

Exam QFIIRM

Date: Friday, November 1, 2024

INSTRUCTIONS TO CANDIDATES

General Instructions

1. This examination has 9 questions numbered 1 through 9 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.

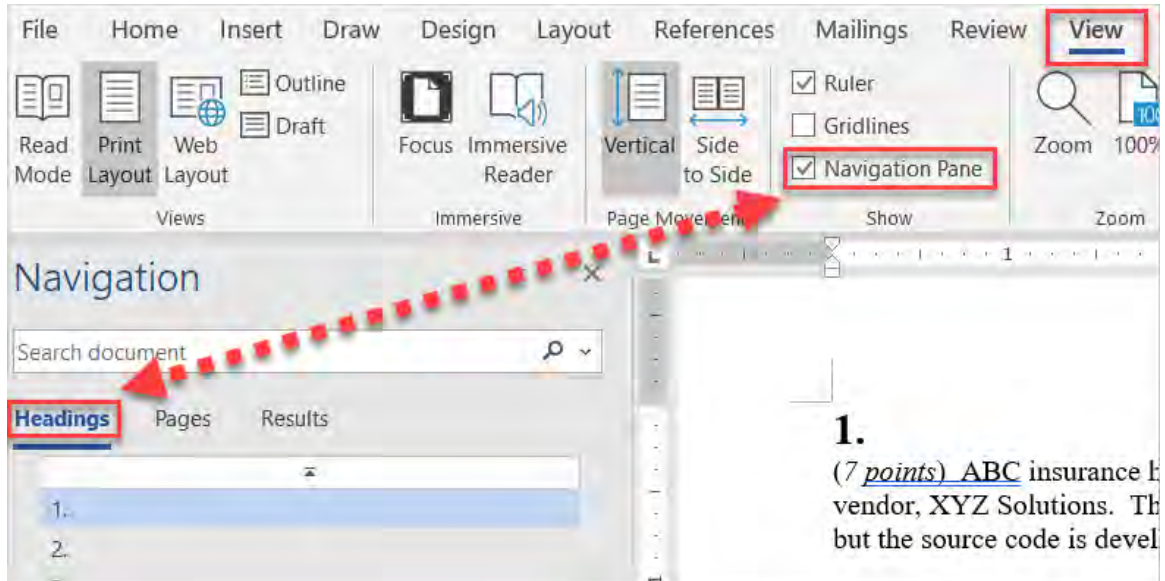
Written-Answer Instructions

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 unique candidate number in the filename. To maintain anonymity, please refrain from using your name and instead use your candidate number.
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:



1.

(4 points) You assist clients in making investment decisions. One of your clients is interested in several new investment opportunities and has come to you for advice.

Your client has a utility function $u(w) = \ln(w)$, where w is the payoff.

- (a) (1 point) Explain whether your client is risk-neutral, risk-seeking, or risk-averse.

ANSWER:

Investment A		Investment B	
Payoff	Probability	Payoff	Probability
4500	5%	500	1%
5500	95%	1000	5%
		5000	10%
		6000	84%

You are comparing the two investment options in the table above for your client. Your client plans to invest \$5,000 and your client will use the investment amount as the reference point for their utility calculation.

- (b) (2 points)
- (i) (1.5 points) Calculate the expected value and expected incremental utility of each investment option.

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

- (ii) (0.5 points) Identify the most appropriate investment option based on results above.

ANSWER:

1. Continued

Your colleague recommends that you also examine the investment opportunities using cumulative prospect theory to capture behavioral effects on the decision-making process. She suggests a set of subjective probabilities for Investment B.

Payoff	Probability
500	0%
1000	10%
5000	10%
6000	80%

- (c) (1 point) Explain whether the suggested probabilities are consistent with the findings based on the cumulative prospect theory.

ANSWER:

2.

(6 points) The board of MNO Insurance Company recently introduced an initiative to incorporate Environmental Social Governance (ESG) factors into its investment practices. You are an investment risk consultant hired to develop a framework for performing due diligence on potential investment opportunities.

