

# Exam QFIIRM

Date: Friday, May 3, 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.

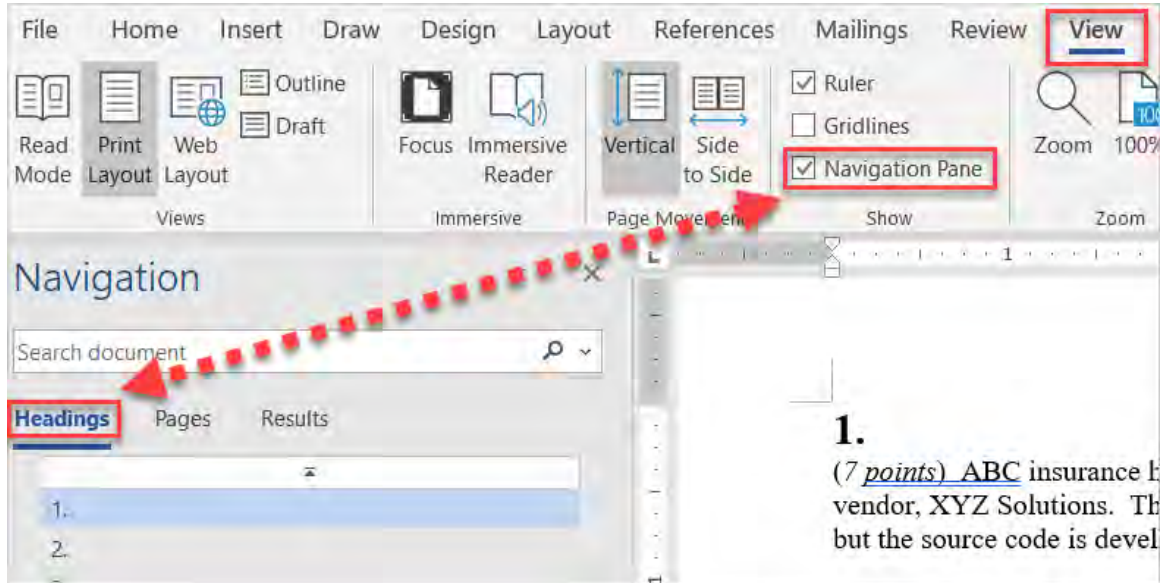
### Written-Answer Instructions

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,  $\beta_1$  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.

## Navigation Instructions

Open the Navigation Pane to jump to questions.

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



# 1.

(5 points) DEF, a life insurance company, has hired you to help the company understand Environment Social Governance (ESG) risks and advise on its investment decisions.

DEF has identified the following key risks:

- Regulatory Risk
- Reputational Risk
- Market Risk
- Environmental Risk

You learn the following:

- DEF's regulator is considering a new regulation that would fine financial service companies lacking proof of responsible investing.
- Life insurance consumers now consider the investment practices of companies in their purchase decisions.
- A recent pandemic has disrupted various industries and has also increased mortality rates.
- Decreased earnings from higher death benefit expenses are pressuring DEF to increase its investment margins. Management is considering purchasing more corporate debt.

(a) (3 points)

(i) (1.5 points) Explain how each key risk applies to DEF.

ANSWER:

(ii) (1.5 points) Explain how incorporating ESG factors into the investment decision making can mitigate each key risk.

ANSWER:

## 1. Continued

DEF is interested in investing in ABC, an onshore oil drilling company. You are given the following details about ABC's daily operations and corporate practices:

- ABC explores new drilling sites, which may require forest clearing.
- ABC operates oil rigs that require burning natural gas.
- ABC is expanding its workforce, actively recruiting and training new employees.
- ABC conducts annual safety inspections on all drilling equipment.
- ABC, a publicly traded company, is governed by a board of directors elected by shareholders.
- ABC's government affairs office engages in government lobbying and campaign donations.

You conduct a risk-focused process analysis based on the information provided above.

- (b) (2 points) Identify, from ABC's daily operations and corporate practices, two activities that it performs in each of the following categories: environmental, social, and governance.

ANSWER:
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## 2.

(4 points) XYZ is an insurance company that sells equity-linked universal life products. XYZ invests in long-term bonds and mortgage-backed securities to fund future claims and has a reinsurance agreement with UVW company to reduce the risk of large claims. You have been hired as a consultant to help with investment risk management at XYZ.

