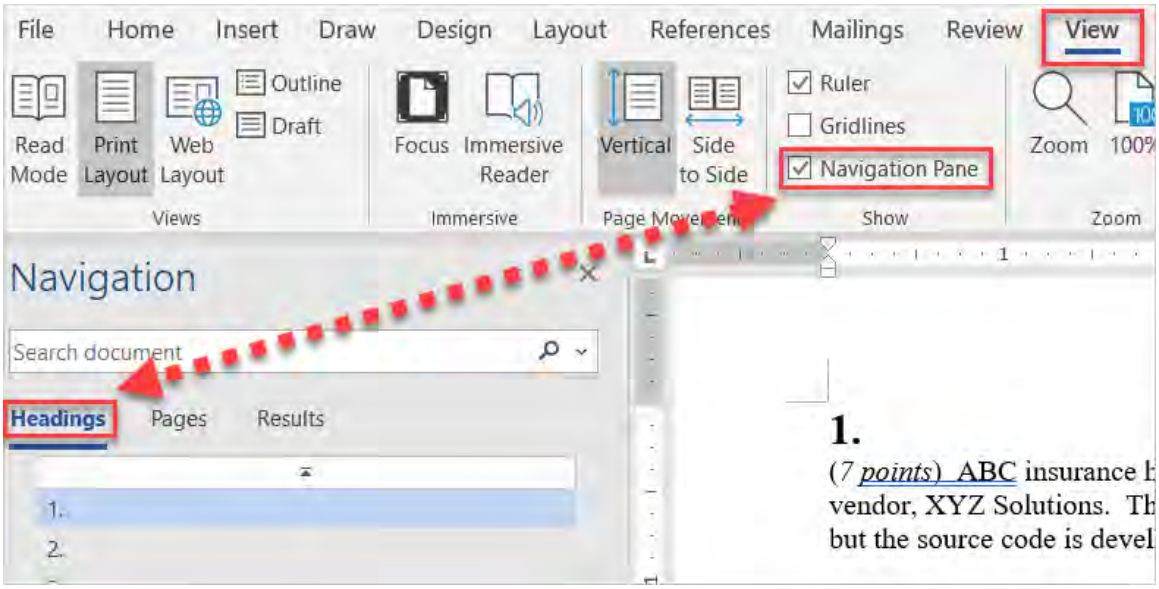
Navigation Instructions

Open the Navigation Pane to jump to questions.

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



1.

(*6 points*) A retirement fund has hired you for your expertise in environmental, social, and governance (ESG) investing. The fund participants recently requested that ESG considerations be incorporated into the fund's decisions and activities.

The fund has had a long-standing investment in equity of LIC. Early this year, LIC was targeted in a cybersecurity hack in which policyholder information was stolen. As a result, LIC's stock price plummeted.

Following the data breach, an independent investigation revealed that LIC lacked effective cybersecurity controls, had poor corporate governance around data safety, and was using very outdated technology across the enterprise. In response, LIC took remediation actions to address stakeholder concerns:

- Replaced several board members and executives with new members with diverse backgrounds
- Invested in a new, up-to-date cybersecurity framework and overhauled its technology platforms
- Began to engage with state and national regulators in developing new regulations on required controls and policies around cybersecurity risk within the industry

(a) (*1.5 points*) Explain, for each of the remediation actions, whether it mitigates any one of three risks: environmental, social, governance.

ANSWER:

The fund manager wants to refresh the estimates of LIC's expected returns. As part of his due diligence, the manager prepares a single questionnaire about the levels of desired and actual risk exposure and distributed it to senior management. He tells you: "This gap analysis accurately identified and measured risk exposures of LIC."

(b) (*1 point*) Recommend changes to the manager's approach.

ANSWER:

1. Continued

Last year, an analyst projected the estimated short-term and long-term returns for LIC. Factoring in the risks identified and costs associated with legal fees, settlements, and investment in new technology, you update the estimates.

