

QFI IRM Model Solutions

Fall 2021

1. Learning Objectives:

2. The candidate will understand and be able to apply the components of an effective risk management system.
3. Understand and be able to apply different approaches to measuring risk exposures.

Learning Outcomes:

- (2b) Identify and describe the various kinds of risks, including market, credit, operational, etc.
- (2c) Identify and describe various approaches for managing risks including risk budgeting, position limits, etc.
- (3e) Evaluate a company's or a portfolio's exposures to various risks.

Sources:

Value at Risk: Chapter 7: Portfolio Risk: Analytical Methods

Value at Risk: Chapter 17: VAR and Risk Budgeting in Investment Management

Commentary on Question:

The aim of this question was initially to ask candidates to identify risks for a company. It then went on to test the candidate's ability to calculate risk exposures (i.e., VaR). Finally, an analysis of the results rounded out the final parts of the question.

Overall, candidate performance was fair on this question. The majority of candidates performed well on parts a)-c) and poorly on parts d)-f).

Solution:

- (a) Describe two measures of sponsor risk that XYZ faces.

Commentary on Question:

Candidate performance was fair for this question part. While most candidates were able to describe either the cash flow risk or the economic risk faced by XYZ, a number of candidates failed to describe both risks sufficiently to earn full credit.

1. Continued

Cash flow risk – risk of year-to-year fluctuations in contributions to the pension fund

Economic risk – risk of variation in total economic earnings of the plan sponsor

(b)

(i) Calculate the expected annual volatility of the fund.

(ii) Determine if the plan violates the VaR guidelines.

Commentary on Question:

Candidate performance was fair for this question part. Most candidates who scored well correctly calculated the volatility and also correctly concluded the annual VaR exceeded the \$20M limit. However, several candidates miscalculated the portfolio volatility in part (i) and incorrectly assessed plan VaR against guidelines.

(i)

Formula for portfolio variance:

$$\sigma_p^2 = [w_1 \cdots w_N] \begin{bmatrix} \sigma_1^2 & \cdots & \sigma_{1,N} \\ \vdots & \ddots & \vdots \\ \sigma_{N,1} & \cdots & \sigma_N^2 \end{bmatrix} \begin{bmatrix} w_1 \\ \vdots \\ w_N \end{bmatrix}$$

Where weights are given in Table 2 and the covariances are given in Table 1.

$$\text{SUMPRODUCT}(\{0.35,0.6,0.05\},\{0.0415,0.0028,0.025\}) = 0.01746$$

$$\text{SUMPRODUCT}(\{0.35,0.6,0.05\},\{0.0028,0.0025,0.0012\}) = 0.00254$$

$$\text{SUMPRODUCT}(\{0.35,0.6,0.05\},\{0.025,0.0012,0.0588\}) = 0.0124$$

$$\text{SUMPRODUCT}(\{0.01746,0.00254,0.0124\},\{0.35,0.6,0.05\}) = 0.83\%$$

$$\text{Volatility} = \text{SQRT}(0.83\%) = 9.08\%$$

The portfolio volatility is 9.08%

(ii)

The portfolio return is given by:

$$R_p = w_1R_1 + w_2R_2 + w_3R_3$$

Using the data in Table 2, the expected return is 5.3%:

$$R_p = 35\% * 7.3\% + 60\% * 4.3\% + 5\% * 2.0\% = 5.3\%$$

1. Continued

The portfolio VaR is given by:

$$VaR_p = \mu_p W - \alpha \sigma_p W$$

Using the results from part (i):

$$VaR_p = (5.3\%)(150) - (2.33)(9.1\%)(150) = 7.9 - (2.33)(13.6) = -23.8$$

This is greater than the \$20M limit, so the portfolio is not within its guidelines.

(c)

- (i) Explain the meaning of Beta in the table above.
- (ii) Identify which index makes the greatest contribution to the total risk of the fund. Justify your response.

Commentary on Question:

Candidate performance was fair for this question part. The majority of candidates were able to correctly calculate the percent contribution in ii). However, fewer candidates were able to sufficiently define Beta.

- (i) Beta is systematic risk and measures the contribution of one security to total portfolio risk.
- (ii) The percent contribution is $w(i) \times \text{Beta}(i)$. This results in the following contributions:
 - Equity (Developed Markets) = 46.00%
 - Equity (Emerging Markets) = 28.12%
 - Corporate Bonds = 14.88%
 - Sovereign Bonds = 3.50%
 - Commodities = 7.50%

This is highest for the Equity (Developed Markets) = $1.84 \times 0.25 = 46\%$.