You have identified the following risks for XYZ:

- Stock Market Risk
- Interest Rate Risk
- Default Risk
- Liquidity Risk

(a) (1 point) Explain how each risk applies to XYZ.

ANSWER:

(b) (1 point) Recommend one mitigating action for each of the risks identified in part (a).

ANSWER:

The investment team at XYZ is composed of six people:

- A manager who has been with the company for 20 years.
- Five others hired by the manager, who have been with the company for 2 years or less
- All attended the same university.

Investment decisions require the approval of the team's manager and a majority of the team; however, almost all decisions are approved unanimously. The team has not experienced any material investment losses over the past 10 years.

(c) (1 point) Explain how each of the following aspects of groupthink may be affecting the investment team:

- Mind-guards
- Self-censoring
- Collective rationalization

ANSWER:

## 2. Continued

- (d) (1 point) Recommend three strategies that could reduce groupthink in the team decision-making process.

ANSWER:

### 3.

(9 points) You are a quantitative analyst at MNO Market Makers, a firm specializing in providing liquidity in the equity markets. Your firm is considering becoming a market maker for company IJK's stocks. You are tasked with assessing the profitability and risk of this deal.

The past year's monthly IJK share prices,  $S_{IJK}$ , and volume,  $V_{IJK}$ , are given below.

Month	1	2	3	4	5	6	7	8	9	10	11	12
$S_{IJK}$ (\$)	50	39	32	38	47	46	50	43	36	43	39	40
$V_{IJK}$ (millions)	8	7	4	6	5	8	6	5	5	10	5	4

You decide to use the independent lognormal model (ILN) to model the stock prices.

(a) (2.5 points)

- (i) (1 point) Estimate the monthly mean log-return,  $\hat{\mu}$ , and monthly volatility,  $\hat{\sigma}$ , from the provided data.

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

IJK's current share price is \$35.

- (ii) (1.5 points) Calculate the probability that IJK's share price is above \$40 in 6 months.

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

(b) (2.5 points)

- (i) (1.5 points) Describe the shortcomings of the ILN model.

ANSWER:

- (ii) (1 point) Recommend an alternative model to address the ILN model's shortcomings.

ANSWER:

### 3. Continued

Your manager is concerned about the liquidity of IJK's shares. STU is a separate company for which your firm currently is a market maker. Company STU is located within the same country as company IJK.

The past year's monthly STU share prices,  $S_{STU}$ , and volume,  $V_{STU}$ , are given below.

Month	1	2	3	4	5	6	7	8	9	10	11	12
$S_{STU}$ (\$)	50	43	48	47	44	33	25	21	24	20	19	21
$V_{STU}$ (millions)	11	8	15	6	5	8	6	5	5	10	5	4

You decide to use monthly data to calculate the Amihud illiquidity ratios (ILLIQ).

(c) (3 points)

- (i) (1.5 points) Calculate the monthly ILLIQ of IJK's shares and STU's shares over the last 12 months.

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

- (ii) (0.5 points) Assess the liquidity of IJK compared to STU under the ILLIQ measure from (i).

ANSWER:

- (iii) (1 point) Describe four sources of illiquidity.

ANSWER:

- (d) (1 point) Compare and contrast the ILLIQ and the Hui and Heubel (HH) liquidity index.

ANSWER:



#### 4.

(9 points) To assess credit risk associated with a portfolio consisting of bonds issued by two companies, A and B, you have been tasked with investigating the probability distribution for the number of defaults:

$$N = \mathbb{I}_A + \mathbb{I}_B$$

where  $\mathbb{I}_A$  and  $\mathbb{I}_B$  represent the default indicators, taking the value of one if the corresponding company defaults before a specific time  $T$ .

Initially, you assumed that the defaults of the companies are independent. After your manager reviewed your model, a concern was raised over the independence assumed among the default events.

- (a) (1 point) Describe two reasons why default events are not expected to be independent.

ANSWER:

Your manager recommends using a binomial-mixture model to address the lack of independence. Specifically, she suggests making the default probability dependent on a common latent random variable  $Z$  distributed uniformly over the interval  $(0, 1)$ .

Moreover, defaults are assumed to be conditionally independent given  $Z$ . The conditional default probability for each company is given:

$$P(\mathbb{I}_i = 1|Z) = Z, \quad i = A, B.$$

- (b) (1.5 points) Calculate the probability of experiencing one or more defaults within the portfolio under the binomial-mixture model.

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

- (c) (1 point) Calculate the covariance  $Cov(\mathbb{I}_A, \mathbb{I}_B)$ .