MNO recently joined the Principles for Responsible Investment (PRI) network as a signatory with a goal of following the PRI. Upon signing onto the PRI, senior management at MNO took the following actions:

- The company would publish a new set of rules on investment decision making, which requires consideration of ESG factors when performing due diligence.
- Several executives joined an industry-wide working group focused on developing new policy proposals related to ESG integration.
- The company will develop its own proprietary methodology for internal reporting of ESG risk exposures.

- (a) (1 point) Assess whether each of the company's actions above achieves its goal of following the PRI.

ANSWER:

- (b) (1.5 points) Recommend additional actions that would help MNO become more compliant with the PRI.

ANSWER:

MNO's asset managers have a good track record when investing in financial services, energy, and consumer goods sectors. The Chief Investment Officer (CIO) would like to diversify the company's holdings by investing in the transportation sector. As the first step, the CIO enlists a panel of research analysts within the company to create a risk checklist to assess some potential investments.

2. Continued

(c) (1.5 points)

- (i) (0.5 points) Explain why the CIO's approach to create a risk checklist is inadequate.

ANSWER:

- (ii) (1 point) Recommend two changes to the CIO's approach that could help ensure the risk checklist is adequate.

ANSWER:

The portfolio managers have narrowed their decision down to two airline companies as prospective investment opportunities:

- Company A has been in business for several decades and is a key player in the airline industry. Its airline fleet consists mostly of older models and their carbon footprint has become the subject of recent scrutiny.
- Company B is a newcomer to the industry. It has a smaller airline fleet than Company A does, but all its airplanes are new and use a modern design that is more efficient.

Your assistant prepared a projection of each company's financials for the upcoming calendar year. A few of the projected metrics are included below:

	Projected 2024 Results	
	Company A	Company B
Estimated fiscal revenue	\$10,000,000	\$500,000
Expected Equity Return	5%	4%
CO2 emissions (Metric ton)	1,000,000	40,000
People affected by noise	2.1M	1.1M
No. of employee	100,000	10,000

Concerning a potential conflict between the fiduciary duty of MNO's investment team and ESG factors,

2. Continued

(d) (2 points)

- (i) (0.5 points) Explain how environmental risks could have a negative impact on the company's long-term investment returns.

ANSWER:

- (ii) (0.5 points) Explain the potential conflict between the fiduciary duty of MNO's investment team and ESG factors.

ANSWER:

- (iii) (1 point) Recommend which of the two companies is a better investment option for MNO.

ANSWER:

3.

(9 points) Company ABC is a Life Insurance company that holds a diversified investment portfolio. Due to the prolonged low interest rates environment, ABC has been increasing allocation to private equity in hope of higher returns.

- (a) (1 point) Compare liquidity ratio (LR) with Martin liquidity (ML)

ANSWER:

ABC's regulator is planning to introduce new regulation that will increase the capital requirements for holding risky assets such as private equities. In anticipation of this, the CFO of ABC wants to quickly sell their private equity assets and rebalance their portfolio before the regulation takes effect.

- (b) (1 point) Recommend an appropriate category of liquidity measures in light of the new regulation.

ANSWER:

The portfolio manager was asked to sell 5 million shares of private equity. Because of the immediacy of the request, the portfolio manager sold the assets to a brokerage firm that works regularly with ABC as a market maker. The trade was completed based on the mid-price under the following transactions:

Day	Volume (Million)	Bid Price	Ask Price	Mid Price
1	2.0	\$9.00	\$11.00	\$10.00
2	0.5	\$7.00	\$9.00	\$8.00
3	0.5	\$6.00	\$8.00	\$7.00
4	1.0	\$7.00	\$9.00	\$8.00
5	1.0	\$9.00	\$11.00	\$10.00

The CFO suggests using a simplified assumption that this is the only asset in the market and proposes Hui and Heubel (HH) liquidity index as the liquidity measure.

3. Continued

(c) (2.5 points)

(i) (1 point) Calculate the HH liquidity index for the trade.

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

(ii) (0.5 points) Assess the level of liquidity for this trade based on the HH liquidity index calculated above.

ANSWER:

(iii) (1 point) Critique the use of HH liquidity index as a liquidity measure for this trade.

