ERM-GC Model Solutions
Fall 2017

1.

Learning Objectives:

2. The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.

5. The candidate will understand the concept of economic capital, risk measures in capital assessment and techniques to allocate the cost of risks within business units.

Learning Outcomes:

(2d) Apply and analyze scenario and stress testing in the risk measurement process.

(5a) Describe the concepts of measures of value and capital requirements (for example, EVA, embedded value, economic capital, regulatory measures, and accounting measures) and demonstrate their uses in the risk management and corporate decision-making processes.

Sources:

ERM-126-15: ORSA - An International Requirement (Section 3.1 and Section 4.1)

ERM-120-14: IAA Note on Stress Testing and Scenario

ERM-117-14: AAA Practice Note: Insurance Enterprise Risk Management Practices

ERM-106-12: Economic Capital-Practical Considerations-Milliman

Commentary on Question:

Commentary listed underneath question component.

Solution:

(a) After reviewing what ORSA is intended to achieve, you are prepared to recommend to the Board changes in the corporate structure of ABC.

(i) Describe three weaknesses of the company's current organizational structure.

(ii) Discuss how ABC's corporate structure needs to be modified to satisfy the requirements of ORSA.

1. **Continued**

Commentary on Question:
Candidates generally performed well on this question. Other correct and appropriate responses were given full credit, examples of which include:

- *Increasing the diversification of members of the board*
- *Maintaining the independence of the audit function as a third line of defense.*

(i) The role of Chairman should be separate from that of the Chief Executive Officer and selected from the independent Directors. This effectively reinforces the independence of the Board.

The selection of the Chairman should be reviewed regularly (e.g., annually). Clear documentation should be created that discusses term limits for directors and outlines the election and re-election processes.

There is currently no risk committee reporting to the Board; ERM responsibility is inappropriately allocated to the Audit Committee. ORSA generally seen as the responsibility of the Board which is responsible for ensuring that the insurer did not take on more risk than the capital base allows.

(ii) A risk committee, with clearly defined role and responsibilities, must be established. This risk committee should report directly to the Board and, as ORSA responsibility ultimately resides with the Board, should ensure that emerging risks, current capital positions, and other risk-related concerns are clearly and effectively reported.

Create the role of CRO and establish team/department responsible for ERM, which includes formalizing risk appetite statements and tolerance limits.

Ensure there is a second line of defense - the oversight functions - including risk management and compliance; and a third line of defense - an independent review and assurance (internal audit function).

(b) To implement ORSA, ABC decided to perform a single stress test combining the following three shocks.

- Equity Shock: Equities down by 5%
- Interest Shock: Interest rate curve shift down by 1% for all maturities
- Lapse Shock: Policy lapse / surrender level increase by a factor of 1.1 for all products and all durations.

Critique ABC's approach.

1. Continued

Commentary on Question:
Most candidates answered well on this part.

The question asked candidates to critique ABC's approach of using the specified stress test. Some candidates answered the question without referencing the approach described and provided more general comments regarding ORSA requirements. In this case, only partial credit was given. Full credit was given for responses in which the described stress test was critiqued with reference to ABC's specific product – term life and variable annuities.

Answers not limited to the listed ones in model answer. Other relevant points include:

- *Consider the appropriate time horizon - specific risks may emerge over extended periods rather than manifest as instantaneous shocks.*
- *Consider testing the consistency of the volatility and stresses of historical financial performance to the volatility and stresses suggested by the model output*
- *Consider adding additional relevant shocks - e.g. mortality or credit*

Consider a more systematic process for scenario generation based on company/ industry data, including the combination and aggregation of specific risks.

Lapse/surrender increase may have positive/negative impact depending on product duration and specific features. Ensure that shocks/scenarios are appropriately severe given ABC's product suite and investment portfolio.

The current stress test may not be sufficient in forward looking assessment of solvency needs. ABC should project its future risk and solvency position allowing for planned levels of new business.

A single shock for each risk may not be sufficient in capturing the entire range of potential outcomes; may consider multiple shocks per risk or incorporating advanced simulation techniques.

(c) Outline three major additional considerations necessary to comply with the ORSA requirements.

Commentary on Question:
The quality of candidates' responses to this question was highly variable. In this question, graders were looking for additional considerations separate from points discussed in previous parts of the question. To receive full credit, answers needed to be focused on the points directly related to ORSA requirements.

1. **Continued**

Allocate board responsibility. The ORSA is generally seen as the responsibility of the Board and so it is the Board's responsibility to ensure that the insurer's processes and procedures are sufficient to assess the insurer's risk and solvency requirements.

Result should be used as a key management information tool – incorporated into pricing, capital planning, strategic planning, setting risk appetite, and determining executive compensation. Enhancement of internal and supervisory understanding may be necessary.

ORSA is to be treated as a continuous, ongoing process. The complete ORSA process should be performed at least annually, and updated following any significant change in the company's risk profile.

2. Learning Objectives:

3. The candidate will understand how the risks faced by an entity can be quantified and the use of metrics to measure risk.

Learning Outcomes:

(3b) Analyze and evaluate the properties of risk measures (e.g., Delta, volatility, duration, VaR, TVaR, etc.) and their limitations.

Sources:

Value-at- Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion Ch. 5 Computing VaR

Value-at- Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion Ch. 12 Monte Carlo Methods

Commentary on Question:

Most candidates did well in the beginning part of the question but performed gradually worse towards the end. This result was expected as progressively higher cognitive skills were required for later parts of the question.

Solution:

(a) For these insurance claims,

(i) Calculate the absolute VaR at 95% confidence level. Show your work.

(ii) Calculate the relative VaR at 95% confidence level. Show your work.

Commentary on Question:

Most candidates did well on this part.

(i) Absolute VaR at 95% confidence level = 5500

(ii) Mean = [100x50 + 150x40 + (5100+6000)x5] / 100 = 665

Relative VaR at 95% confidence level
= Absolute VaR at 95% confidence level – Mean
= 5500 – 665 = 4835

(b) Calculate the following items using direct simulation from the 10 random numbers (i.e., the "naïve" simulation):

I. Mean
II. Absolute VaR at 95% confidence level
III. Relative VaR at 95% confidence level

2. Continued

Commentary on Question:
Many candidates did well but some candidates misunderstood the question and complicated the issue by applying a normal distribution calculation which is not relevant.

The insurance claim associated with each random number (determined by matching the random number to its place in the claim table from Part a):
0.08 : 100
0.23 : 100
0.26 : 100
0.29 : 100
0.49 : 100
0.65 : 150
0.69 : 150
0.80 : 150
0.91 : 5100
0.92 : 5200

I. Mean = (100x5 + 150x3 + 5100 + 5200) / 10 = 1125

II. Absolute VaR at 95% confidence level
= (5100+5200)/2 = 5150

III. Relative VaR at 95% confidence level
= Absolute VaR at 95% confidence level – Mean
= 5150 – 1125 = 4025

(c)

(i) Recalculate the simulated insurance claims for each of the 10 random numbers in part (b) using the accumulated shifted unequal probabilities. Show your work.