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

#### 4. Continued

Next, your manager asks you to use the covariance obtained in part (c) to explain the impact of dependence on the calculation of non-zero default probability.

- (d) (1 point) Describe the difference between the probability of non-zero default obtained from the independence and binomial-mixture models.

ANSWER:

After further investigation of the portfolio, you learn the following facts:

Company	Total Market Value (\$ M)	Expect rate of growth	STD of rate of growth	Total borrowing (\$ M) repayable in exactly one year
A	500	0.10	0.30	300
B	800	0.05	0.10	750

Based on the new information, your manager asks you to re-evaluate the credit risk associated with the portfolio.

- (e) (2 points) Calculate the one-year default probability for each company using Merton's model.

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

You are also given that the market values of the two companies are linked by a Frank copula:

$$C(F(x), G(y)) = -\frac{1}{\alpha} \ln \left[ 1 + \frac{(e^{-\alpha F(x)} - 1)(e^{-\alpha G(y)} - 1)}{e^{-\alpha} - 1} \right],$$

with  $\alpha = 2.5$ .

- (f) (1 point) Calculate the probability that both companies will default in one year.

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

- (g) (1 point) Contrast reduced-form models and structural models as they are applied to modelling default probabilities.

ANSWER:

#### 4. Continued

(h) (0.5 points) State whether each of the following models is a reduced-form model or a structural model:

- Binomial-mixture model
- Merton's model

ANSWER:
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## 5.

(8 points) You are asked to analyze an asset portfolio using risk-budgeting techniques.

Your colleague provides you with details of the portfolio, which consists of three assets with the following characteristics:

Asset	Expected Return	Allocation (\$M)	Volatility
A	0%	100	10%
B	0%	100	20%
C	0%	200	15%

The return correlations of the three assets A, B, and C are shown in the following matrix:

$$\rho = \begin{pmatrix} 1.0 & -0.5 & 0.25 \\ -0.5 & 1.0 & -0.5 \\ 0.25 & -0.5 & 1.0 \end{pmatrix}$$

Your colleague suggests using Value-at-Risk (VaR) to measure the risk of the portfolio.

- (a) (1.5 points) Calculate the 99<sup>th</sup> percentile VaR of the portfolio, assuming a normal distribution of returns.

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

- (b) (0.5 points) Explain why VaR is not a coherent risk measure.

ANSWER:

You are asked to decompose the portfolio risk into risk contributions using marginal analysis.

- (c) (1.5 points) Calculate the marginal risks (MR) and risk contributions (RC) for assets A, B, and C.

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

You are considering an alternative asset portfolio with only assets A and C with risk budget contributions of \$20M each.

- (d) (2 points) Calculate the amount of assets A and C needed for this risk budget portfolio.

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

## 5. Continued

You want to determine whether the risk-budgeting portfolio constructed in part (d) is optimal by examining the performance contribution defined by  $PC_i$  for assets A and C.

- (e) (0.5 points) Assess whether the portfolio is optimal when  $PC_A = 2\%$  and  $PC_C = 3\%$ .

ANSWER:

Next, you are exploring different portfolio construction approaches. Let

- (i)  $\{b_i\}$  be a vector of risk budgets
- (ii)  $\{x_i\}$  be a vector of weights.
- Approach 1:  $x_i/b_i = x_j/b_j$
  - Approach 2:  $\partial_{x_i} R(x) = \partial_{x_j} R(x)$
  - Approach 3:  $RC_i/b_i = RC_j/b_j$
- (f) (1 point)
- (i) (0.5 points) Identify the portfolio construction method corresponding to each of the three approaches above.

ANSWER:

- (ii) (0.5 points) State the relative ranking of resulting portfolio risks using an appropriate inequality relation.

ANSWER:

## 5. Continued

Three portfolios are constructed using Approach 3 with different budgets  $\{b_i\}$ . The resulting portfolios have weights  $x_i$  and risk contributions  $RC_i^* = RC_i/R(x)$ . Your portfolio construction objective is to minimize the variance of the portfolio.

Portfolio	Asset	$x_i$	$RC_i^*$
X	F	33.33	45.81
	G	33.33	22.23
	H	33.33	31.96
Y	F	18.11	33.33
	G	47.23	33.33
	H	34.66	33.33
Z	F	0.00	0.00
	G	30.34	30.34
	H	69.66	69.66

- (g) (1 point) Assess which portfolios described above meet the objective.

