ERM-INV 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

Part a (i)

Dealers - 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.

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

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

Part a (ii)

1. Valuation and Market Risk Management Practices - 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. Credit Risk Management – 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. Systems and Operations – 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. Accounting – 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. Supervisors – 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.

Part b (i)

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.

Part b (ii)

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

Historical Data and Observation Period
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

Agency Risk
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.

Bricolage
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.

Historical Data and Observation Period
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.

Agency Risk
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)
For A
E[Loss] = 5% x (0 + 1.5 + 2.5 + 15) + 80% x 2 = 2.55
VaR(95%) = 15 - 2.55 = 12.45

For B
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%)

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

For B
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:**

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:

(2b) Evaluate how risks are correlated, and give examples of risks that are positively correlated and risks that are negatively correlated.

(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.

(3c) Analyze quantitative financial data and insurance data (including asset prices, credit spreads and defaults, interest rates, incidence, causes and losses) using modern statistical methods. Construct measures from the data and contrast the methods with respect to scope, coverage and application.

(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 -329-17: Risk Factors as building blocks for Portfolio Diversification: The Chemistry of Asset Allocation, Podkaminer

7. Continued

Value-at- Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion Ch. 7 Portfolio Risk: Analytical Methods

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

Commentary on Question:
Commentary listed underneath question component.

Solution:
(a)

(i) Explain to the committee what risk factors represent.

(ii) Describe a key shortcoming of traditionally constructed asset portfolios that a risk factor-based SAA could overcome.

Commentary on Question:
Most candidates were able to provide a satisfactory answer for part a).

(i) Risk factors are the smallest systematic (or non-idiosyncratic) units that influence investment return and risk characteristics. They include such elements as inflation, GDP growth, currency, and convexity of returns.

(ii) The traditional approach focuses on assets classes in which multiple risk factors are bundled together. A factor-based approach can expose the hidden risks of the portfolio, such as unexpected higher correlation and poor diversification due to the exposure to overlapping risk factors.

(b) Consider the following individual risk factors:

I. Real Rates
II. Inflation
III. Volatility
IV. Credit Spread

Explain an investable index position(s) that would gain positive exposure to each of the factors above.

Commentary on Question:
Most candidates provided satisfactory answers to part b). Some participants identified non-index positions and/or positions that would provide negative exposure to the risk factors mentioned.

7. Continued

I. Invest in a long position in a TIPS (Treasury Inflation-Protected Securities) index.
II. Invest in a long position in a nominal Treasury index, and take short position in a TIPS index.
III. Invest in a long position in the VIX index.
IV. Invest in a long position in a high-quality credit index, and take a short position in a Treasury index.

(c) Calculate the 1-year 97.5% VaR of the traditional asset portfolio. Show your work.

Commentary on Question:
Candidates calculated either or both absolute and relative VaR. Due to two ways of interpreting the question, credit was given for either answer.

$$VaR(97.5\%) = \alpha\sigma = 1.96 \times \sqrt{(w'\Sigma w)}$$
$$= 1.96 \times \sqrt{\begin{bmatrix}0.6 & 0.4\end{bmatrix}\begin{bmatrix}0.0225 & 0.0012\\ 0.0012 & 0.0225\end{bmatrix}\begin{bmatrix}0.6\\ 0.4\end{bmatrix}} = 18.5\%$$

(d)

(i) Calculate the 1-year 97.5% VaR of an equal-weighted portfolio of the three risk factor groups. Show your work.

(ii) Explain the sources of difference in VaR between the traditional asset portfolio and the risk factor group portfolio.

Commentary on Question:
Many participants neglected to apply an equal weighting to the individual factor group VaRs, producing a factor-based VaR higher than the asset-based VaR. This result should have seemed unreasonable in the context of the objective of factor-based modeling. This omission made it difficult for these candidates to get full credit for (ii). In part (ii), candidates were ideally expected to back out asset correlations and factor group volatilities for direct comparison. Most candidates were able to describe the different levels of correlation between assets verus factor groups as a source of difference between the two VaRs, but did not identify that the factor group variances or volatilities (risks) were lower than asset-based ones. Full credit for (ii) required an appropriate observation regarding both relative volatilities and relative correlations.