(ii) After the shift of the probabilities, VaR needs to be calculated using a shifted confidence level.

Calculate the absolute VaR at 95% using the recalculated insurance claims in (i) and a shifted confidence level of 50%. Show your work.

2. Continued

The following are the likelihood ratios for the ten simulated insurance claims from (i) (simulated claim 1 was generated using the random number 0.08):

Simulated Claim	Likelihood Ratio
1	10.00
2-10	0.11

(iii) Calculate the claims based on the importance sampling method for each of the simulated insurance claims from (i). Show your work.

(iv) Calculate the relative VaR at 95% confidence level using the importance sampling method. Show your work.

Commentary on Question:
Only a few candidates received full credit. Most candidates got confused by the new probability and did not apply the right calculations.

(i) The recalculated insurance claim associated with each random number: (e.g. to get to 0.08 requires 80 scenarios (80*0.001); from original table the claim is 150; to get to 0.23 requires another 10 scenarios to 0.09, then scenario 91 will get us 0.09+0.091=0.181, then scenario 92 will get us to 0.09+0.091*2 > 0.23, so 5200 from the original table)
0.08 : 150
0.23 : 5200
0.26 : 5200
0.29 : 5300
0.49 : 5500
0.65 : 5700
0.69 : 5700
0.80 : 5800
0.91 : 6000
0.92 : 6000

(ii) Absolute VaR at 95% confidence level = 5500 from shifted confidence level of 50% (see the answer to (i) - close to 0.49)

2. Continued

(iii) Claims based on importance sampling method (= Likelihood ratio x claim amount from Part c(i)):
150 x 10.00 = 1500
5200 x 0.11 = 572
5200 x 0.11 = 572
5300 x 0.11 = 583
5500 x 0.11 = 605
5700 x 0.11 = 627
5700 x 0.11 = 627
5800 x 0.11 = 638
6000 x 0.11 = 660
6000 x 0.11 = 660

(iv) Mean = (1500+572+572+583+605+627+627+638+660+660)/10
= 704

Relative VaR at 95% confidence level
= Absolute VaR at 95% confidence level – Mean
= 5500 – 704 = 4796

(d) After the calculations, you are ready to inspect the results based on the various approaches.

Analyze the results produced in your calculations of VaR using naïve simulation and importance sampling. Include the reasoning behind the results they produce.

Commentary on Question:
Very few candidates understood the main concept which was the acceleration or variance reduction issues. Many of them received partial credit by describing the emphasis on the tail of the distribution. They did not realize that larger or smaller VaR values are not relevant in this question. The key is the accuracy of VaR based on different simulation methods.

True VaR = 4835
Naïve simulation VaR = 4025
Importance sampling VaR = 4796

With only 10 random numbers, the importance sampling technique can produce the VaR number which is much closer to the true value than the naïve simulation can produce based on the same set of random numbers. This is called an acceleration method, which is a search of faster convergence to the true value with much fewer iterations. This is also called a control variates technique or variance reduction technique which is used to reduce the variance of the simulated numbers, leading to faster convergence.

2. Continued

Most of the insurance claims are around 100-150, with only 10% above 5000. The naïve simulations select evenly among them, even enough 90% of them are not significant for the VaR. It “wastes” its selection in those non-important values. In contrast, importance sampling applies a change of measure approach by increasing the probabilities for those claims that are above 5000, decreasing the probabilities for those claims that are 100-150. The change of measure approach keeps the domain of insurance claims the same and the total probability the same. After recalculating the insurance claims, it applies the likelihood ratios to change the expectation back to the original measure. The mean of the new measure insurance claim was shown to be much closer to the true value.

3. Learning Objectives:

4. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

Learning Outcomes:

(4f) Analyze the practicalities of market risk hedging, including dynamic hedging.

(4g) Demonstrate the use of tools and techniques for analyzing and managing credit and counterparty risk.

Sources:

ERM-110-12: Derivatives: Practices and Principles

ERM-124-15: Counterparty Credit Risk, First Edition, Jon Gregory, Chapter 2: Defining Counterparty Credit Risk

ERM-126-15: ORSA - An International Requirement (Section 3.1 and Section 4.1)

Risk Appetite: Linkage with Strategic Planning Report

Commentary on Question:

The goals of this question were: (1) test candidates' understanding of practices and principles of derivatives and financial contracting; (2) have candidates demonstrate the capability of using tools and techniques for analyzing and managing credit and counterparty risk. There were a wide range of scores.

Solution:

(a) In derivatives activity, there are three important stakeholders:

- Dealers
- End-Users
- Supervisors

(i) Provide two examples of each stakeholder.

(ii) Compare and contrast the roles of each stakeholder with respect to derivatives risk management.

Commentary on Question:

Most candidates got at least partial credit for Part (i). Candidates generally did not do well on Part (ii) because they misunderstood what was being sought and failed to provide specific references to derivatives risk management which was the focus of the question.

3. Continued

Model Solution

<u>Part a (i)</u>

<u>Dealers</u> - examples include banks, securities firms, a few insurance companies and highly-rated corporations. Some of them may participate in derivatives activity as both dealers and end-users.

<u>End-Users</u> - examples include corporations, government entities, institutional investors, and financial institutions. Individuals could also be considered end-users.

<u>Supervisors</u> - examples include central banks, local regulators in different countries, international organizations, and accounting standards-setters.

<u>Part a (ii)</u>

1. <u>Valuation and Market Risk Management Practices</u> - end-users and dealers should have the same practices such as regularly marking-to-market, periodically forecasting, and independent and authoritative function for setting risk limits.
2. <u>Credit Risk Management</u> – dealers should have an independent credit risk management group for monitoring credit exposures but end-users may not need a separate group for this function.
3. <u>Systems and Operations</u> – while end-users may only use derivatives as a tool to manage risks, changes in value can be deferred. Dealers should have an efficient and reliable system to handle their high-volume transactions. End-users may manage their group exposure and analyze aggregated risk in a meaningful and useful way.
4. <u>Accounting</u> – depending on size and scope, dealers should regularly mark-to-market each of their derivatives transactions taking changes in value into income each period. End-users should account for derivatives not qualifying for risk management treatment on a mark-to-market basis.
5. <u>Supervisors</u> – should work with dealers and end-users on improving regulations and reducing legal and regulatory uncertainty.

(b) The CFO decided that the finance department would control the overall credit risk exposure and the company's risk appetite. The CFO asked you to add the responsibility of derivatives credit risk management into your existing team as an additional function.