ANSWER:

Upon completing the trade, the portfolio manager rebalances the portfolio with investment grade corporate bonds. The CFO wants to verify that the new portfolio will comply with the firm's risk appetite.

The firm's risk appetite statement is as follow:

- Economic Capital is set to the maximum loss of the company's portfolio value at the end of the year with 95% confidence interval.
- Assume the initial value of the portfolio is 10,000,000, and at the end of the year the value of the portfolio is $10,000,000 * S$ where S follows a lognormal distribution with parameters ($\mu = 0.1$ and $\sigma = 0.2$).

3. Continued

(d) (2.5 points)

- (i) (1 point) Calculate the probability that the company's portfolio will experience a loss at the end of the year.

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

- (ii) (1.5 points) Calculate the economic capital according to the company's risk appetite.

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

The CFO has concerns that the current risk appetite does not adequately capture the tail risk of the loss and suggests to revise the economic capital using expected shortfall.

(e) (2 points)

- (i) (1 point) Calculate the 95% expected shortfall of the loss in portfolio value.

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

- (ii) (1 point) Critique the CFO's suggestion.

ANSWER:

4.

(5 points) You are studying risk modeling techniques, including copulas and correlation.

- (a) (1 point) Describe two advantages of using copulas.

ANSWER:

- (b) (1 point) Describe four drawbacks of using correlation as a measure of the relationship among risks.

ANSWER:

A colleague is modeling joint risks and suggests using a multivariate normal distribution is appropriate when the marginal distributions are normally distributed.

- (c) (0.5 points) Critique your colleague's suggestion.

ANSWER:

- (d) (1.5 points) Describe two tests to determine if the multivariate normal distribution is appropriate.

ANSWER:

- (e) (1 point) List three properties of the generating function $\phi(u)$ of an Archimedean copula.

ANSWER:

5.

(6 points) Your manager asked you to recommend the best model to evaluate equity risk using the expected shortfall measure. She provided you with the following information on the maximum log-likelihoods for three models, after fitting the model using 500 data points for both monthly and daily data.

Model	Maximum Log-likelihood (Monthly)	Maximum Log-likelihood (Daily)	Number of Parameters
ILN	595	1335	2
GARCH	611	1609	4
RSLN	619	1579	6

- (a) (2 points) Explain which models above are appropriate for short-term risk assessment and which are appropriate for long-term risk assessment.

ANSWER:

- (b) (2 points) Describe practical considerations in deciding which model to use.

ANSWER:

- (c) (2 points) Recommend one of these models using both of Akaike Information Criterion and Bayes Information Criterion, based on:

- (i) (1 point) daily data

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

- (ii) (1 point) monthly data

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

6.

(6 points) You are an actuary in the growing Enterprise Risk Management (ERM) department of a mid-sized life insurance company.

You are asked to identify potential enhancements to its overall ERM framework.

- (a) (1.5 points) Identify the two key features according to the IAIS standard that relate to your company's ERM framework.

ANSWER:

The company adopts an ERM framework largely based on that of a large multinational insurer about 5 years ago, the last time the framework was reviewed. In the meantime, the Chief Risk Officer (CRO) position has been eliminated; the CFO has taken on most CRO responsibilities and oversees all aspects of the ERM function.

- (b) (1.5 points) Recommend three changes to the ERM framework for your company.

ANSWER:

Your team provides three suggestions to improve the ERM framework:

- The framework's risk language should utilize terms already used within the organization to promote a smooth integration.
- The internal audit team should lead the development of the risk management framework because of the skill set match between auditors and those needed to implement ERM.
- The company operates on a conservative basis as compared with peers. Risk tolerances should therefore be set more aggressively than company practice in the ERM framework. This will ease adoption and promote a strong risk culture.

- (c) (3 points) Critique these suggestions.

ANSWER:

7.

(8 points) You are tasked with developing and calibrating an equity projection model to be used in the pricing of a variable annuity product. You are considering whether to use a Maximum Likelihood Estimation (MLE) or Bayesian Markov Chain Monte Carlo (MCMC) approach to estimate your parameters.

- (a) (1 point) Identify three parameter estimation risks.