1. Continued

- (d) Critique your coworker's suggestion.

Commentary on Question:

Candidate performed poorly on this question part, as the majority of candidates were unable to address both the short-selling error and the effect on the return from short-selling equities. Some candidates correctly concluded that the coworker's assertion was mistaken because of the short-selling suggestion.

The coworker's suggestion is inaccurate.

- Since the indices are negatively correlated, a long position in both provides a natural diversification.
 - Short selling will also reduce the return, since equities contribute the most return, so a reduction in exposure will decrease the portfolio return.
- (e) Determine whether allocating 30% to each active manager would cause the fund to exceed the fund's risk budget.

Commentary on Question:

Candidates performed poorly on this section. While some candidates correctly concluded that the fund's risk budget would be exceeded, only a small portion were able to perform the calculation accurately.

$$\$15\text{M} \times 2.33 \times \sqrt{2 \times 30\%^2 \times 5\%^2} = \$15\text{M} \times 2.33 \times \sqrt{2} \times 1.5\% = \$0.74\text{M}$$

Since 0.74M exceeds 0.7M, the 30% allocation exceeds the fund's budget.

- (f) Explain the advantages of risk budgeting over the use of notional limits.

Commentary on Question:

Candidates performed poorly on this section. Many candidates were able to state the limits of notional limits; however, only a small portion were able to then describe the overall benefits on risk budgeting.

Risk budgeting directs managers to maximize return for the firm's specific risk tolerance, while notional limits will focus performance targets only on return and may subject funds to excessive risk.

1. Continued

With risk budgeting, senior management does not need to micromanage their fund managers to avoid excessive risk, as risk is already captured in the allocation.

2. Learning Objectives:

1. The candidate will understand the value of governance and its key elements in general and in the context of an investment operation.
2. The candidate will understand and be able to apply the components of an effective risk management system.

Learning Outcomes:

- (1e) Explain how governance may be structured to gain competitive advantages and efficiencies.
- (2b) Identify and describe the various kinds of risks, including market, credit, operational, etc.
- (2c) Identify and describe various approaches for managing risks including risk budgeting, position limits, etc.

Sources:

QFII-120-20: IAA Note on ERM for Capital and Solvency Purposes in the Insurance Industry

QFII-121-20: Chapter 2 of Quantitative Enterprise Risk Management

Managing Investment Portfolios, Maginn, John L. & Tuttle, Donald L., 3rd Edition, 2007, Ch. 9: Risk Management (section 6)

Commentary on Question:

This question aims to test candidates' knowledge on how governance can be structured to gain competitive advantages and efficiencies. In addition, the question asks the candidates to identify and describe various risks applied to an organization, and to recommend investment strategies based on calculations using risk metrics. Overall, candidates performed well on this question.

Solution:

- (a)
 - (i) Describe one drawback of a decentralized governance structure.
 - (ii) Describe one way to address this drawback while maintaining a decentralized governance structure.

Commentary on Question:

Candidates performed poorly on this question part. Few candidates were able to identify that matrix reporting should be used in a decentralized risk management structure.

2. Continued

- (i) Possibility of risk functions operating in isolation from each other, inhibiting information flows and escalation of key issues
 - (ii) A decentralized risk management structure can be supported by matrix reporting that clarifies respective roles and responsibilities, which serves to help create a more effective management of risk issues.
- (b) Explain how each of the risks above apply to ZYX.

Commentary on Question:

Candidates performed very well on this question. Some candidates matched the risks correctly but failed to explain how each risk is applied to ZYX's specific situation. Some candidates struggled to explain how exchange rate risk impacts ZYX's foreign bond portfolio.

1. Interest rate risk:

- The rising interest rates decrease the market value of bonds, exposing ZYX to interest rate risk.

2. Exchange rate risk

- If the FX rate of the currencies currently being traded strengthen, then the foreign bonds will cost more for ZYX to trade in USD.

3. Credit risk:

- Because ZYX has two counterparties with high concentration (25%), any one of them defaulting could risk a lot of the assets.

2. Continued

4. Model risk:

- ZYX uses bond pricing model to make trading decision. ZYX recently decided to use a new model but does not have an expert on the model. This imposes model risk on ZYX.