LIC Expected Returns:

	Short-term	Long-term
Original	8%	13%
Revised	-5%	15%

(c) (*1.5 points*) Explain how the measures taken by LIC will enhance its expected returns in the long term.

ANSWER:

The fund manager decides to reduce the fund's investment in LIC, citing the poor expected performance in the short term.

(d) (*2 points*)

(i) (*1 point*) Assess whether the fund manager's decision is consistent with the participants' desire to have ESG factors incorporated into decision making.

ANSWER:

(ii) (*1 point*) Recommend another action the fund can take to integrate ESG practices, beyond security selection.

ANSWER:

2.

(*5 points*) YUL is an investment management firm specializing in providing mutual funds and ETFs. Its largest funds have seen high returns over the past few years and a large influx of investors. The Chief Investment Officer (CIO) has hired your consulting firm to provide guidance around the risk management process.

You have learned that the bonus structure of the fund managers is a percentage of their annual fund performance if it is positive and 0 otherwise.

(a) (*1.5 points*)

(i) (*0.75 points*) Assess the effectiveness of this bonus structure based on prospect theory.

ANSWER:

(ii) (*0.75 points*) Recommend an alternative bonus structure to improve long-term stability.

ANSWER:

You have conducted an interview with the leading fund managers and notice their comments appear to highlight behavioral biases.

- Manager A: "Because my fund has had positive returns for the past 5 years, my investment strategy must be a good one."
- Manager B: "Under my management, the fund has had annual returns exceeding 10%, except for one year when company PQR defaulted, but that was just bad luck."
- Manager C: "Although company DEF didn't meet its earnings target this year, my previous analysis is still reliable, and I am sure that they will continue to have strong future success."
- Manager D: "I have been so successful because my ability to select stocks to invest in is better than anyone else in the industry, including at this company."

(b) (*2 points*) Describe how each manager is displaying a behavioral bias.

ANSWER:

2. Continued

You have identified the following risks facing YUL:

- Stock Market Risk
- Systemic Risk
- Reputational Risk

(c) (*1.5 points*) Describe how each risk is applicable to YUL.

ANSWER:

3.

(*6 points*) You are a risk analyst for a pension fund. Your fund considers investing in riskier assets like equities by using leverage to increase their exposure to long-term bonds. The goal is to ensure enough money is available to pay retirees, and payouts are years in the future.

Your boss is concerned about investing in long-term bonds, because he heard of a collapse of a Commercial Bank that invested in long-term securities and had short term liabilities.

(a) (*1 point*) Critique your boss' concerns.

ANSWER:

(b) (*1 point*) Explain how market liquidity and funding liquidity are related.

ANSWER:

(c) (*1 point*) Define each of the four dimensions of trading liquidity.

ANSWER:

3. Continued

(d) (*2 points*) Describe these two liquidity measures below and their advantages and disadvantages.

(i) (*1 point*) Amihud Illiquidity Ratio (ILLIQ)

ANSWER:

(ii) (*1 point*) Effective Spread (as introduced by Roll)

ANSWER:

Time	**Security A**		**Security B**	
	Price	**Volume**	**Price**	**Volume**
1	6.16	173,200	232.78	26,978,900
2	5.92	222,300	233.27	16,400,500
3	5.74	230,100	233.37	16,865,600
4	5.59	209,300	233.08	19,119,000
5	5.73	181,600	235.79	20,449,000
6	5.61	229,100	233.81	16,155,300
7	5.34	301,700	238.86	20,653,200
8	5.43	192,500	238.82	18,163,800
9	5.63	224,400	242.49	21,193,100
10	5.59	166,600	246.85	22,943,300
11	5.75	224,300	245.64	21,599,800
12	5.87	355,600	248.32	27,738,500
13	5.68	206,000	246.74	17,748,100
14	5.68	154,800	249.21	17,724,300
15	5.63	144,900	252.69	22,371,400
16	5.88	163,800	262.04	25,727,200
17	5.59	136,600	262.52	23,816,500
18	5.59	123,300	264.72	25,473,700

(e) (*1 point*) Calculate the ILLIQ (average over the 18 periods) for Security A and Security B.