(i) Describe the responsibilities of a derivatives credit risk management function.

(ii) Identify three areas of concern in regard to the CFO's decisions. Justify your response.

3. Continued

Commentary on Question:
Candidates generally got at least partial credit on this part.

<u>Part b (i)</u>

1. Approving credit exposure measurement standard. The independent credit risk management function should ensure that exposure is assessed objectively.
2. Setting credit limits and monitoring their use. Establish credit limits for counterparties consistent with management standards.
3. Reviewing credits and concentrations of credit risk to avoid over-concentrations and meet the appropriate credit standards.
4. Reviewing and monitoring risk reduction arrangements. Continually review the risk reduction processes.

<u>Part b (ii)</u>

1. This is not an appropriate assignment because the qualifications of risk management function should be clear independence and authority, and with analytical capabilities in derivatives. As the leader of trading team, you are not independent from dealing personnel. There are potential conflicts of interest.
2. The company's risk appetite should be approved by board and included in company's risk polices. The finance department should not control it independently.
3. Overall credit risk exposure is also a part of enterprise ERM framework, which should be controlled by senior management and board instead of just the finance department.

(c)

(i) Describe three areas of concern in regard to Bank MC's reporting process and current counterparty exposure.

(ii) Recommend a risk mitigation strategy for each of the concerns identified in (i).

(iii) MC wants to evaluate the impact of entering into a bilateral netting agreement with Counterparty B.

Calculate the impact of this agreement, from MC's perspective, on the counterparty credit default risk for both MC and Counterparty B using the provided weekly data. Show your work.

(iv) Recommend additional steps Bank MC should take to help monitor and mitigate its current counterparty exposure.

3. Continued

Commentary on Question:
There was a wide range of scores on this part. For Part c (iii), many candidates calculated only MC's exposure when they were asked to calculate the exposure for both MC and counterparty B.

Part c (i)

1. Evaluation prior to transaction. New transactions need to be reviewed for credit risk in advance.
2. Concentration of counterparties need to be continually reviewed to avoid over- concentration in certain parties, which will increase the credit risks.
3. Smaller counterparties - a large portion of the total credit exposure is with them but not enough information is given on how many there are or range of exposures.

Part c (ii)

1. Internal control should be setup to assess the credit risk prior to entering into transactions instead of checking risk on existing transactions.
2. Reduce and limit the credit exposure of dealing with particular counterparties. Concentration of CP B is too high in the portfolio. Either reduce the concentration or enhance the credit of CP B should be considered.
3. Provide more information on smaller counterparties - possibilities include defining a threshold for inclusion in this category and consider listing separately companies above that limit.

Part c (iii)

1. Risk for MC without netting = Max((8.4+2.3+25), 0)= 35.7
2. Risk for MC with netting = Max((8.4-2.9-11.3+2.3+25-13.2), 0) = 8.3
3. Exposure to MC without netting = 35.7 – 8.3 = 27.4

4. Risk for CP B without netting = Max((2.9+11.3+13.2), 0) = 27.4
5. Risk for CP B with netting = Max(-(8.4-2.9-11.3+2.3+25-13.2), 0) = 0
6. Exposure to CP B without netting = 27.4 – 0 = 27.4

Part c (iv) – possible answers include:

1. Request weekly or even daily derivatives credit risk reports on all transactions.
2. Set aggregated credit limits and counter party credits limit and guidelines. Keep monitoring the current credit exposure under the limits and guidelines.
3. Consider setting master agreement and require items such as payment and close-out netting to reduce credit exposure.
4. Provide more information on some of the companies in the "smaller counterparties" line since the threshold is not defined.

3. Continued

(d) The CFO has approached you about the management of market risk within your department. Your team currently uses a dynamic hedge on option-based derivatives.

(i) Describe advantages and disadvantages of using dynamic hedging versus static hedging on option-based derivatives.

(ii) Describe the risks associated with the dynamic hedging of MC's market risk.

Commentary on Question:
There were a wide range of scores for this part. For Part d (ii), many candidates either did not identify any dynamic hedging risks or else listed only operations risk.

Part d (i) – Advantages and disadvantages include the following:
Advantages
1. Dynamic hedging involves continuously hedging an option with a position in underlying, which is an improvement from static hedging.
2. Corrects for changes in prices more quickly.

Disadvantages
1. Cost of hedging may be higher than expected
2. Timing may still be an issue.
3. Expertise is needed - this would be an additional cost.

Part d (ii)
1. Market liquidity risk - As a dealer, some transactions could have a discernible effect on the price of the instrument, which will significant increase the hedge cost or even result in a sharp price move. To manage the risk, MC should hedge the product basing on their fundamental risks instead of the product specific risks.
2. Basis or correlation risk - With a complicated position portfolio, it's hard to perfectly hedge and remain unchanged on combined position. Additional hedge or adjustments need to be considered on maturity mismatches and variations in price movement.
3. Investing and funding risk - With high volume of the derivatives portfolio, MC needs to meet the investing and funding requirements, which can come from cash flow mismatches and collateral provisions.
4. Operational risk - examples include such things as aligning information with counterparties, gathering and using correct data to price options, staffing knowledge and experience, having IT systems to handle dynamic hedging.

4. Learning Objectives:

1. The candidate will understand the types of risks faced by an entity and be able to identify and analyze these risks.

2. The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.

3. The candidate will understand how the risks faced by an entity can be quantified and the use of metrics to measure risk.

Learning Outcomes:

(1b) Explain risk taxonomy and its application to different frameworks.

(2c) Analyze and evaluate risk aggregation techniques, including use of correlation, integrated risk distributions and copulas.

(2e) Evaluate the theory and applications of extreme value theory in the measuring and modeling of risk.

(2f) Analyze the importance of tails of distributions, tail correlations, and low frequency/high severity events.

(3d) Analyze risks that are not easily quantifiable, such as operational and liquidity risks.

Sources:

SOA Monograph- A New Approach to Managing Operational – Chapter 8

Financial Enterprise Risk Management, Sweeting, 2011, Ch. 15.5 Unquantifiable Risks

ERM-119-14: Aggregation of risks and Allocation of Capital (Sections 4-7)

ERM-103-12: Basel Committee - Developments in Modelling Risk Aggregation

ERM-702-12: IAA Note on ERM for Capital and Solvency Purposes in the Insurance Industry

Commentary on Question:

This question tests candidates on unquantifiable risks, risk aggregation techniques, and evaluating tail risk and extreme value theory.

Many candidates did not write down answers sufficient to receive full marks for parts: (a)(ii); (b)(ii); and (c)(iii). Overall, candidates performed well on this question.

4. **Continued**

Solution:
(a)

(i) List advantages and disadvantages of using a risk map.

(ii) Rank the risks. Justify your answer.