- (c) Identify and describe three approaches for ZYX to mitigate credit risk.

Commentary on Question:

Candidate performance was fair on this question. Many candidates identified three approaches but failed to describe them.

- i. Netting: in two-way contracts, reducing all obligations owed between counterparties into a single cash transaction that eliminates the liabilities of one party.
 - ii. Credit default swap: protection buyer pays the protection seller in return for the right to receive a payment from the seller in the event of a specified credit event
 - iii. Minimum credit standard: to ensure all credit-based business is undertaken with entities that have adequate level of credit quality from rating agencies such as Moody's or S&P
- (d)
- (i) Compare the relative performance of the two portfolios.
 - (ii) Recommend how to allocate the capital next year if the portfolios are fully correlated. Justify your response.
 - (iii) Calculate the annual profits and daily 95% VaR that result after making your proposed change to the allocation of capital.

2. Continued

Commentary on Question:

Candidates performed well on this question. The first section tests candidates' understanding of Return on Capital and Return on VaR. Some candidates failed to calculate Return on VaR and used other metrics to compare the two portfolios. In the second section, some candidates failed to explicitly recognize that there are no diversification benefits because the two portfolios are perfectly correlated.

(i)

The domestic bond portfolio generated better return on VaR than the foreign bond portfolio.

- Domestic bond portfolio return on VaR = \$6.50M per \$17M VaR (38.2%)
- Foreign bond portfolio return on VaR = \$9.75M per \$38M VaR (25.7%)

The two bond portfolios generated the same return on capital.

- Domestic bond portfolio return on capital = \$6.50M per \$200M or 3.25%
- Foreign bond portfolio return on capital = \$9.75M per \$300M or 3.25%

(ii)

- Propose to close out the foreign bond portfolio because allocating the capital to domestic bond portfolio generates more return on given VaR.
- The return on capital will be the same on the combined portfolio regardless of the allocation because the two portfolios have equivalent return on capital.
- Because the two portfolios are perfectly correlated, there are no diversification benefits.

(iii)

Proposed annual profits = $3.25\% * \$500M = \$16.25M$ (since the portfolios had same return on capital)

Proposed daily 95% VaR = $\$16.25M / 38.2\% = \$42.5M$ VaR

3. Learning Objectives:

1. The candidate will understand the value of governance and its key elements in general and in the context of an investment operation.
2. The candidate will understand and be able to apply the components of an effective risk management system.

Learning Outcomes:

- (1a) Compare the interest of key stakeholders.
- (1d) Understand the importance of an organizations culture in effectuating governance.
- (1f) Demonstrate understanding of how ethics relates to business decision-making, and relate ethics in business to personal ethics.
- (2a) Explain the importance of risk culture in an investment firm.
- (2b) Identify and describe the various kinds of risks, including market, credit, operational, etc.
- (2c) Identify and describe various approaches for managing risks including risk budgeting, position limits, etc.

Sources:

QFII-111-17 Tracing the True Origins of Bad Behavior
Investment Ethics, Chapter 9

Commentary on Question:

This question aims to test candidates' knowledge of culture, the pitfalls of a poor risk culture in a firm and business ethics. Candidate performance was fair on this question.

Solution:

- (a)
 - (i) Describe how tribal culture forms in a company.
 - (ii) Explain two reasons why tribal culture adversely impacts the effectiveness of governance.

Commentary on Question:

Candidates performed well for this part. Some candidates identified issues with immediate work group but not loyalty to the organization.

- (i)
 - No loyalty to the organization
 - Cares more about peers/immediate work group and cares less about company's policies

3. Continued

(ii)

- Tribes are narrow, exclusive, and not interested in formal hierarchy
- Negative allegiance towards outsiders and resists company's control structure

(b) Critique each of the proposed solutions.

Commentary on Question:

Candidate performance was fair on this part. Few candidates mentioned that productivity would be affected with detailed documentation and non-compete agreement required.

First bullet:

Proposed solution does not directly address the issue.

- Tone at middle matters more than tone at the top because it legitimizes bad behavior
- Direct line managers' behaviors indicate the "truly applicable rules"

Second bullet:

This suggestion would be considered overregulation.

- Documentation should not make up a significant portion of an individual's regular work and would likely detract from other tasks
- Non-compete agreement is excessive, so it may cause pushback and be counterproductive

3. Continued

- (c)
- (i) Identify two stakeholders of Company X who are adversely affected by these practices.
 - (ii) Describe how each stakeholder is adversely affected.