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

4.

(*5 points*) The following dataset represents the monthly returns of two stocks. You are tasked with analyzing the dependency between these variables using the Gumbel copula.

	X	Y
January	2.1	1.8
February	-0.5	-0.3
March	1.2	-0.7
April	-1	2.6
May	0.8	1.5
June	-1.5	-2
July	0.3	-1.2
August	2.7	3.2
September	-0.9	0.1
October	1.4	0.6
November	-0.3	-0.5
December	2.3	1.9

(a) (*1.5 points*) Calculate the probability that the returns of both X and Y are below 0 using the Gumbel copula with $\theta = 2$.

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

(b) (*2.5 points*) Calculate the following between X and Y:

(i) (*1.5 points*) Kendall's rank correlation coefficient τ

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

(ii) (*0.5 points*) Spearman's rank correlation ρ

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

(iii) (*0.5 points*) Pearson correlation

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

(c) (*1 point*) Describe how the copula plays a role in stress testing by providing two applications.

ANSWER:

5.

(*6 points*) You work on the stress testing team at an insurance company. You are reviewing four scenarios based on the following events:

(i) 1918 influenza pandemic

(ii) A terror event that kills thousands and leads to a large regional war

(iii) A hurricane in Florida for a company that has significant exposure to property in Florida

(iv) Mortality experience that would result in your company becoming insolvent within the next twenty years

(a) (*1 point*) Identify the type of scenario, as defined by the IAA, to which each scenario belongs.

ANSWER:

You built two models of equity returns based on 500 historical monthly returns for the S&P500 index. Incomplete statistics for the two models are shown below:

Akaike Information Criterion (AIC)
Bayes Information Criterion (BIC)

Model	*Log-likelihood*	*k*	*AIC*	*BIC*
A		2	120	
B	138	6		119

(b) (*2.5 points*)

(i) (*1.5 points*) Recommend which model should be chosen based on completed statistics.

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

(ii) (*1 point*) Describe two other factors you might take into consideration in deciding which model to use for stress testing.

ANSWER:

5. Continued

You decide to simulate the S&P500 log returns (Y_t) with a RSLN-2 model.

Regime 1	$\mu_1 = 0.018$	$\sigma_1 = 0.04$	$p_{12} = 0.1$
Regime 2	$\mu_2 = -0.012$	$\sigma_2 = 0.08$	$p_{21} = 0.3$

(c) (*1.5 points*) Calculate $E[Y_t]$ and $Var[Y_t]$

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

(d) (*1 point*) Describe how you would estimate the magnitude of the decline in the S&P500 associated with a 1-in-100-year event at the end of year 1.

ANSWER:

6.

(*9 points*) SAM investment management has a portfolio composed of stocks and is actively monitoring its Value-at-Risk (VaR) and Expected Shortfall (ES).

The current portfolio composition as well as each stock's prior day's closing price and annualized volatility are shown below:

Stock	Position (Shares)	Closing Price (S)	Volatility (σ)
X	750	100	0.25
Y	3,000	50	0.35
Z	-4,000	77	0.1

The correlations between each stock's return are shown below:

ρ	X	Y	Z
X	1	0.8	0.2
Y	0.8	1	0.5
Z	0.2	0.5	1

Assume returns over the risk horizon are normally distributed with a mean of zero and there are 250 trading days per year.

(a) (*1.5 points*) Calculate the following for one share of each stock in the portfolio:

(i) (*0.5 points*) 10-day 99% VaR

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

(ii) (*1 point*) 10-day 97.5% ES

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

(b) (*1.5 points*) Calculate the following for the portfolio:

(i) (*0.5 points*) 1-day 99% VaR

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

(ii) (*1 point*) 1-day 99% ES

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

6. Continued

(c) (*1 point*) Interpret the results from part (b)

ANSWER:

Your colleague is working on a separate portfolio which makes significant use of derivatives. She assumes for this fund that all the returns have a joint normal distribution. She considers different methods to calculate VaR and ES for this portfolio.

