SOCIETY OF ACTUARIES
QFI Investment Risk Management Exam

Exam QFIIRM

Date: Friday, April 27, 2018
Time: 2:00 p.m. – 4:15 p.m.

INSTRUCTIONS TO CANDIDATES

General Instructions

1. This examination has a total of 40 points.

   This exam consists of 6 questions, numbered 1 through 6.

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

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. When you are asked to recommend, provide proper justification supporting your recommendation.

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 QFIIRM.

6. Be sure your written-answer envelope is signed because if it is not, your examination will not be graded.

Tournez le cahier d'examen pour la version française.

1. (*5 points*) Shareholders of XYZ Life Insurance company questioned if the Enterprise Risk Management (ERM) in XYZ was strong enough to weather another financial crisis like 2008. XYZ hired you to review its ERM independently.

You begin with a review of XYZ's board structure and make the following notes:

- The Chief Executive Officer (CEO) is the chairman of the board.
- The Chief Risk Officer (CRO) reports only to the CEO.
- The board consists of 20% inside directors and 80% outside directors.
- The compensation committee consists of 10% inside directors and 90% outside directors.
- The audit committee consists of 100% outside directors.
- All outside director terms are limited to 1 year to prevent directors from becoming entrenched.

(a) (*1.5 points*)

(i) Identify which bullets are deficient from a governance perspective.

(ii) Recommend improvements for the bullets identified in (i).

A colleague of yours makes the following two statements:

Statement 1 - "When appointing inside or outside directors, the most important quality he or she must possess is detailed specialist industry knowledge."

Statement 2 - "Individuals who are retired from their primary professions usually make good candidates for outside directors. In that group, we should have a preference for candidates who are involved with more directorships as that is indicative of their continued engagement in our industry."

(b) (*1.5 points*) Assess each statement.

Senior management is currently compensated with a generous flat salary. The compensation committee has recently suggested introducing stock options into the compensation package for senior management. You recall that one of the disadvantages of stock options is the potential for option grant abuses.

(c) (*1 point*) Identify and describe two forms of option grant abuses.

1.   Continued

One director is arguing for accounting-based bonuses over stock-based compensation. He acknowledges that one concern with accounting-based bonuses is the potential for earnings manipulation.

(d)   (*1 point*) Recommend two ways to discourage earnings manipulation in setting accounting-based bonuses.

2. (*6 points*) Dale is an investment analyst with several clients. One of his clients is his younger brother, Pat.

Dale has been allocated 2,000 shares for an upcoming IPO. Each of the following clients would like shares of this company. Dale would also like shares for his own personal account. You are given the following information:

Account Holder	Current Account Value ($USD)	Requested Number of Shares
Client A	300,000	1,200
Client B	200,000	2,000
Pat (Dale's brother)	50,000	500
Dale	150,000	500

(a) (*2 points*) Recommend the appropriate allocation of shares. Justify your recommendation with two reasons.

Dale meets his brother for drinks at a local bar. He and Pat notice an executive from an AA-rated firm and overhear the executive telling a co-worker that the latest project has produced results below expectations, and expects the firm to cut dividends considerably. After they leave, Pat asks Dale to sell his shares of the firm. Dale is concerned with treating his clients fairly in using this information.

(b) (*2 points*) Recommend any actions Dale should take. Justify your recommendation with two reasons.

Dale recommends a "buy" rating for a company called ABC. Part of ABC's financial disclosures includes a return figure of 18.5%. Some of Dale's clients decided to buy shares of ABC, following his recommendation. Three months later, ABC disclosed that the return was erroneous and should have been 8.5%.

Dale has not informed his clients of the correction, but one of Dale's colleagues believes they should be notified.

(c) (*2 points*) Recommend any actions, if any, Dale should take. Justify your recommendation with two reasons.

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3. (*9 points*) ABC is a small U.S. public investment management firm that specializes in real estate and property management. It also has a small insurance subsidiary. As the Chief Risk Officer (CRO), you make the following notes about ABC's business model:

- ABC has partnered with a social media company that develops and manages an award-winning mobile application (app) that has enabled ABC to successfully market its funds to millennials.
  - The success of the app has allowed ABC's assets under management to grow rapidly, helping to mitigate the effects of industry-wide pressure to decrease fees.
- ABC's funds consist solely of mortgages and real estate.
- A large proportion of the funds' investment income comes from rental income from about 100 renters.
  - The rental properties are located in cities in different countries that have been experiencing rapid growth.
  - Part of ABC's value proposition to renters is that the rent also pays for renter's insurance and life insurance issued by ABC's subsidiary.
- ABC reinsures 40% of its insurance business with reinsurance company XYZ.