ANSWER:

**6.**

(6 points) You are an actuarial analyst on the risk management team for PQR Life Insurance supporting the assessment and management of PQR's liquidity risk.

To support your analysis, you are provided PQR's most recent balance sheet:

<b>Assets</b>	<b>Total</b>
Sovereigns Bonds backing same-jurisdiction liabilities	10,000
Non-Financial Corporate Bonds AA-/Aa3 and better	55,000
Financial Corporate Bonds AA-/Aa3 and better	20,000
Non-Financial Corporate Bonds at least BBB-/Baa3 but below AA-/Aa3	2,500
Common Equity, Publicly Traded	25,000
Private Equity	10,000
Diversified Demand Deposits	10,000
Governance Money Market Funds	2,500
<b>Total Assets</b>	<b>135,000</b>

<b>Liabilities</b>	<b>Total</b>
Liabilities for Insurance and Investment Contracts	100,000
Universal Life without Secondary Guarantees	80,000
Term	20,000
Other Liabilities	20,000
<b>Total Liabilities</b>	<b>120,000</b>
<b>Surplus</b>	<b>15,000</b>

Your colleague notes that PQR is well capitalized and is expected to maintain target capital ratios even under stress conditions. Therefore, there should be no concerns around liquidity risk.

- (a) (1.5 points) Critique your colleague's conclusion about liquidity risk.

ANSWER:
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## 6. Continued

You are asked to develop a liquidity stress scenario.

- (b) (1.5 points) List six liquidity risk drivers to be considered when developing a liquidity stress scenario.

ANSWER:

Management is concerned with the ability of the asset portfolio to support unexpected liquidity outflow events. You note that only highly liquid assets should be used to support liquidity shortfalls as they arise.

- (c) (1 point) Summarize four key characteristics of highly liquid assets.

ANSWER:

You are told that in projecting liquidity stress scenarios, PQR assumes that:

- Primary assets are sold before Secondary assets.
- Primary asset sales incur no haircuts.
- Secondary asset sales incur a 5% haircut.
- No regular asset inflows, such as from coupons or maturities, are assumed over a short-term horizon

- (d) (1 point) Calculate the amount of Secondary asset sales needed to meet a short-term liquidity need of 30,000, based on assumptions described above and the current balance sheet.

ANSWER:

After performing your liquidity stress analysis, you are asked to draft a report for the Financial Risk Committee summarizing key aspects of PQR's liquidity position and risks.

- (e) (1 points) List six key features of a liquidity risk management report.

ANSWER:



## 7.

(9 points) You are the Chief Financial Officer (CFO) of a small startup in the US which just received a seed fund invested in the money market. It is expected the seeding fund will be sufficient to fund operations for the next three years without additional capital raises. The company is relying on your expertise to ensure this commitment despite marketplace volatility. You are actively exploring possible actions.

The business must purchase significant amounts of agricultural commodity A to process into its final commercial product. The commercial product is in a highly competitive market and price elastic. Clearly, large increases in the price of commodity A pose a material risk.

You are considering two financial instruments, forward agreements and futures contracts to mitigate this risk.

(a) (3 points)

(i) (2 points) Contrast the advantages and disadvantages of forward agreements and future contracts, regarding the following risks:

- Customization and Basis Risk
- Counterparty/Credit Risk
- Rollover Risk
- Liquidity Risk

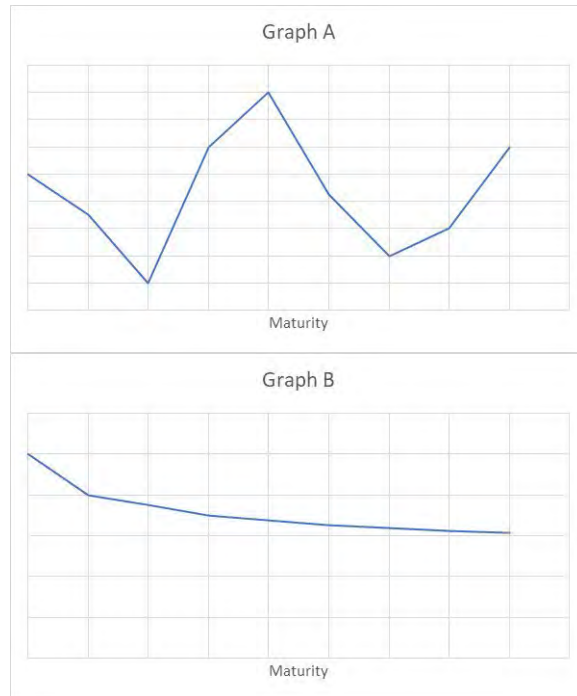
ANSWER:

(ii) (1 point) Recommend the most appropriate financial instrument of the two for the business.