(d) (*1.5 points*) Compare Delta-Gamma-Normal Method, Delta-Gamma-MC method, and Full Monte Carlo simulation.

ANSWER:

A fellow actuary has indicated that they are reviewing a set of assets to combine into a new portfolio. However, they only have few months of return data. Based on the data, the returns appear to have a negative skew and high kurtosis.

(e) (*1.5 point*s) Assess whether Empirical VaR is appropriate to model the returns of this new portfolio.

ANSWER:

The Chief Risk Officer wants to understand how backtesting can assess whether a 10-day VaR is appropriate.

(f) (*2 points*)

(i) (*1.5 points*) Design a statistical test to determine whether the VaR is both adequate and not too conservative.

ANSWER:

(ii) (*0.5 points*) Identify two assumptions used in backtesting.

ANSWER:

7.

(*6 points*) Company A has a receivable of $100 million dollars that will be paid in quarter 3 and wishes to invest that amount for an additional 5 quarters to fund a liability of $105.5 million. A bank offers a Forward Rate Agreement (FRA) for the applicable period using pricing based on the table below for a notional amount of $100 million dollars. If Company A were to enter the FRA, the bank would pay the fixed rate while Company A would pay the floating rate. You are given the following incomplete data.

Quarter T	Time	Zero Coupon Price Z(0.T)	Forward Rate f(0,T-1, T)	Spot Rate r(0,T)
0	0	1		
1	0.25	0.990		
2	0.5	0.980		
3	0.75	0.970		
4	1		4.145%	
5	1.25		4.189%	
6	1.5		4.233%	
7	1.75			4.147%
8	2			4.169%
9	2.25			4.192%

Assuming that there are no arbitrage conditions and all rates are continuously compounded and annualized.

(a) (*2.5 points*) Calculate the amount the bank will pay at the end of the forward contract.

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

(b) (*1.5 points*) Calculate the current value (time 0) of any additional investment Company A would need to fund the liability given that Company A were entering into this FRA.

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

7. Continued

You are asked to give advice to a couple of investors on whether to pursue the above FRA with the bank. Both investors have the same receivable and liability at the same times as Company A.

Investor X is a small company with relatively tight cash flows and without any strong convictions on the direction of future interest rates.

Investor Y is a large company with a large investment department with a strong view that interest rates will decrease over the next year and stay lower for another 2 years.

(c) (*1 point*) Assess whether each investor should enter into the FRA being offered by the bank.

ANSWER:

(d) (*1 point*) Recommend another strategy based on Investor Y's view on the future movement of interest rates.

ANSWER:

8.

(*7 points*) You are an investment analyst working for BLI Life Insurance Company. You are considering using credit default swaps (CDS) to hedge the credit risk of your company's asset portfolio. Your manager would like you to perform a calibration exercise using the assumptions given below:

T	CDS Par Spread	Discount Factor
1	80 bps	0.99010
2	90 bps	0.97066
3	95 bps	0.94929

- Issue date of these contracts is December 20, 2019
- Coupon is paid annually
- Recovery rate is 40%
- T is the CDS contract terms in years

Before starting the calibration exercise, you are given that the hazard rate for 1-year CDS contract is 0.0133114.

(a) (*1 point*) Calculate the following for 1-year CDS contract:

(i) (*0.5 points*) Value of protection leg, at contract issue date

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

(ii) (*0.5 points*) Value of premium leg, at contract issue date

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

(b) (*1 point*) Describe the calibration steps to obtain the term structure of survival probabilities.

ANSWER:

Now, you will continue the calibration exercise for 2-year and 3-year CDS contract.