Commentary on Question:
For part (a)(i), many candidates received full marks by listing and also providing enough details; some candidates who were too brief did not get full marks. Other alternative answers received full marks depending on the quality.

For part (a)(ii), a few candidates incorrectly used the traditional way to rank: A (rank=2x2) = B (rank 4x1) = C (rank=1x4).

(i)
Advantages:
1. The advantage of risk map is that it provides us with a way to assess unquantifiable risks.
2. Using this method, the relative importance of various risks can be assessed.

Disadvantages:
1. Risk severity cannot be accurately evaluated in risk map especially for the risk with high severity and low frequency which is the real risk we need to focus on.
2. The risk map does not take into account correlations and do not provide a method for aggregating the risk.

(ii)
In terms of operational risk such as severe epidemic, the risk distribution is not normal but heavily tailed in many cases. We should focus on the impact of the risk, which is more important. If the potential size of a loss is great enough, then no matter how likely is the loss, action should be taken to mitigate the risk. Therefore, Risk C (impact 4) > A (impact 2) > B (impact 1).

(b)

(i) Calculate the aggregated expected loss and aggregated unexpected loss. Show your work.

(ii) Your manager has recommended that only hard data be used when developing the annual aggregated loss probability distribution table.

Critique your manager's statement.

4. Continued

Commentary on Question:
Many candidates were able to correctly answer part (b)(i) and calculate the aggregated expected loss. A few candidates did not show work and therefore did not receive full marks.

For the remainder of part (b)(i), there is more than one answer, and many candidates answered correctly using either $10M or $20M less $244,205.

For part (b)(ii), many candidates did not provide sufficient critique and did not receive full marks: e.g., only describing the limitations of using hard data, and not describing the benefits of using soft data. Candidates needed to do more than just define hard data and soft data to receive substantial credit. Overall, candidates received less than half the marks for this part (b)(ii).

(i)
Aggregated Expected Loss is weighted annual aggregated loss by probability:
1,000*20.5% +
10,000*60% +
100,000*18% +
10,000,000*0.8% +
20,000,000*0.7%
===============
$244,205

Aggregated Unexpected Loss is dependent on risk tolerance level, which is 99.3%.
$10,000,000 –$244,205 = $9,755,795

Alternative answers for Aggregated Unexpected Loss are:
$X –$244,205 = $Y
where $X is any number between $10,000,000 and $20,000,000, inclusive.

(ii)
If the goal is to estimate a large loss with very low frequency, then a combination of soft data and hard data might be more valuable because most of the hard data are collected in a relative short period and are collected through a systemic process on a prospective basis while soft data are information that are based on empirical observations and not from a robust process.

4. **Continued**

A severe epidemic risk is a catastrophic and rare event, i.e., low frequency but high severity. Because these events are rare, there may be insufficient hard data. We would need to supplement hard data with soft data to reflect changes since the hard data was collected, e.g., advances in medicine, technology, ease of travel/transport.

Therefore, both soft data and hard data ought to be used to assess these risks.

(c)

(i) Calculate the aggregate unexpected loss using the correlation matrix. Show your work.

(ii) Recommend a method for aggregating the three risks. Justify your response.

(iii) The maximum risk capital you are prepared in any given year for aggregate unexpected risk loss of the three risks is $20,000,000.

Determine whether the current risk capital meets HIC's risk tolerance level.

Commentary on Question:
For part (c)(i), some candidates did not receive full marks because of: a calculation error, and using incorrect correlation factors. Some candidates calculated using only two of the risks instead of all three which also did not receive full marks.

For part (c)(ii), some candidates did not provide sufficient justification. Some candidates correctly recommended Scenario-based and provided justification but did not provide justification why the other two methods (Correlation Matrix / VarCov and Copula) are not recommended.

For part (c)(iii), there is a typo in the question in that an action verb was missing. Some candidates noted the typo as part of their answer and assumed that the verb was "to lose" or "to hold" after "The maximum risk capital you are prepared." Many candidates compared one or all of the Aggregate Risk Value for each method to the $20M and did not evaluate if one or all three values would meet HIC's risk tolerance level, which is fairly high at 99.3%; these candidates received partial marks. Depending on the quality of the answers, some candidates received partial marks when they wrote that they would need additional data, the use of a consultant or external data; they would need to frequently monitor or periodically change the methods & assumptions. Overall, many candidates performed poorly in part (c)(iii).

4. **Continued**

(i)
=SQRT
(8^2+5.5^2+9.755795^2+
2*0.2*8*5.5+
2*0.02*8*9.755795+
2*0.01*5.5*9.755795)
*1,000,000
= 14,533,428

Common alternative answer:
=SQRT
(8^2+5.5^2+19.755795^2+
2*0.2*8*5.5+
2*0.02*8*19.755795+
2*0.01*5.5*19.755795)
*1,000,000
= 22,597,266

Generic answer: where M=Y/1,000,000 and Y is the answer from (b)(i)
=SQRT
(8^2+5.5^2+M^2+
2*0.2*8*5.5+
2*0.02*8*M+
2*0.01*5.5*M)
*1,000,000
= N

(ii)
I recommend Scenario-based method for aggregating the three risks.

Only in certain scenarios, the Copula method can be used to calculate aggregated risks in the tail; however, it requires precisely specifying the dependencies in the tail areas of the loss distributions. It is abstract and difficult to interpret. In our case, operational risks are hard to quantify and with heavy tails, which makes it difficult to accurately fit the parameters of the copula formula.

Correlation matrix should be used in normal distribution but all three risks are not normally distributed

4. **Continued**

Each of the risks has its own distribution, which may or may not be a normal distribution. The scenario-based method requires deeper understanding of the risks from a more fundamental point of view, as it aggregates the risks at their source, i.e., in the form of risk drivers. The results of scenario-based aggregation can usually be interpreted in a much more meaningful economic and financial sense than can arbitrary quantities of distributions.

(iii)
The company's current risk tolerance level is 99.3% for each risk. All three risks were calculated on the same risk tolerance level. Simply aggregating three risks with the same risk tolerance level may or may not be enough to calculate the aggregated risk loss. The aggregated risk capital needs to be calculated on a total risk tolerance level at 99.3%. Depending on the approaches and formulas that were used in copula and scenario-based aggregation, and the correlation factors from part (c)(i) for Correlation Matrix, the results (aggregate risk values) may not be enough to determine the aggregated unexpected risk loss. That is, $20,000,000 may not be enough to meets HIC's risk tolerance level.

The key point here should be that even though the maximum risk capital > aggregate risk value of all three methods, there is still the possibility of not meeting the risk tolerance because of unknown distributions and the complication of calculating the aggregated risk/loss.

5. Learning Objectives:

2. The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.

3. The candidate will understand how the risks faced by an entity can be quantified and the use of metrics to measure risk.

4. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

Learning Outcomes:

(2a) Demonstrate how each of the financial and non-financial risks faced by an entity can be amenable to quantitative analysis including an explanation of the advantages and disadvantages of various techniques such as Value at Risk (VaR), stochastic analysis, and scenario analysis.

(2c) Analyze and evaluate risk aggregation techniques, including use of correlation, integrated risk distributions and copulas.

(3a) Apply and construct risk metrics to quantify major types of risk exposure such as market risk, credit risk, liquidity risk, regulatory risk, etc., and tolerances in the context of an integrated risk management process.

(3b) Analyze and evaluate the properties of risk measures (e.g., Delta, volatility, duration, VaR, TVaR, etc.) and their limitations.

(4b) Demonstrate means for transferring risk to a third party, and estimate the costs and benefits of doing so.

Sources:

ERM-102-12: Value-at-Risk: Evolution, Deficiencies, and Alternatives

ERM-119-14: Aggregation of risks and Allocation of Capital (Sections 4-7)

Value-at- Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion Ch. 5 Computing VaR

ERM-128-17: The Breadth and Scope of the Global Reinsurance Market and the Critical Role Such Market Plays in Supporting Insurance in the United States, Ch. III, IV, and VI]

ERM-102-12: Value-at-Risk: Evolution, Deficiencies, and Alternatives

5. Continued

Commentary on Question:
This question was intended to test the candidate's knowledge of Value at Risk as it pertains to reinsurance. Overall candidates did pretty well, with the majority of points being earned in the calculation portions of the question.

Solution:
(a) Consider each of the following deficiencies of VaR:

- Bricolage
- Historical Data and Observation Period
- Agency Risk

For each of the deficiencies identified above:

(i) Define the deficiency.

(ii) Explain whether or not the deficiency is relevant in the context of the MH pricing exercise.

Commentary on Question:
For part (i) most candidates could define one of the deficiencies, many could define two, but rarely was a candidate able to define all three. Bricolage was the deficiency candidates found most difficult to define. Several candidates confused Agency Risk with Bricolage; in these cases points were not received for part (i) but could be for part (ii) if they were able to explain if that deficiency was relevant.

Some candidates were able to define all three deficiencies indicating the question could be answered by those who knew the material.

For part (ii) candidates did generally poorly. Many explanations were generic, and not specific to MH. A generic response not relevant to the situation described received no points.

(i) Define the deficiency.

<u>Bricolage</u>
Bricolage is the risk of using VaR when undisclosed assumptions have been used in determining VaR, using VaR which has been determined (distorted) due to underlying adjustments to data.

5. **Continued**

<u>Historical Data and Observation Period</u>
HD&OP relates to the risk of selecting an in appropriate data range when determining VaR and the resulting distortion to the computed VaR attributable to the selection of too long or too short an observation period. Data may be not representative of future losses

<u>Agency Risk</u>
Agency risk relates to the anti-selective actions of risk managers to expose the firm to excessive risks based on their understanding of the limitations of VaR.

(ii) Explain whether or not the deficiency is relevant in the context of the MH pricing exercise.

<u>Bricolage</u>
This is a relevant issue for MH as it is not clear how the cedent provided loss distributions have been determined, what assumptions underlie these distributions, what adjustments have been made to the underlying data.

<u>Historical Data and Observation Period</u>
This is a relevant risk given that MH does not know what period of data underlies the provided loss distributions. If the loss distributions are based on very recent data, they may reflect current loss trends but miss the historical range of such losses.

<u>Agency Risk</u>
This may be a risk if the cedents have manipulated the loss data with the understanding of how MH prices. However, this does not appear to be the case given the typical "gaming" of VaR entails taking on extreme tail risk (which is not present in the loss distributions provided).

(b) Your manager wants you to calculate premiums for the two reinsurance opportunities, and tells you to use the following simplified formula for profit:

Profit = Premiums – E(Loss)

(i) Demonstrate that the VaR (95%) for both options is 12.45.

(ii) Demonstrate that the minimum premiums which satisfy MH's pricing objectives are 5 for Cedent A and 39 for Cedent B.

5. **Continued**

Commentary on Question:
Candidates did well on both of these parts.

Part (i): In order to receive full points, a candidate needed to show the expected loss calculation, and not just provide the result. The question did not specifically state we are looking for relative VaR, and if the candidate addressed this issue full points could still be earned.
Part (ii): In order to receive full points, the candidate needed to demonstrate an understanding of the ROC formula.

(i)
<u>For A</u>
E[Loss] = 5% x (0 + 1.5 + 2.5 + 15) + 80% x 2 = 2.55
VaR(95%) = 15 - 2.55 = 12.45

<u>For B</u>
E[Loss] = 10% x (33 + 38 + 44 + 46) + 50% x 36 + 5% x 49 = 36.55
VaR(95%) = 49 – 36.55 = 12.45

(ii)
Objective = 20% ROC
ROC = E[Profit] / Capital = [Prem – E[L]] / Capital = 20%
Capital = Var(95%)

<u>For A</u>
ROC = [Prem – E[L]] / Capital = 20%
Prem = 20% * 12.45 + 2.55 = 5.04 (rounds to 5)

<u>For B</u>
ROC = [Prem – E[L]] / Capital = 20%
Prem = 20% * 12.45 + 36.55 = 39.04 (rounds to 39)

(c) Propose two conditions to be introduced to MH pricing guidelines which would complement the ROC based pricing hurdle.

Commentary on Question:
Most candidates were able to identify at least one condition that could be added.

Many candidates listed multiple measures to include in the pricing guidelines; this was viewed as only one condition.

Other relevant conditions with coherent explanations complementing ROC were awarded points.

5. Continued

Consider stress testing scenarios to compliment the VaR based pricing.

Do not rely on only one measure; consider IRR, RAROC, RARAC, etc.

(d) MH can enter only one of the two reinsurance treaties.

Explain whether MH should be indifferent between these two treaties from a capital perspective. Justify your response.

Commentary on Question:
Most candidates did poorly on this question. Candidates often didn't make their response in the context of ROC.

In order to receive full points, candidates needed to identify which treaty was preferable from a capital perspective.

Partial points could be earned if the candidate justified their response based on the expected loss AND showed that the probability of being above the expected loss is lower for A without reference to the ROC.

Probability that the ROC will not be met:
Prob (Return / Capital) < 20%, from part (b) you know VaR (95%) = 12.45
Prob (Return) < 2.49 (20% of 12.45),
Return = Premium - Loss, Premiums = 5 (for A) and 39 (for B)

For Cedent A
Prob (5 - Loss) < 2.49 = Prob (Loss) > 2.51 = 5%

For Cedent B
Prob (39 - Loss) < 2.49 = Prob (Loss) > 36.51 = 35%

MH should prefer the reinsurance for Cedent A, as the probability that the ROC will not be met is smaller.