Commentary on Question:

Candidates performed well for this part.

Shareholders

- Sales teams is not at its full capability, limiting revenue from new sales
- Limited sales in certain regions

Customers

- Regional monopolies cause higher prices due to lack of competition and limited choice of products

- (d)
- (i) Critique the Company X's selling practices.
 - (ii) Explain two risks that these practices pose to Company X.

Commentary on Question:

Candidates performed poorly on this part. Most candidates did not critique each component of selling practices, in particular the practice of selling small annuities. The two risk types identified in part (ii) should be related to the sales practices.

- (i)
 - Sales team more likely to aim for large quantity of small annuities to earn more commission, however, variable annuities are more suited for wealthy clients
 - Communicating the commission is not sufficient. Should ensure the suitability of product for customers.
 - Current commission structure incentivizes sales quantity over quality
- (ii)
 - Financial
 - Upfront commission without linkage to profitability
 - Fixed commission is not appropriate for small annuities
 - Reputational
 - Prioritization of wrong type of customers and reputation risk if it is revealed that product sold is not suitable for customers.

3. Continued

- (e) Describe how sensitivity testing can be used to supplement the investment team's current methodology.

Commentary on Question:

Candidates performance was fair on this part. Many candidates did not describe the flaws of the current hedging method that sensitivity testing could supplement.

- Sensitivity testing helps reveal the investment performance under extreme market movements. Hedge may be insufficient for large market movements with weekly rebalance
- Sensitivity testing gives portfolio manager a view of the effectiveness of the weekly rebalancing hedging program

- (f) Explain whether the limits that Company X currently has in place will protect the company from potential losses under this strategy.

Commentary on Question:

Candidates performance was fair on this part. Many candidates did not provide an opinion whether the market value limit is effective at minimizing loss and identify that the market value of put option is relatively low.

- Limit is not effective to protect losses under the short-put strategy
- Puts have low market values but short positions can cause large losses in market downturn
- Large position can be established without exceeding the market value limit

4. Learning Objectives:

3. Understand and be able to apply different approaches to measuring risk exposures.

Learning Outcomes:

- (3a) Explain the advantages and limitations of different risk metrics
- (3c) Analyze and evaluate risk aggregation techniques, including the use and misuse of correlation, integrated risk distributions and copulas.

Sources:

Quantitative Enterprise Risk Management, Hardy and Saunders, Ch. 7

Commentary on Question:

Candidates performed poorly on this question. Scores varied widely with most candidates struggling on the more technical and quantitative aspects of the question (e.g. demonstrating whether a function is a copula, assessing lower tail dependence).

Solution:

- (a)
 - (i) Describe each type of copula listed above.
 - (ii) Recommend the best copula to model returns for this portfolio. Justify your response.

Commentary on Question: *Performance on this question part was fair. Most candidates correctly described each type of copula listed through qualitative descriptions and by providing correct examples. Few candidates, however, identified the explicit copula as the appropriate recommendation with sufficient justification.*

- (i) Fundamental copulas capture basic relationships between random variables (e.g. independence, monotonicity, and counter-monotonicity) and are derived from a clear relationship between the risks.

Implicit copulas are derived from existing multivariate distributions

Explicit copulas are multivariate functions that meet the definition of a copula but are not otherwise derived from existing multivariate distributions

- (ii) An explicit copula is the best choice for this portfolio.

Explicit copulas can be determined based on a statistical analysis of the dependency structure between the risks.

4. Continued

The asset classes in question (Venture Capital and Public Equity) have very different return distribution characteristics, including high skew and kurtosis for Venture Capital and high volatility for Public Equity. As a result, they are unlikely to conform to a single implicit copula.

Fundamental copulas are too simplistic for distinct asset classes.

(b)

- (i) List three requirements a function $C : [0,1]^2 \rightarrow [0,1]$ must meet for C to be a copula.
- (ii) Assess whether each of Form A and Form B is a copula. Justify your response.
- (iii) Identify the functional form of each of the upper and lower bounds of all bivariate copulas.