ANSWER:

- (b) (1.5 points) Describe the advantages and disadvantages of Bayesian MCMC and MLE for parameter estimation.

ANSWER:

For your equity model, you decide to use the following monthly GARCH model, where S_t is stock price, Y_t are monthly returns, and σ_t^2 is monthly variance:

$$\begin{aligned}S_t &= S_0 e^{Y_{i,t}} \\ Y_t &= \mu + \sigma_t Z_t \\ \sigma_t^2 &= a_0 + a_1(Y_{t-1} - \mu)^2 + b\sigma_{t-1}^2\end{aligned}$$

You are also provided the following initial conditions:

$S_0 = 100$
$Y_0 = 0.0109$
$\sigma_0 = 0.0528$

The remaining four parameters (μ, a_0, a_1, b) are to be estimated using historical data.

Using both MLE and Bayesian MCMC approach, you have derived different sets of parameters in Exhibit 1.

7. Continued

Exhibit 1: MLE and Bayesian MCMC Parameters.

	μ	a_0	a_1	b
MLE	0.00968	0.00021	0.3236	0.6252
MCMC1	0.01019	0.00014	0.2539	0.7086
MCMC2	0.01042	0.00031	0.4056	0.5617
MCMC3	0.01035	0.00021	0.3756	0.5959
MCMC4	0.01011	0.00018	0.3191	0.6213
MCMC5	0.00931	0.00022	0.2568	0.6545

You have also generated the standard normal variates to be used in simulating the stock values in Exhibit 2 under five scenarios.

Exhibit 2: Standard Normal Variates.

	$t=1$	$t=2$	$t=3$	$t=4$	$t=5$
Scenario 1	-0.1449	-0.0749	-0.3011	-0.0177	0.909
Scenario 2	-0.0787	-0.1756	-0.6861	-0.5235	-0.337
Scenario 3	1.3441	0.7898	1.408	1.4273	1.0044
Scenario 4	-0.4315	-0.4599	-0.7912	-0.8513	-0.5208
Scenario 5	-0.5603	-0.4274	-1.1632	-1.0544	-1.3103

7. Continued

(c) (4.5 points)

- (i) (2 points) Calculate the expected value and standard deviation of the stock value at $T=5$, using the five simulations and MLE parameters.

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

- (ii) (2 points) Calculate the expected value and standard deviation of the stock value at $T=5$, using the five simulations and Bayesian MCMC parameters.

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

- (iii) (0.5 points) Assess the impact of simulating results using Bayesian MCMC versus with MLE-estimated parameters.

ANSWER:

For a separate model used to assess losses on hedge assets, your colleague compares the simulated losses using an Independent Lognormal (ILN) model and a Regime-Switching Lognormal (RSLN-2) model with two regimes. Both models were calibrated using the same 30 years of monthly data. Results of the simulated losses are shown in the table below:

Model	99% Expected Shortfall	99% Value at Risk	Standard Error of Expected Shortfall
ILN	35.6	28.7	2.45
RSLN-2	52.2	41.8	3.73

Your colleague states that the ILN has less model and parameter uncertainty and thus we should choose the ILN over the RSLN-2.

- (d) (1 point) Critique your colleague's statement.

ANSWER:

8.

(7 points) In a recent risk committee meeting for NewTech, the committee members expressed their concerns on the market risks faced by NewTech. The risk committee also considers the following:

- Instead of eliminating risks, risk-return trade-off should be considered.
- The hedging portfolio should be efficiently managed by the current small investment team.

NewTech hires you as a financial analyst to review the company's market risk profile.

The risk committee is considering the following three hedging options to mitigate the company's equity exposure:

- Delta-neutral hedging
- Delta-gamma-neutral hedging
- Hedging with option combinations

(a) (2 points)

(i) (1 point) Describe each of the three hedging options above.

ANSWER:

(ii) (1 point) Assess the suitability of each option, in light of the risk committee's considerations.