(e)

(i) Provide a loss distribution reflecting each of I, II and III from MH's perspective.

(ii) Explain using qualitative arguments why options I and II are unlikely to be attractive reinsurance structures for the cedent.

(iii) Provide qualitative and quantitative arguments supporting option III.

5. Continued

Commentary on Question:

(i) *Most candidates did well on this part. Partial points were earned when candidates provided a formula instead of a loss distribution.*

(ii) *Most candidates were able to identify one argument. Partial points were earned when candidates stated the same argument for both treaties*

(iii) *Candidates generally did well, providing qualitative arguments, but many didn't provide a quantitative argument. In order to earn full points, candidates needed to demonstrate lower premiums.*

(i)

Prob	Loss	I	II	III
0.05	0	0	0	0
0.1	33	24.75	33	0
0.5	36	27	36	0
0.1	38	28.5	36.55	1.45
0.1	44	33	36.55	7.45
0.1	46	34.5	36.55	9.45
0.05	49	36.75	36.55	12.45

(ii)

Option I

If the cedent believes the premium is too high, then charging the same premium but scaling back the amount of coverage by 25% is unlikely to be viewed favorably by the cedent.

Option II

The proposed structure has MH providing indemnification for losses up to the level of expected losses. This does not appear to be an attractive structure as cedent is concerned with tail losses (not losses around the expected level).

(iii)

The proposed structure is more sensible, it provides cedent with relief for tail losses rather than losses around the expected level. Further, the reinsurance premium is commensurately lower.

E[Loss] = 2.46
Relative VaR = 12.45 – 2.46 = 9.99
Premium = .20% * 9.99 + 2.46 = 4.46

6. **Learning Objectives:**

4. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

Learning Outcomes:

(4h) Analyze funding and portfolio management strategies to control equity and interest rate risk, including key rate risks. Contrast the various risk measures and be able to apply these risk measures to various entities. Explain the concepts of immunization including modern refinements and practical limitations.

Sources:

ERM-111-12: Key Rate Durations: Measures of Interest Rate Risks

Commentary on Question:

The goal of the question is to test the candidate's understanding of the Key Rate Duration (KRD) concepts and how it applies to assessing the impact of various interest rate shifts to the balance sheet.

Solution:

(a) Construct a replicating portfolio using cash and zero-coupon bonds that immunizes against any yield curve shift. Show your work.

Commentary on Question:

The goal is to test the candidate's knowledge of using the concept of KRDs and apply it to calculate a replicating portfolio, similar to the example in the study notes. Some candidates were not able to fully calculate the replicating portfolio – some used the wrong liability amount (1.1M), while some did not divide the KRDs with the time period (e.g. KRD(t)/t).

1-year zero-coupon bond (ZCB) = 0.09/1*1,100,000 = 99,000
2-year ZCB = 0.36/2*1,100,000 = 198,000
3-year ZCB = 1.36/3*1,100,000 = 498,666.67
4-year ZCB = 0.73/4*1,100,000 = 200,750
5-year ZCB = 0.46/5*1,100,000 = 101,200
Cash = 1,100,000-99,000-198,000-498,667-200,750-101,200= 2,383

The replicating portfolio consists of:
Buy $99,000 1Y ZCB
Buy $198,000 2Y ZCB
Buy $498,667 3Y ZCB
Buy $200,750 4Y ZCB
Buy $101,200 5Y ZCB
Hold $2,383 cash

6. **Continued**

(b)

(i) Calculate the change in surplus (equity) under scenario 3 using the actuarial student's approach. Show your work.

(ii) Provide a qualitative description of the change in surplus under Scenarios 1 and 2.

Commentary on Question:
In part b(i), candidates were expected to apply KRD knowledge in calculating the impact of the interest rate changes to the assets, liabilities and surplus. Only partial marks were given if the candidate only calculated either asset or liability impact. Some candidates failed to recognize that surplus = assets – liabilities. Some candidates also did not use the fact that KRD of zero coupon bonds are equal to its duration.

To get full marks in part b(ii), candidates are expected to qualitatively assess and discuss the impact of interest rate changes on the surplus. Only partial marks were given if only assets or liabilities were discussed. Some candidates failed to recognize that the portfolio is duration matched under effective duration, which implies that it is immunized to small parallel shifts to the yield curve.

b(i)
% Decrease in assets = (2*1*.5 + 4*34*.5)/100 = 0.69%
New asset value = 0.9931*1,100,000 = 1,092,410

% Decrease in liabilities = (0.09*-20 + 0.36*1 + 1.36*20 + 0.73*34 + 0.46*60)/100 = 0.7818%
New liability value = (1-0.0078185)*1100=0.99218*1,100,000=1,091,400.20

Change in surplus (equity) = +1,009.80
Surplus (equity) increased by 1,009.80.

b(ii)
Scenario 1: No change in equity since effective duration immunizes small parallel shifts to yield curve.

Scenario 2: In Scenario 2, only duration 4 & 5 change. There will be a decrease in equity as assets go down in value more than the liabilities. By looking at the total KRD for periods 4 & 5 for assets, it is greater than the total KRD for liabilities for the same duration. Higher KRD means higher sensitivity, and the positive change in yields will cause a directionally negative impact. Therefore, the assets will have a more negative impact than the liabilities due to their higher KRD.

6. **Continued**

(c)

(i) Describe the advantages and disadvantages of your actuarial student's suggestion with respect to the portfolio determined in (a).

(ii) Determine whether the suggestion satisfies NewCo's objective. Show your work.

(iii) Recommend whether the company should accept the suggestion.

Commentary on Question:
Candidates were able to receive full marks if they provided a concrete example for c(ii), as required by the question. Some candidates referred to b(ii), and full marks were given as long as the answer in b(ii) is correct. In c(iii), candidates needed to provide a short justification on their recommendation to provide full credit.

Some candidates interpreted the company's requirement to "fully immunize its surplus against interest rate changes" as satisfying Redington or full immunization. Points were given as long as the candidate was able to correctly show that the conditions for these kinds of immunization were violated.

c(i)
Advantage of proposal: Simple to implement, cheaper transaction costs as you're only buying fewer bonds.

Disadvantage: Effective duration is often inadequate in measuring interest rate risk exposure since spot curve rarely moves in parallel fashion. For non-parallel shifts, portfolios that are immunized on an effective duration basis might still need significant rebalancing of assets/liabilities.

c(ii)
Using Scenario 3 as an example:
% Change in liabilities: 0.73*25 + .46*35=0.3435
Change in liabilities = 1,100,000 * (1-.003435) - 1,100,000 = (3,780)

% Change in assets: (4*25*.5)/100 = 0.5
Change in assets = 1,100,000 * (1-.0050)-1,100,100 = (5,500)

Assets and liabilities are not fully immunized against each other for a non-parallel shift, therefore risk tolerance requirement was not met.

c(iii)
I do not recommend that the proposal is used. Immunizing the portfolio is better as it captures the interest risk profile better than effective duration.

