SOCIETY OF ACTUARIES
QFI Investment Risk Management Exam

Exam QFIIRM

Date: Wednesday, October 29, 2014
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 5 questions, numbered 1 through 5.

   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.

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BEGINNING OF EXAM

1. (*6 points*) Representatives of an OECD country have approached your consulting firm for guidance in setting up a public pension fund.

They are reviewing the qualifications for members of the governance board and seeking your opinion in assessing the qualifications of two candidates, Mr. Smith and Ms. Jones. Both candidates are high caliber individuals with strong professional backgrounds. Ms. Jones is a college professor who also has a strong professional investment background. She has a reputation for independent views on various subjects even when they conflict with popular views. Mr. Smith is an executive officer of a consulting firm and is well connected to members of the political arena. He generally takes views that are aligned with current political thinking and that has earned him the reputation of being "an easy guy to work with."

(a) (*1 point*) Recommend a candidate for the position on the governance board.

The newly established governance board wants to ensure that ethical issues are considered in investment decisions. A board member makes the following comment:

> *"Ethics are principles of right and wrong and are codified into law thus I view ethics as a function of our legal department. If we ensure our operations are within the bounds of the law then there should not be any ethical violations."*

(b) (*1 point*) Evaluate the above statement and support your response with an example.

The board has identified the following as ways to promote the consideration of ethical issues in the decision making process:

- Favor hiring and promoting people with a well-grounded sense of personal ethics
- Build an organizational culture that places a high value on ethical behavior

(c) (*1.5 points*) Describe three additional ways to promote ethical decision making in the management of the pension fund.

1. **Continued**

The board would also like guidance on best practice areas that are of critical importance to managing pension fund assets. They have identified the following factors as being critical to the successful management of the fund:

- Risk management
- Time horizon
- Innovation capability

(d) (*1.5 points*) Identify two additional governance factors and describe why they are critical to the successful management of the pension fund.

5 years have gone by since the public pension fund was set up and your firm has been approached to review the fund's performance. In your review you observe that the fund's cost structure is higher than expected for a well-run fund.

(e) (*1 point*) Identify what areas should be the focus of an investigation into the fund's cost structure.

2. (*8 points*) You are starting your new job with the Risk Modeling team at Big Bank, responsible for risk aggregation. Previously, another member of the team has summarized the dependence structure of the firm's risk exposures using a correlation matrix. You are aware of the potential shortcomings of using correlations and want to explore alternative methods for risk aggregation.

(a) (*1 point*) List four drawbacks for the use of linear correlation as a dependency measure of the risks.

(b) (*0.5 points*) Describe one class of multivariate distribution for which the use of correlation to measure dependence between risks would be appropriate.

Your boss is concerned about tail dependence and he wonders if it can be effectively captured using a Gaussian copula.

(c) (*1.5 points*)

(i) (*0.5 points*) Describe tail dependence in the context of two risks.

(ii) (*1 point*) Explain whether the Gaussian copula is a good choice for modeling tail dependence.

You want to examine the simulated aggregate losses from the first two exposures only. Historical data suggests that loss X_1 is exponentially distributed with mean of 8, and loss X_2 is exponentially distributed with mean of 13. The table below contains uniform random numbers generated from the copula that describes the dependence structure of the two risks.

Scenario Number	**Loss X_1 Random Number**	**Loss X_2 Random Number**	**Simulated Loss X_1**	**Simulated Loss X_2**	**Simulated Aggregate Loss**
1			10.33	1.83	12.15
2			2.08	1.87	3.95
3	0.864	0.160			

2. **Continued**

(d) (*3 points*) Calculate the aggregate loss for the third scenario.
(Note: The cumulative distribution function and the probability density function of an exponentially distributed random variable x is $F(x) = 1 - e^{-\lambda x}$, respectively with the mean being $1/\lambda$.)

At the end, you fitted a Gumbel copula of the form

$C_\beta(u,v) = e^{-\left\{(-\ln u)^{1/\beta} + (-\ln v)^{1/\beta}\right\}^\beta}$, $0 < \beta < 1$ to these two risk factors.