(c) (*2.5 points*) Calculate (use the "Goal Seek" function as needed) the following for each CDS contract:

(i) (*1.5 points*) Hazard rate

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

8. Continued

(ii) (*0.5 points*) Value of protection leg, at contract issue date

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

(iii) (*0.5 points*) Value of premium leg, at contract issue date

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

On December 20, 2019, your manager entered into the 2-year term CDS contract to hedge against credit risk. The contract notional is $1 million. The upfront cost of entering the contract is zero.

(d) (*1 point*) Calculate the coupon payment that the protection buyer would pay assuming a credit event is triggered on Feb 4, 2021.

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

(e) (*1.5 points*)

(i) (*0.5 points*) List two mechanisms for the protection buyer to receive the protection payment.

ANSWER:

(ii) (*1 point*) Describe what the protection buyer would receive under each mechanism.

ANSWER:

9.

(*5 points*) Oliver is the CEO of a small hedge fund company. Recently the firm experienced a large loss related to its investment in company PMC, a portfolio management company. Oliver requested an internal investigation and concluded that the lack of operational due diligence and internal controls are the root causes of the loss.

(a) (*1 point*) Describe two ways that internal controls are related to the loss.

ANSWER:

Upon completion of the investigation, the major findings are as follows regarding the hedge fund operation:

1) PMC's accounting function was outsourced and it caused a major delay in a recent quarterly reporting.
2) Five employees out of seven on the auditing team at PMC, including the manager, recently resigned, and the remaining two were under intense pressure afterwards. The same employees at PMC answered the same questions differently when interviewed by different investigators.
3) The reporting team at PMC, whose primary responsibility is to reconcile the books, took on parts of the internal auditing role.
4) The operational due diligence documentation and communication records found at Oliver's company were lacking critical details and appeared to be freshly made right before the investigation.

(b) (*2 points*) Describe the operational risk associated with each of the findings.

ANSWER:

(c) (*2 points*) Recommend actions to address each of the risks identified in Part (b).

ANSWER:

10.

(*5 points*) David is an investment actuary working in the product development area of a large insurance company Pitt Life. David has developed a variable annuity (VA) product that targets customers who are soon to be retired.

Below is the surrender charge table for the VA product should a participant decide to withdraw any amount from their account.

Year	Surrender Charge
1	8%
2	7%
3	6%
4	5%
5	4%
6	3%
7	2%

Since the product is very successful, David's manager Eric suggests to expand the customer base to retirees over age 70. He also wants to increase commissions of financial advisors for sales in this age group to boost sales.

(a) (*1 point*) Explain two potential unethical behaviors that may arise based on Eric's suggestions.

ANSWER:

(b) (*1 point*) Recommend two actions to address the potential issues identified in (a).

ANSWER:

10. Continued

David is looking to add the following funds to the variable annuity investment options:

Fund	Annualized Total Gross Average Return	Annualized Volatility	Management Fee per year	Use of Derivatives	Inception Date	Benchmark
A	10%	12%	2%	N	1/1/2006	S&P Technology Index
B	8%	6%	1%	Y	1/1/2021	S&P Value Enhanced Index

(c) (*1.5 points*) Compare these two funds based on the information provided.

ANSWER:

Fund A is managed by Pitt Life. Eric thinks that it is important to keep profits within the company. He suggests setting Fund A as a default option where the money will automatically invest in Fund A when the policyholder deposits new money. This way, the policyholders would not lose any time in the market by having the money sit in cash after depositing.

Eric also proposes giving policyholders a bonus of 1% if the policyholder's asset allocation has more than 50% of their total amount in Fund A. The financial advisors are very supportive of this initiative.

(d) (*1 point*) Explain the potential unethical behaviors that may arise based on Eric's suggestion.

ANSWER:

(e) (*0.5 points*) Recommend one approach to address an unethical behavior identified in (d).

ANSWER:

****END OF EXAMINATION****