7. Learning Objectives:

3. The candidate will understand how the risks faced by an entity can be quantified and the use of metrics to measure risk.

4. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

Learning Outcomes:

(3d) Analyze risks that are not easily quantifiable, such as operational and liquidity risks.

(4b) Demonstrate means for transferring risk to a third party, and estimate the costs and benefits of doing so.

(4k) Apply best practices in risk measurement, modeling and management of various financial and non-financial risks faced by an entity.

Sources:

ERM-817-17: Speech by SEC Staff: The Role of Compliance and Ethics in Risk Management

Incentive Compensation/Risk Management - Integration Incentive Alignment and Risk Mitigation - Beal

SOA Monograph - A New Approach for Managing Operational Risk (sections 5 - 7)

Case Study

Commentary on Question:

Commentary listed underneath question component.

7. Continued

Solution:

(a) You are reviewing Patrick Lyon's Corporate ERM Department memo in section 2.6 of the case study.

(i) Assess to what extent the Corporate ERM Department framework he lays out meets the three lines of defense risk management framework. Justify your response.

(ii) Assess how Patrick Lyon's memo is evidence of a robust risk management culture with respect to the responsibilities of senior management and the Board of Directors.

Commentary on Question:
Referencing the memo, the candidate was asked for evidence that addressed the three lines of defense identified in the Speech by SEC Staff paper and also a robust risk management culture. The candidate needed to identify and define the three lines of defense and to point out whether or not the memo discussed those three lines to receive full credit. Generally, candidates did well on this initial part of the question. For the second part some candidates saw a robust management culture; others did not as they were bothered by the CRO reporting to the treasurer. Both approaches received credit.

(i) The First Line of Defense is the business unit. This line of defense responsible for taking, managing and supervising risk effectively and in accordance with the risk appetite and tolerances set by the board/senior management of the organization. The memo discusses the promotion of risk culture to rank and file and meets the first life of defense.

The Second line of Defense is the key support functions (e.g. compliance, risk management). They need to have adequate resources, independence, standing and authority to implement effective programs and objectively monitor and escalate risk issues. Mr. Lyon addresses this need in his email.

The Third Line of Defense is Internal Audit and is responsible for providing independent verification and assurance that controls are in place and operating effectively. Mr. Lyon does not address this need in his email.

7. Continued

(ii) Senior management and the Board are responsible for reinforcing the tone from the top, driving a culture of compliance. The appointment of a CRO and a corporate ERM department and the fact that Mr. Lyon, himself, is promulgating the email seems to suggest that senior management will be highly involved in the process. And, since Mr. Lyon is on the Board, we can assume that the Board is setting the tone at the top, too.

(b)

(i) Describe four principles to be followed in designing an effective incentive compensation plan.

(ii) Evaluate how AHA's proposed Contingent Compensation Plan for brokers aligns with each of the four principles.

Commentary on Question:
Part (i) is a simple recall question, but many candidates did not start off by correctly stating Principle 1, which was risk focused. This prevented them from getting full credit. Part (ii) was designed to see if the candidate could apply the principles to AHA based on the information available in the case study. If the candidate did not answer Part (i) well, then the candidate tended to score poorly on this section. The answers to Part (ii) were not black and white, so credit was given for answers not necessarily following the model answer format.

(i)
Principle # 1 - Understand the risk context; Producers are certainly associates of a company that can expose the company to adverse material risk.
Principle # 2 - Apply risk balancing/design interventions to minimize risk
Principle # 3 - Establish an incentive governance framework to ensure balances
Principal # 4 - Monitor regularly

(ii)
1. AHA has taken a rigorous approach to making sure the producers are party to the risks AHA takes on. However, the metrics are Volume, Growth and Retention. Having producers also share in the profits, would help to reduce "rogue" behavior.
2. The proposed incentive plan includes some balance as it incorporates both growth and retention, however other balancing items such as: profit, outcomes, and risk-adjusted performance metrics are excluded.
3. The plan also does not include any claw back. The plan has a weakness in that it is only administered by the sales department and there is no oversight by the Finance, Legal or the Risk Management units.
4. The system will be monitored annually. Is this regular enough?

7. **Continued**

(c) Jimmy Pike, a senior broker for AHA, worked hard to sign up a large institutional client. This sale could potentially double his book of business. Jimmy received a report from the new business department showing that this would be a profitable case for AHA. Shortly before his meeting to sign the contract with the client, Jimmy found an error in the analysis. Specifically, he noticed that certain administrative expenses had been understated by a factor of 10. He could see that correcting the error would likely make the case unprofitable. However, he proceeded to sign the contract with the client anyway.

(i) Categorize the type of operational risk illustrated in the case above. Justify your response.

(ii) Explain how AHA's current risk management philosophy, as highlighted in AHA's Report to Corporate and their broker compensation plan, may contribute to this type of risk.

(iii) Recommend changes AHA should make to mitigate this type of risk.

Commentary on Question:
This question was designed to see if the candidate could properly identify the risk present in a sales situation. About half of the candidates were able to properly identify the risk illustrated and received full credit. Candidates that did not correctly answer (i) generally performed poorly on parts (ii) and (iii). Answers that listed actions that could help prevent this type of situation were given full credit.

(i)
This is the Principle agent risk – a tier 1 operational risk
- Information asymmetric
- The broker is benefiting himself by ignoring the information could potential harm the company

(ii)
AHA current risk management does not prevent or mitigate the Principle Agent risk
- AHA management believes the company can prosper by being aggressive and is willing to take risks
- AHA's incentive compensation plan criteria include membership growth, but not profitability, or quality of care.

7. Continued

(iii)
Institute controls and audit procedures in order to prevent this happening in the future

- Include profitability as a component of the incentive compensation plan
- Fully verify the method of determining whether business managers are taking risks that are in conformity with the risk tolerance standards of the stakeholders
- Develop a set of disincentives that reduce the broker's or manager's associated payoff

(d) You are considering the unique compensation structure of AHA's potential acquisition target, Columbia Health, as an alternative example of a health insurance company approach to compensation.

Evaluate the pros and cons of Columbia's compensation structure from the perspective of risk to Columbia.

Commentary on Question:
The purpose of this question was to see if candidates could take the material on compensation plans and apply it to Columbia. By design, Columbia's compensation plan and company structure are quite different from AHA's. Many candidates had problems sorting the pros and cons of the two plans and received little to no credit. Other candidates did a reasonable job of identifying differences.