(e) (*2 points*) Demonstrate that each marginal risk distribution is uniform on [0, 1].

3. (*10 points*) David Puddy is a portfolio analyst at Kramerica Industries. He has been asked to evaluate the risk exposures of his portfolio. He has decided to use tracking error as the primary risk metric.

(a) (*1 point*) Identify advantages and disadvantages of using the tracking error metric.

David has developed a model to project returns for his portfolio. His model also projects returns for an index fund he uses as a benchmark. David uses his model to project for 5 periods. He calculates the following values:

Portfolio Returns for David and Benchmark

Period	1	2	3	4	5
David	5%	7%	8%	8%	5%
Benchmark	3%	5%	4%	8%	4%

(b) (*2 points*) Calculate the ex-ante tracking error of David's forecast.

Jackie Chiles, a colleague of David's at Kramerica, analyzes another portfolio which uses the same index as a benchmark. Jackie's projected portfolio returns are provided below.

Portfolio Returns for Jackie

Period	1	2	3	4	5
Jackie	1%	2%	7%	6%	6%

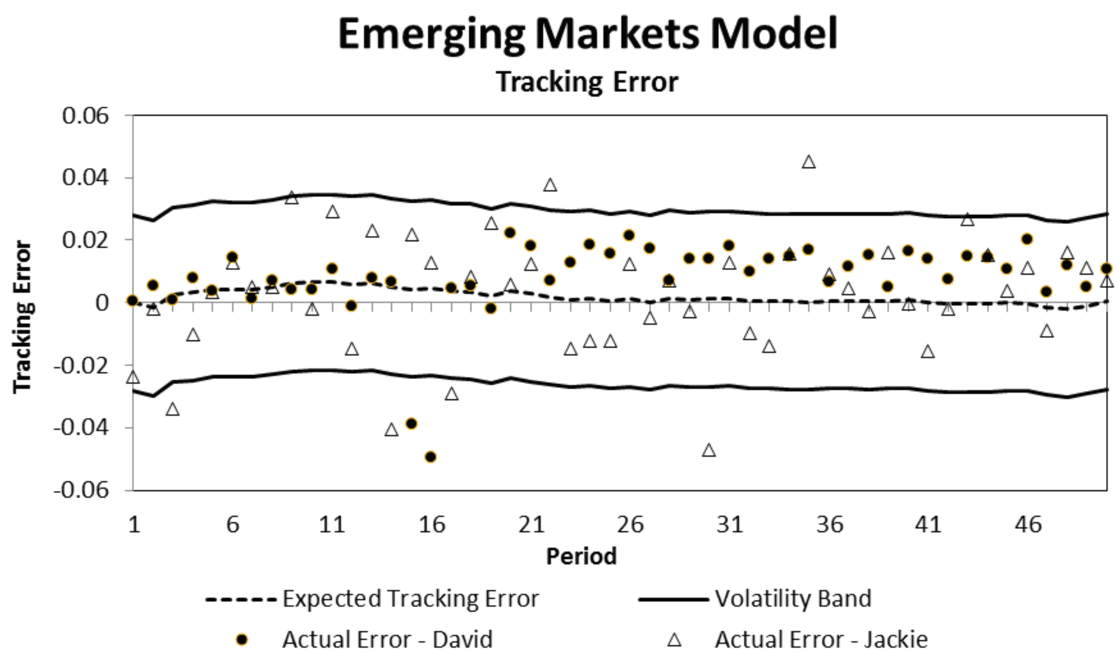
Jackie makes the following statements:

- "My portfolio has a lower duration than David's, and therefore a lower level of tracking error."
- "There will be no change in my portfolio's securities holdings over the next three years, therefore I don't need to re-calculate ex-ante tracking error."
- "Analysis shows that my portfolio's spread duration gap is greater than the interest duration gap, therefore spread risk contributes the most to tracking error."

(c) (*2 points*) Critique each statement above.