Commentary on Question: *Candidates performed poorly on this question part. Many candidates did not identify all three requirements for a function to be a copula. Further, most struggled to assess whether each of Form A and Form B was a copula for the correct reasons. Many candidates, however, correctly identified the functional forms of the upper and lower bounds of all bivariate copulas.*

- (i) A function $C : [0,1]^2 \rightarrow [0,1]$ must meet the following three criteria to be a copula:
 - $C(u, v)$ must be non-decreasing in both u and v .
 - The marginal distributions of C must be uniform, that is, $C(u, 1) = u$ and $C(1, v) = v$.
 - C must satisfy the Rectangle Inequality, that is, for all $a_1 < b_1$ and $a_2 < b_2$, we must have $C(b_1, b_2) - C(a_1, b_2) - C(b_1, a_2) + C(a_1, a_2) > 0$.
- (ii) Form A is not a copula as it fails the condition (for example) that the marginal distributions be uniform: $C(u, 1) = \max(u, 1) = 1 \neq u$.

Form B is a copula, as it can be demonstrated to satisfy all three requirements to be a copula as follows:

- Non-decreasing: For any $u_1 > u_2$ and $v_1 > v_2$, $C(u_1, v_1) = u_1 v_1 > u_2 v_1 = C(u_2, v_2)$. A similar argument shows that C is non-decreasing in v .

4. Continued

- Uniform marginals: $C(u, 1) = u \cdot 1 = u$ and $C(1, v) = 1 \cdot v = v$.
- Rectangle inequality: For given $a_1 < b_1$ and $a_2 < b_2$, $C(b_1, b_2) - C(a_1, b_2) - C(b_1, a_2) + C(a_1, a_2) = b_1 b_2 - a_1 b_2 - b_1 a_2 + a_1 a_2 = b_2(b_1 - a_1) - a_2(b_1 - a_1) = (b_1 - a_1)(b_2 - a_2) > 0$, since both $b_1 - a_1$ and $b_2 - a_2$ are greater than zero by assumption.

(iii) The functional form of the upper bound is $\min(u, v)$. The functional form of the lower bound is $\max(u + v - 1, 0)$.

(c)

- Define upper and lower tail dependence.
- Explain the interpretation and importance of lower tail dependence in the context of portfolio risk management.
- Assess whether the copula $C_c(u, v)$ above exhibits lower tail dependence. Justify your response.

Commentary on Question: *Candidates performed well on this part of the question. Most could qualitatively or quantitatively define upper and lower tail dependence, interpret tail dependence in a risk management context, and identify lower tail dependence in the copula listed.*

- Lower tail dependence is the limit probability of loss beyond quantile q for one variable given loss below q for another. Similarly, upper tail dependence is the limit probability of gain beyond quantile q for one variable given gain above q for another.

Expressed mathematically, lower tail dependence is given by

$$\lambda_L = \lim_{q \rightarrow 0} \Pr[X \leq Q_q(X) | Y \leq Q_q(Y)]$$

And upper tail dependence is given by

$$\lambda_U = \lim_{q \rightarrow 1} \Pr[X > Q_q(X) | Y > Q_q(Y)]$$

- The interpretation and importance of lower tail dependence in the context of portfolio risk management include the following:

4. Continued

- Risk management is focused on adverse tails of distributions and joint behavior in the tails is important for understanding how to manage such risks
- Tail dependency captures the insight that there is increased dependency in adverse conditions where “everything goes wrong together”
- Lower tail dependency indicates that, in severe down scenarios, losses are likely to occur together
- The more severe the loss is on one asset class, the more near-certain it is both asset classes experience large losses

(iii) The copula $C_c(u, v)$ is a Clayton copula which is known to exhibit lower tail dependence. Further, the lower tail dependence of the copula can be calculated as follows:

$$\begin{aligned}
 \lim_{q \rightarrow 0} \frac{C(q, q)}{q} &= \lim_{q \rightarrow 0} \frac{\max\left(\left[q^{-\frac{1}{2}} + q^{-\frac{1}{2}} - 1\right]^{-2}, 0\right)}{q} \\
 &= \lim_{q \rightarrow 0} \frac{\left[q^{-\frac{1}{2}} + q^{-\frac{1}{2}} - 1\right]^{-2}}{q} = \lim_{q \rightarrow 0} \frac{\left[2q^{-\frac{1}{2}} - 1\right]^{-2}}{q} \\
 &= \lim_{q \rightarrow 0} \frac{1}{q \left[2q^{-\frac{1}{2}} - 1\right]^2} \\
 &= \lim_{q \rightarrow 0} \frac{1}{q(4q^{-1} - 4q^{-\frac{1}{2}} + 1)} = \lim_{q \rightarrow 0} \frac{1}{(4 - 4q^{\frac{1}{2}} + q)} = \frac{1}{4}
 \end{aligned}$$

Because $\frac{1}{4} > 0$, the copula is shown to exhibit lower tail dependence.