Columbia Health's compensation is well above industry average and is totally fixed; there is no variable compensation.
Pros:
- No incentive to aggressively take risk - prevent Principle Agent risk
- Lower turnover as compensation is well above the industry average

Cons:
- No incentive to aggressively take risk – maybe lose business opportunities as compensation is not tied to performance and the employee may have low motivation
- Not cost effective to have well above industry level compensation

8. **Learning Objectives:**

2. The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.

4. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

5. The candidate will understand the concept of economic capital, risk measures in capital assessment and techniques to allocate the cost of risks within business units.

Learning Outcomes:

(2f) Analyze the importance of tails of distributions, tail correlations, and low frequency/high severity events.

(4b) Demonstrate means for transferring risk to a third party, and estimate the costs and benefits of doing so.

(4c) Demonstrate means for reducing risk without transferring it.

(4e) Develop an appropriate choice of a risk mitigation strategy for a given situation (e.g., reinsurance, derivatives, financial contracting), which balances benefits with inherent costs, including exposure to credit risk, basis risk, moral hazard and other risks.

(5a) Describe the concepts of measures of value and capital requirements (for example, EVA, embedded value, economic capital, regulatory measures, and accounting measures) and demonstrate their uses in the risk management and corporate decision-making processes.

Sources:

ERM-811-15: Agency Theory and Asymmetric Information

ERM-123-14: S&P Enterprise Risk Management Criteria

ERM-122-16: Chapter 1 of Captives and the Management of Risk

The Five Critical Attributes of Effective Cybersecurity Risk Management

Case Study

Commentary on Question:

This question aimed to test the candidate's understanding of cybersecurity risk and the potential agency conflicts that could occur when managing this risk. In general, candidates did worse on questions with the higher cognitive level verbs, such as 'critique' and 'compare and contrast.'.

8. **Continued**

Solution:

(a) Contrast, from Lyon's perspective, two ways in which cybersecurity risk differs from the risks associated with the Personal Auto line of business.

Commentary on Question:
Candidates did well on part (a). Full credit required an acknowledgement of the fact that cybersecurity risk is a tail risk.

The risks associated with the auto line of business are high-frequency, low-severity; whereas cybersecurity risk is low-frequency, high-severity. The risks associated with the auto line of business emanate largely from human error; whereas cybersecurity risk emanates largely from those with malicious intent.

(b) Compare and contrast management of cybersecurity risk through internal mitigation versus risk transfer.

Commentary on Question:
Most candidates did not compare and contrast, but rather just described internal mitigation and risk transfer. Due to this, full credit was given if the methods were described accurately even though this was not the intended response.

Both methods seek to reduce cybersecurity risk and can help improve the rating from Kelly's Ratings.

Risk transfer manages the risk by swapping a potentially large loss for fixed insurance premiums. Reputational risk from a cybersecurity incident remains.

Risk mitigation focuses on having the company develop strong cybersecurity capabilities so the frequency and severity of events is less. Reputational risk could be lowered.

(c) With respect to internal risk mitigation, you intend to follow the five critical attributes of effective cybersecurity risk management, as follows:

I. An Effective Framework
II. End-to-End Scope
III. Thorough Risk Assessment and Threat Modeling
IV. Proactive Incident Response Planning
V. Dedicated Cybersecurity Resources

8. Continued

For each attribute, I through V:

(i) Describe the objective of the attribute.

(ii) Identify one gap in Lyon’s current cybersecurity risk management processes as outlined in section 2.6.2.3 of the Case Study.

(iii) Recommend a remediation action to address the gap identified in (ii).

Commentary on Question:
Few candidates described a gap and an action for all five attributes. Most only described one gap and one action. Due to this, enhanced partial credit was given for describing one gap and action, but full credit was only received if they described three or more gaps and actions.

<u>Effective Framework</u>
(i) Provide a risk-based set of standards, guidelines, and practices.
(ii) Framework has not yet been defined
(iii) Adopt a framework like NIST, which uses a cycle of Identify, Protect, Detect, Respond, and Recover

<u>End-to-End Scope</u>
(i) Cover all devices, outside-in and inside-out approach
(ii) Only applies to servers and PCs, is missing mobile phones, IoT, etc.
(iii) Expand scope to cover mobile phones

<u>Thorough Risk Assessment and Threat Modeling</u>
(i) Monitor emerging threats and map likelihood and damage of threats
(ii) No quantification of threats. Assessment is limited to heat map analysis
(iii) Translate heat map to stress testing

<u>Proactive Incident Response Planning</u>
(i) Need protocol for reaction: data inventory, response team, communication to stakeholders
(ii) No evidence of any business disruption protocol
(iii) Set up business disruption procedure

<u>Dedicated Cybersecurity Resources</u>
(i) Independent, dedicated cybersecurity reporting structure
(ii) Cybersecurity is administered by IT. There are no dedicated resources. IT might not have the capabilities to administer cybersecurity properly
(iii) Develop a dedicated cybersecurity team

8. Continued

(d) For the above financial structure:

(i) Explain how investors could be exposed to adverse selection.

(ii) Explain how investors could be exposed to moral hazard.

(iii) Recommend two specific features that should be included in the structure to remediate the issues identified in (i) and (ii).

Commentary on Question:
Many candidates did well on part (d). Those candidates that did not do well did not understand adverse selection and moral hazard.

(i) Lyon has a much better understanding of their cybersecurity than investors, so there is a potential for Lyon to impose far greater risk on investors than they anticipated and priced for.

(ii) The current structure completely indemnifies Lyon for losses, leaving little incentive for Lyon to invest in cybersecurity risk management. This exposes investors to moral hazard.

(iii) To remediate adverse selection, the contract should detail the events that are covered or excluded from scope.

To remediate moral hazard, the payoff should be structured such that Lyon has a financial stake (e.g. deductible or co-pay).

(e) Critique Tomas Lyon's statement and propose a suitable response.

Commentary on Question:
Many candidates did not critique and respond to Tomas Lyon's statement.

Critique:

Tomas is very focused on the short-term and hasn't considered the long-term effects of not having a comprehensive cybersecurity program. There is an overreliance on Datashield and this is causing Tomas to overlook the fact that the current cybersecurity program is not end-to-end in scope, does not have a dedicated cybersecurity team, and does not do any quantification of potential risks. Cybersecurity is a tail risk and as such, could cause significant volatility in the earnings of the company if it were to occur.

8. **Continued**

Response:

While a comprehensive cybersecurity program could reduce earnings, it would help protect against far greater losses in the future. A cybersecurity event could cause great reputational damage. This would be mitigated through a more extensive cybersecurity program, one that encompasses the five attributes of cybersecurity risk management. Tomas thinks Datashield is providing this, but they have a limited reach and are missing out on key attributes, such as covering mobile phones. With an effective cybersecurity program, it is more likely that Kelly Ratings will improve our ratings. This means we can borrow at a lower cost and this would help offset the additional costs of cybersecurity risk management.