ANSWER:

## 7. Continued

A draft report from your team contained two graphs as of the same date: (1) the yield curve and (2) the futures prices of an agricultural commodity across maturities, but there were no associated labels or descriptions.



- (b) (1.5 points) Explain which graph most likely represents the commodity futures and which one represents the yield curve.

ANSWER:

The CEO suggests entering into an interest rate swap agreement to avoid any financial impact implied by the yield curve identified in part (b).

- (c) (1 point) Assess the CEO's suggestion.

ANSWER:

The company anticipates purchasing 11,200 units of commodity A in the coming year and would like to fully hedge, if possible. You are considering cross-hedging the risk. One possibility has a  $\beta$  of 0.7 with each 1-year contract representing 250 units of the underlying, where  $\beta$  is an estimate of the optimal hedge ratio.

## 7. Continued

(d) (2 points)

(i) (0.5 points) Calculate the number of contracts for this cross-hedge.

ANSWER:

(ii) (1.5 points) Describe three factors that would impact the effectiveness of the cross-hedge if using futures.

ANSWER:

Company Y is a foreign company operating in currency CY. It receives a 2% discount on commodity A from the US market rate (in USD) due to its relationship with the supplier. Your company incurs no foreign exchange transaction costs between USD and CY, while the foreign exchange transaction cost between USD and CY is 2% for company Y.

(e) (1.5 points) Recommend a mutually beneficial arrangement between your company and company Y.

ANSWER:

## 8.

(5 points) You are asked to review the structure of an insurance company's board of directors and its recent activities.

The current board structure is as follows:

- The board has 13 members, amongst which are 7 members who used to have a work relationship with the company as employees or service providers, which means that they are familiar with the company's business.
- The chairman of the board is the CEO of the company, who participates in all board meetings.

(a) (1 point) Critique the effectiveness of the board structure of the company.

ANSWER:

A candidate is identified to fill an open director role on the board. The candidate's background information is listed below:

- Age: 61
- Has 30+ years of insurance experience and extensive expertise in accounting and finance.
- Serves as a board member at three different companies in the industry where she has done so for many years.
- Partner of a consulting firm that mainly provides investment services to insurance companies, including this one.
- A friend of the current CEO.

(b) (1 point) Critique the suitability of this candidate for the director role.

ANSWER:

The compensation committee of the board is evaluating CEO compensation, where there is a proposal to replace the current CEO's generous golden parachute with golden handcuffs and a golden coffin in order to encourage the CEO to stay with the company and consistently increase shareholder wealth.

(c) (1.5 points) Evaluate this proposal.

ANSWER:

## 8. Continued

The investment manager of the company's pension fund, Sarah, invested a significant portion of the pension fund in ZZZ company's stock. Three days after the transaction was made, Sarah sold her own stake in ZZZ.

- (d) (1.5 points) Assess Sarah's professional conduct.

ANSWER:
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## 9.

(5 points) You work as an ALM actuary for a mid-size insurance company with core businesses of life insurance and annuities. As interest rates rose in the last few years, the experience studies team reported significantly higher than expected surrenders for the fixed deferred annuities, especially those issued with a lower minimum crediting rate guarantee, when interest rates were low.

- (a) (1.5 points) Explain potential risks associated with the above situation.

ANSWER:

You have received several recommendations from your colleagues in response to excess losses from interest rate movements:

1. Your company's investment manager recommends that you invest in a company that he knows will be making a public announcement about a merger imminently, where their stock price will likely increase after the announcement.
2. Invest in a company today that your company investment manager knows has a large buy order being placed the next day.
3. In order to discourage surrenders, the company raises the crediting rate to a very attractive level for the existing policyholders and uses the same high crediting rate to attract new money from new policyholders. A substantial amount of the new money will be used to support a higher crediting rate for the existing contracts.
4. Accept the losses because any potential actions to fix prior mistakes would create a bigger mistake.

- (b) (3.5 points)

- (i) (2.5 points) Evaluate each recommendation.

ANSWER:

- (ii) (1 point) Recommend the most appropriate active risk management action, which may or may not be from the above list. Justify your recommendation.

ANSWER:

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