(d) Describe two methods of calibrating the copula parameter.

Commentary on Question: *Performance on this question part was fair. Most candidates correctly described at least one of the two methods below, but many could not identify and describe both.*

Two methods of calibrating the copula parameter are as follows:

- Estimate Kendall’s Tau from the data sample. Then, choose the parameter such that the Tau of the copula generates the same value. This is appropriate because Tau depends only on the copula, not the marginal distributions.

4. Continued

- Apply Maximum Likelihood Estimation (MLE) to the sample using the empirical estimator for the marginal distribution functions.

5. Learning Objectives:

1. The candidate will understand the value of governance and its key elements in general and in the context of an investment operation.
2. The candidate will understand and be able to apply the components of an effective risk management system.

Learning Outcomes:

- (1e) Explain how governance may be structured to gain competitive advantages and efficiencies.
- (2a) Explain the importance of risk culture in an investment firm.
- (2b) Identify and describe the various kinds of risks, including market, credit, operational, etc.
- (2d) Explain the features of a best practices enterprise risk management system.

Sources:

QFII-120-20_IAA Note on ERM for Capital and Solvency Purposes in the Insurance Industry

Investment Ethics, Chapter 1

Commentary on Question:

This question asked candidates to explain and identify best practices for risk management within a company, as well as provide suggestions and identifying where improvements in the risk management approach should be made.

Solution:

- (a) Describe the role of the Board with regard to a company's risk management framework.

Commentary on Question:

Candidates performed well on this question, describing the key roles within a risk management board.

1. Approving the insurer's overall risk management strategy and/or policy
2. Overseeing the process of ensuring the insurer's responsible persons are fit and proper
3. Setting the Risk Appetite of the insurer
4. Monitoring key risks by ensuring the implementation of a suitable risk management and internal controls framework

5. Continued

- (b) Evaluate the appropriateness of each action above.

Commentary on Question:

Candidate performance was fair on this question. Many candidates did not address whether or not each action is appropriate and explain why the action may not be appropriate.

1. Needs improvement- Risk Committee should consider the appropriateness of the level and volume of reporting to the Risk Committee and ensure the right information is being communicated
2. Needs improvement – While it is good that the new Board member has a diverse background (a stage theater company is quite different from an insurance company) and relevant experience (finance), we must also ensure they have other appropriate qualities such as knowledge of the organization, inquisitiveness, and objectivity
3. Needs improvement – The KPI proposed is quite vague. There is no way to measure what makes the CRO comfortable; it should be explicitly defined so that it can be evaluated objectively by all, not just the CRO.
4. Sufficient – The Risk Committee should ask questions of reports and management and promote inquisitive/questioning minds

- (c)

- (i) Explain two reasons why an effective risk culture is important.
- (ii) Propose three ways to improve the risk culture of a company.

Commentary on Question:

Candidates performed poorly on this question. Many candidates failed to provide responses specific to risk culture and instead answered related to an overall risk management approach. Candidates especially struggled with section (ii) where they were asked to identify ways to improve risk culture.

5. Continued

- (i)
 - 1. An effective risk culture limits fear of retribution of reporting risks
 - 2. An effective risk culture promotes transparency of potential risks across the company
- (ii)
 - 1. Provide time for the implementation since it can take at least three years to take hold
 - 2. Set goals for senior management on improving risk culture
 - 3. Develop Training programs to promote the behaviors associated with strong risk culture
- (d)
 - (i) Critique each element of the product development process.
 - (ii) Recommend how the ERM team could be involved in each element of the process.

Commentary on Question:

Candidates performed poorly on this question. Overall, candidates were able to critique the statements at a high level but failed to connect back to specific improvements that should be made and how the ERM team should be involved.