3. **Continued**

After 50 periods, David is reviewing the returns of his and Jackie's portfolios in terms of tracking error to the benchmark. He decides to plot a risk boundary at one standard deviation from the mean of the expected tracking error. David prepares a graph illustrating each portfolio's actual error returns compared to the expected error:



David is especially concerned about three aspects of portfolio performance:

- Style Drift
- Extreme Events
- Return Volatility

(d) (*2 points*) Identify the issues with both portfolios with respect to the three aspects above.

(e) (*3 points*) David would like to reduce tracking error in the future by improving his model (described earlier). Recommend a process for improving the accuracy of David's model.

4. (*10 points*) Your Board of Directors has questioned why your company does not have a formal risk management program. They have cited Barings Banks and Equitable Life as two high profile cases where lack of risk management led to failures.

(a) (*1.5 points*) Describe how risk culture in each of the two cases contributed to their respective failures.

The CFO recently came across the following 5 axioms regarding the management and control of risk:

1. Do not rely solely on quantitative models
2. Ask "What if I am wrong?"
3. Ensure that accountability and authority match
4. Revise strategies and policies constantly
5. Address the least likely events which often cause the most damage

(b) (*2 points*) Explain how these axioms could have helped prevent the failures in each case study.

Upon review of the case studies and industry best practices, the Board of Directors has directed senior management to compile a Risk Register. You've identified inflation risk to be a material risk to your company. You're considering the following techniques to better assess this risk:

I. Delphi Technique
II. Gap Analysis
III. Pilot Survey

(c) (*2 points*) Recommend the most appropriate technique to assess this risk.

4. **Continued**

(d) Your company hired a consultant to look into possible operational risks. The consultant provided a full report on the operations of the company. Below are excerpts from the report, providing some observations from the consultant:

Excerpt 1

The firm contains many small, highly specialized operational teams to handle specific asset classes, investment strategies and clients. We note that this allows management to place their best people in particularly challenging areas. Additionally, clients like to hear that the firm has teams dedicated to their fund. Further, there are numerous, irreplaceable specialists within the firm, assuming either sole responsibility for a function or client relationship. We view this as an advantage as it sends a signal of expertise to clients. Additionally, having an individual responsible for maintaining the relationship with clients helps build continuity and rapport between the firm and the clients.

Excerpt 2

In review of the firm's formal documentation of processes, procedures and workflows, we find the firm to be significantly deficient. For the majority of the firm, documentation is absent or severely outdated. The firm likely experiences significant duplication of work efforts and management cannot ensure operational controls are in place. Additionally, we expect the firm will have difficulties in training new employees and is severely at risk of being unable to perform critical functions if it were to experience significant employee turnover or a disaster. This is a serious issue that requires immediate attention from the firm.

(i) (*0.5 points*) Identify any potential operational risks uncovered by the consultant.

(ii) (*2 points*) Critique the consultant's conclusions.

(iii) (*2 points*) Recommend to the firm 4 corrective actions that could be taken to mitigate the operational risks you identified in part (i).

5. (*6 points*) Students are discussing various topics on tax effects, transaction costs, agency costs and the benefits of hedging for firms. Below are statements made by the students:

> *"Firms have to pay taxes and the expected value of these taxes is affected by risk. This is driven by convexity in the tax function."*

(a) (*1 point*) Describe two features of a country's tax code that could create the convexity referenced in the statement above.

(b) (*1 point*) Illustrate how convexity in the tax function can cause the expected value of taxes to be affected by risk.

> *"The attraction of shareholders to high risk investments always leads to 'asset substitution.' 'Asset substitution' involves the firm raising debt and promising to undertake a low-risk project. After securing the funds, it then substitutes a high risk investment causing a wealth transfer from bondholders to shareholders."*

(c) (*0.5 points*) Assess the above statement.

(d) (*0.5 points*) Describe the measures that could be taken by bondholders to mitigate the situation.

(e) (*1 point*) Describe an alternative situation which could also arise from the asymmetry in the payoff to shareholders and bondholders.

> *"One way to incent managers of a company to hedge risks, and thus add value, is to compensate them with a company stock-options plan."*

(f) (*1 point*) Assess the above statement.

(g) (*1 point*) Describe an alternative compensation scheme that would better incent managers to hedge company risks.

****END OF EXAMINATION****

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