ANSWER:

8. Continued

NewTech asks you to construct an example for delta-neutral hedging and compare it against the portfolio without hedging (assume fully invested in stock). You come up with the following portfolio as an example:

	Time = 0
Investment	5,000
Unit of stock	202.8
Unit of put	624.3
Stock price	20
Strike price	19
Option term	1.00
Risk free rate	0.04
Volatility	0.3
$N(-d1)$	0.3248
$N(-d2)$	0.4387
Trading days per year	250
$z_{99\%}$	2.3263

(b) (1 point)

(i) (0.5 points) Verify that the portfolio value at time $T=0$ was \$5,000.

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

(ii) (0.5 points) Verify that the portfolio is delta-neutral at time $T=0$.

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

At time $T=0.05$, stock price increases to 22 per unit. Assume options are priced based on the Black–Scholes formula and that risk-free rate and volatility are constant. You compare this delta-neutral portfolio with the \$5,000 investment portfolio consisting of only stocks with no hedging.

(c) (2 points) Calculate the return of the portfolio with and without delta-neutral hedging.

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

8. Continued

- (d) (2 points) Calculate the 1-day 99% VaR for the portfolio with and without delta-neutral hedging, as a percentage of the portfolio value, using the delta-normal method.

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

9.

(9 points) Ron is a portfolio manager of a pension fund with total assets of \$100 million.

(a) (1 point)

(i) (0.5 points) Identify the principal-agent relationship.

ANSWER:

(ii) (0.5 points) Explain each party's incentive in this situation.

ANSWER:

A broker, Bob, suggests that Ron trade with him and adopt a new strategy for the pension fund that involves actively buying and selling fixed income securities frequently. He says that if Ron agrees, he will give him various research materials for free.

Ron proposes to carve out 10% of the pension fund to test the strategy before employing it on a larger amount.

(b) (2.5 points)

(i) (0.5 points) Explain the potential unethical behavior in Bob's suggestion.

ANSWER:

(ii) (1 point) Critique Ron's proposal.

ANSWER:

(iii) (1 point) Recommend an action that Ron should take to avoid any unethical behavior.

ANSWER:

9. Continued

Ron wants to change his team's bonus structure, which currently is 80% weighted towards individual performance and 20% weighted towards the team's performance. He is thinking of swapping the two weights.

- (c) (1 point) Explain the pros and cons of increasing the weight towards the team's performance in the bonus structure.

ANSWER:

Ron is thinking of investing in one of the following funds:

- Fund A has a management fee of 20bps per year
- Fund B has a management fee of 125bps per year

Fund B is a new fund, where its inception date is in Year 7. The Fund B manager provides the historical performance by backfilling the return data using a CAPM model.

Both funds measure their performance against their benchmark. However, Fund A switched its benchmark for years 5 through 8 as the benchmark has easier access to its underlying data than the previous one.

Below is a table showing the two funds' performances versus their benchmarks, as well as arithmetic average gross returns, as provided by their respective managers.

Year	Gross Return %					
	Fund A	Benchmark A	Difference	Fund B	Benchmark B	Difference
1	5	5	0	3	2	1
2	6	5	1	9	10	-1
3	3	2	1	1	2	-1
4	4	4	0	8	7	1
5	10	8	2	12	11	1
6	1	0.5	0.5	-6	-5	-1
7	4	2	2	9	8	1
8	3	1	2	5	6	-1
Average Return	4.5	3.4	1.1	5.1	5.1	0.0

While going through the due diligence process, Ron discovers that Fund A's manager only shows historical return of a number of his clients where they have similar size of investment as the pension fund.

9. Continued

- (d) (1 point) Explain the potential unethical behavior that Fund A's manager might be exhibiting.

ANSWER:

Based on the average returns shown in the above table, Ron thinks that Fund B performs better than Fund A does.

- (e) (2 points)

- (i) (1 point) Recommend two improvements to the average return calculation.

ANSWER:

- (ii) (1 point) Describe two other factors Ron should consider before choosing the fund to invest in.

ANSWER:

- (f) (1 point) Explain additional considerations in selecting a fund, in light of Fund A's benchmark change and Fund B's backfill of historical performance data.

ANSWER:

You review both Fund A and Fund B's income statements and notice that there is a high amount of interest expense in Fund A.

- (g) (0.5 points) Explain what would cause Fund A to have a large interest expense.

ANSWER:

****END OF EXAMINATION****