(a) (*1 point*) Identify four stakeholders explicitly mentioned in the case and describe their interests in ABC.

(b) (*1.5 points*)

   (i) Explain how ABC and its funds' investors are each exposed to credit risk.

   (ii) Recommend actions that could be taken to mitigate these risks.

(c) (*1.5 points*)

   (i) Explain how ABC is exposed to insurance risk.

   (ii) Recommend actions that ABC could take to mitigate these risks.

(d) (*1 point*) Explain whether each of the following pairings constitutes a principal-agent relationship.

   (i) ABC and its social media partner.

   (ii) ABC and XYZ.

3. **Continued**

In preparation for a meeting with senior management, you decide to create a presentation on SWOT analysis.

(e) (*2 points*) Analyze ABC's business strategy using a SWOT analysis.

You want to gather employees' thoughts on the firm's risks. A consultant presents the following table to you, which summarizes some of his past experiences utilizing different risk identification techniques.

Data Type	Risk Identification Technique		
	A	**B**	**C**
Sample size	20	1000	5
Number of respondents	16	250	5
Percentage of respondents "very familiar" with risks	50	20	100
Rate of emergence of new ideas	High early in the process only	Consistently low throughout the process	Consistently high throughout the process

(f) (*2 points*) Determine the risk identification technique represented in each column of the table above. Justify your response for each technique using the data in the table.

4. (*6 points*) You are the Chief Risk Officer (CRO) at XYZ Life Insurance Company. Your firm just hired a new Chief Financial Officer (CFO) and your first project with him is to update the firm's liquidity risk measurement framework.

(a) (*1 point*) Identify and describe two quantitative frameworks for liquidity risk measurement.

The CFO has prior work experience in banking and non-life insurance. He would like to gain a better understanding of a life insurance company's exposure to liquidity risk.

(b) (*1 point*)

    (i) Rank the liquidity risk for a life insurance company, a bank and a non-life insurance company.

    (ii) Explain the differences in liquidity risk among these three financial institutions.

The CFO is reviewing the allocated capital to each of the company's different sub advisors, along with their risk budgets (daily VaR) and their annual investment profits.

Investment Sub Advisor	Allocated Capital ($M)	Daily VaR ($M)	Annual Investment Profits ($M)
Real Estate Group	100	5	20
Alternatives Group	300	10	25
Fixed Income Group	200	10	15
Company Total	600	20	60

While reviewing the table above, the CFO was wondering if risk allocation is the same as traditional asset allocation. He also believes that the Investment Sub Advisors' asset returns are perfectly correlated.

(c) (*1.5 points*) Explain the differences between asset allocation and risk allocation.

(d) (*0.5 points*) Describe how the total Daily VaR would change if the CFO's belief were correct.

4. **Continued**

Maintaining his current belief of perfect correlation among the Sub Advisors, the CFO would like to de-risk the portfolio by lowering the Company Total VaR limit to $18M and is willing to withdraw some of the capital invested in the business. The CFO's goal is to minimize the impact on the company's annual investment profits.

(e)   (*2 points*)

     (i)   Recommend the sub advisor from which to withdraw capital.

     (ii)   Calculate how much capital needs to be withdrawn from the sub advisor identified in (i).

     (iii)   Calculate the impact on the company's annual investment profits.

5. (*7 points*) The Chief Risk Officer (CRO), has assigned you, a risk analyst, to research scenario based risk aggregation analysis.

(a)　(*0.5 points*) Explain the advantages of scenario based risk aggregation analysis.

(b)　(*1.5 points*) Describe three types of models or algorithms that are commonly used as scenario generators.

The CRO decided to use copulas and asked you to estimate the aggregate losses from exposure Y_1 and Y_2 via simulations. The CRO has instructed you to assume exposures Y_1 and Y_2 which follow certain known parametric distributions.

(c)　(*1 point*) Describe the steps you should use to sample aggregate losses with a copula.

Based on external studies, you concluded Y_1 resembles a Pareto distribution with $\alpha = 3$ and $\theta = 5$ and Y_2 resembles an exponential distribution with $\theta = 15$. You generate 100 simulations and the results are summarized in the following table:

Simulation (i)	Loss Y_1 Uniform Random Number	Loss Y_2 Uniform Random Number	Simulated Loss Y_1	Simulated Loss Y_2	Simulated Aggregate Loss
1		Z		13.25	
2	5.2%			24.52	X
...	...	...	...	...	
100			24.2	6.48	

Pareto distribution probability density function and cumulative distribution function:

$$f(x) = \frac{\alpha\theta^{\alpha}}{(x+\theta)^{\alpha+1}} \qquad F(x) = 1 - \left(\frac{\theta}{x+\theta}\right)^{\alpha}$$

Exponential distribution probability density function and cumulative distribution function:

$$f(x) = \frac{e^{-x/\theta}}{\theta} \qquad F(x) = 1 - e^{-x/\theta}$$

(d)　(*2 points*) Calculate the unknowns Z and X.