- (i)
 - A. Evaluating market potential and consumer value proposition is not enough. The product might be popular among other companies and valuable to consumers, but the underlying risks and technical valuation/modeling issues need to be understood in order to proceed with offering the product.
 - B. Not every product offering in the market will align with the company's strategy and competitive advantage, so it doesn't make sense for the company to immediately start developing each product without evaluating this first.
 - C. Seeking approval near the end of the product development process will likely lead to issues where senior management and/or the ERM team raise objections that could have been addressed earlier in the process at a lower cost/delay to the project timeline.
- (ii)
 - A. Involving ERM team in due diligence work where skills of the actuary and other risk management professionals can be utilized to help identify and assess risks and to assist with valuation and modeling

5. Continued

- B. Working with the insurer's pricing/product team on the strategy ensures appropriate assessment of risks associated with the chosen strategic direction.
 - C. The ERM team should be involved in managing and coordinating engagement with relevant supervisors with respect to pursuit of new activities
- (e)
- (i) Explain how moral hazard could apply in this situation.
 - (ii) Recommend an alternative compensation structure for the product development team.

Commentary on Question:

Candidates performed well on this question. They were able to identify how this situation applied to moral hazard and recommend ways to improve the situation.

- (i) Short-term profits could result in good bonuses for the team, but they may not be accountable for associated long-term risks
- (ii) The bonus should not be weighted so heavily towards early years. The bonus could equally weight all years' profits, perhaps waiting to pay out for a number of years, once some historical experience plays out.

6. Learning Objectives:

1. The candidate will understand the value of governance and its key elements in general and in the context of an investment operation.
2. The candidate will understand and be able to apply the components of an effective risk management system.
3. Understand and be able to apply different approaches to measuring risk exposures.

Learning Outcomes:

- (1d) Understand the importance of an organizations culture in effectuating governance.
- (2e) Evaluate a company's risk management process.
- (2f) Examine examples of risk management failure.
- (3c) Analyze and evaluate risk aggregation techniques, including the use and misuse of correlation, integrated risk distributions and copulas.

Sources:

QFII-110-15: The Devil is in the Tails: Actuarial Mathematics and the Subprime Mortgage Crisis

QFII-103-14: Advances in Risk Management and Risk Governance

Commentary on Question:

This question tested candidates' knowledge of risk culture, risk management failure and various approaches to modeling CDOs. Candidates performed well overall on this question.

Solution:

- (a) Describe two examples of moral hazard in the securitization of mortgages during the 2008 financial crisis.

Commentary on Question:

Candidates performed well on this part. To receive full credit, candidates identified two examples with some explanation of moral hazard.

- Failure of originators to retain some of the riskiest parts of the CDO
 - “Too big to fail” thinking among some financial institutions
- (b) Describe four other strategies that the firm can use to promote a risk-conscious culture.

6. Continued

Commentary on Question:

Candidates performed well on this part. Candidates who identified four strategies received full credit.

- Focus on employee education and sound policies and procedures
- Tie compensation to risk
- Risk-reward tradeoffs are considered when decisions are made
- Responsibility for risk must also be clearly delineated to avoid finger-pointing

(c)

- (i) Assess the appropriateness of Copula X for this loss distribution based on the simulated results.
- (ii) Recommend an alternative type of copula for this loss distribution.

Commentary on Question:

Candidates performed well on this part. Candidates identified that the fat tail in the simulation did not model the data well and noted an example copula to better model the given situation.

- (i) Data being modeled has a fat tail. The number of data points in their model (only one loss over \$4M) inadequately models the fat tail.
- (ii) The Gumbel copula can better model extreme events and thus the fat tail. The Gumbel copula is one type of copula that exhibits upper tail dependence.

(d) Describe two alternatives to copulas for modeling CDOs.

Commentary on Question:

Candidate performance was fair on this part. Most candidates did not explain that how a structural model or hazard rate model could be used to model CDOs.

Structural models:

- Models default via the dynamics of the firm
- Includes CreditMetrics and KMV

Hazard Rate models:

- Attempt to model infinitesimal chance of default
- CreditRisk+ is an example

6. Continued

(e)

- (i) Critique your colleague's statement.
- (ii) Describe two lessons learned from AIG's failure.

Commentary on Question:

Candidates performed well on this part. To get full credit, candidates needed to critique the current statement and provide a couple of lessons.

- (i)
 - Inadequate mathematical modeling is one factor associated with the failure of AIG
 - AIG did not recognize the risk inherent in the super-senior tranches of the CDOs
 - More complicated models may accurately reflect situations and allow realistic stress testing
 - But understanding the model is more important than the complexity of the model.
- (ii)
 - Choose models that adequately model the risk and know their limitations
 - Conduct adequate stress testing and modeling of extreme events