5. **Continued**

Upon revision, the CRO advised that the two exposures should be normally distributed. The CRO then suggested to estimate VaR using the sigma-based and quantile-based approaches. You generate 10,000 simulations and the results are shown in the following table.

VaR Estimation	Based on 10,000 Simulations		
Statistic	Average	Standard Error	Asymptotic Standard Error
Method 1			
- @ 10%	-1.77	0.066	0.065
- @ 1%	-4.27	0.152	0.151
Method 2			
- @ 10%	-1.74	0.033	0.034
- @ 1%	-4.22	0.067	0.068

(e)   (*2 points*) Determine which VaR estimation methodologies were used as Method 1 and Method 2. Justify your response using the data in the table.
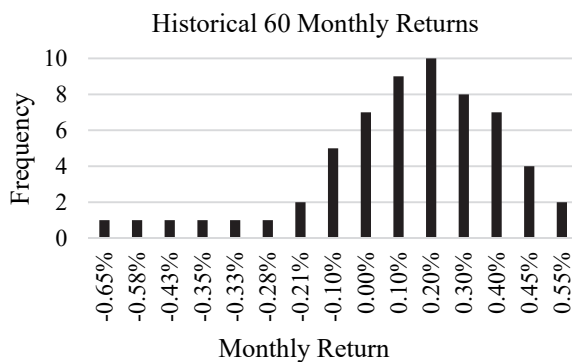
6. (*7 points*) ABC investment management company owns a Capital Preservation Plus Fund, which consists of short-term and intermediate-term bonds with a principal protection feature. Interest rate options are utilized for hedging purposes.

The fund manager has the following information about the fund:
- Returns are assumed to be normally distributed.
- The expected annual return is 1.59%.
- The assumed annual standard deviation is 1.21%.
- The fund value at valuation date is $9,000,000.

(a) (*0.5 points*) Calculate the monthly 5% VaR using the Analytical Method.

The Chief Actuary questions the fund manager's assumption and requests historical performance data. The histogram shows the historical monthly returns for 60 months. The table shows the worst 10 out of 60 monthly returns.

Historical 60 Monthly Returns

Rank	Monthly Return	Rank	Monthly Return
1	-0.65%	6	-0.28%
2	-0.58%	7	-0.21%
3	-0.43%	8	-0.21%
4	-0.35%	9	-0.10%
5	-0.33%	10	-0.10%

(b) (*0.5 points*) Calculate the monthly 5% VaR using the Historical Method based on the monthly returns above.

(c) (*2 points*) Recommend either the Analytical Method or the Historical Method. Justify your answer.

6. **Continued**

The fund manager wants to improve the yield on the fund by allocating more to Mortgage Backed Securities (MBS) and Asset Backed Securities (ABS). The fund manager researched the correlation among the assets to ensure proper diversification and makes the following statement:

"We monitor the correlation matrix annually to measure dependencies between assets. The values do not change much based on our experience. Most coefficients are far from 1 and -1 indicating low tail dependence. In addition, Treasury Inflation Protected Securities (TIPS) exhibit near zero correlation with other assets, which demonstrates independence of risks. The new allocation can be developed based on this assumption."

Table 1: Current Assumption

	MBS	TIPS	ABS	Treasuries
MBS	1.00			
TIPS	0.01	1.00		
ABS	0.62	0.01	1.00	
Treasuries	0.54	0.02	0.46	1.00

You heard about this project and provided the actual historical correlation matrix during the previous financial crisis to the fund manager.

Table 2: Historical data during financial crisis

	MBS	TIPS	ABS	Treasuries
MBS	1.00			
TIPS	0.15 (+.14)	1.00		
ABS	0.97 (+.35)	0.11 (+.10)	1.00	
Treasuries	0.41 (-.13)	0.10 (+.08)	0.43 (-.03)	1.00

Note: The difference between Table 1 and Table 2 are shown in the parenthesis.

(d)   (*2 points*) Critique the fund manager's statements. Justify your response using the data in the tables.

After viewing the results, the Chief Actuary emphasized the importance of modeling tail dependence. The Chief Actuary proposed the Clayton copula;

$$C(x, y) = \left(x^{-\theta} + y^{-\theta} - 1 \right)^{-\frac{1}{\theta}}; \quad \theta \neq 0$$

(e)   (*2 points*) Verify whether the copula exhibits the lower tail dependence. Show all work.

END OF EXAMINATION

USE THIS PAGE FOR YOUR SCRATCH WORK