7. Continued

(i)

$$VaR(97.5\%) = \sqrt{VaR'\ C\ VaR} =$$

$$\sqrt{\begin{bmatrix}\frac{0.196}{3} & \frac{0.039}{3} & \frac{0.118}{3}\end{bmatrix}\begin{bmatrix}1 & -0.3 & -0.05\\ -0.3 & 1 & 0.75\\ -0.05 & 0.75 & 1\end{bmatrix}\begin{bmatrix}0.196/3\\ 0.039/3\\ 0.118/3\end{bmatrix}} = 7.7\%$$

(ii) The factor portfolio has a much smaller VaR than the traditional portfolio due to the following factors:

1. Volatilities: The equity volatility is 15% and bond volatility is 4%. The portfolio weight is slightly skewed to Equity, the higher volatility asset. The volatilities for the factors are (dividing each VaR by 1.96) are 10%, 2%, and 6% for Economic Development, Macro and Fixed Income, respectively. Thus, the average or portfolio-weighted volatilities are higher for the asset classes than the factors.

2. Correlations: The correlations for the factors are -0.05, -0.30, and 0.75. There is high correlation between Macro (Real rates, Inflation, etc.) and Fixed Income factors (duration, credit spread), but other pairs have negative correlations. Equal weighting gives equal weight to the correlations. For the traditional portfolio, the correlation between equity and bonds is 0.0012/(0.15*0.04) = 0.20. While this is relatively low, it is still positive.

(e) Describe four challenges in using a risk factor-based approach to SAA.

Commentary on Question:
Most candidates were able to provide a sufficient answer to part (e). Other reasonable answers other than those shown below were eligible for credit.

- It is impossible to determine and include all the risk factors.
- Many factors have poor investable proxies and thus have no "natural" way to invest in them.
- It is difficult to assign proper weight/exposures to the risk factors.
- Must be implemented by using short exposures and derivatives, which may not be permitted by investment policies.

8. **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:

(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.

(4a) Demonstrate and analyze applicability of risk optimization techniques and the impact of an ERM strategy on an organization's value. Analyze the risk and return trade-offs that result from changes in the organization's risk profile.

(4d) Demonstrate how derivatives, synthetic securities, and financial contracting may be used to reduce risk or to assign it to the party most able to bear 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.

(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.

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

Sources:

Value at Risk, Jorion, Chapter 17, VAR and Risk Budgeting in Investment Management (excluding 17.3 and 17.4)

ERM-611-17: Investment Management for Insurers, Chapter 26, The Use of Derivatives in Managing Equity Portfolios

Commentary on Question:

The goal of this question is to test candidates' understanding of equity derivatives and equity portfolio management. Candidates are expected to assess several equity investment strategies relative to SLIC's goals and expertise and to demonstrate an understanding of risk appetite and risk budgeting.

8. Continued

Solution:

(a) The S&P 500 Index currently has an expected return of 7% and an annual volatility of 15%.

Estimate SLIC's standalone absolute 1-year VaR at the 95% confidence level from its allocation to U.S. equity. Show your work.

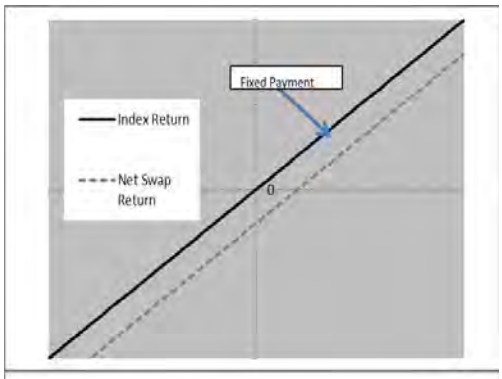
Commentary on Question:
Most candidates did well on this part

$VaR_{95\%} = \alpha * \sigma * W$
$VaR_{95\%} = 1.645 * 0.15 * 40M$
$VaR_{95\%} = \$9.87M$

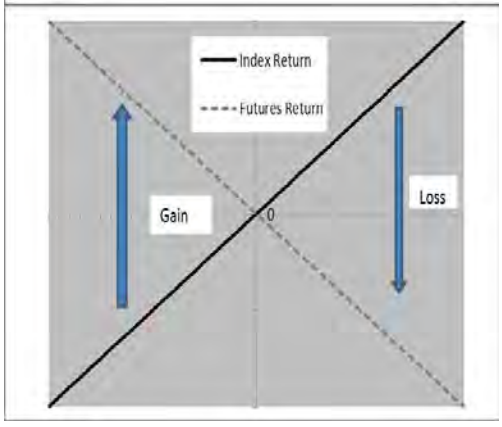
(b) Sketch the payoff profile from SLIC's perspective for each of the three equity derivative positions. Label key aspects of your diagram.

Commentary on Question:
Performance on part (b) varied among candidates. Some areas of common mistakes were sketching the profit graph (subtracting the premium from the payoff) instead of the payoff graph for the put option or not deducting the fixed leg for the swap payoff.

(i)

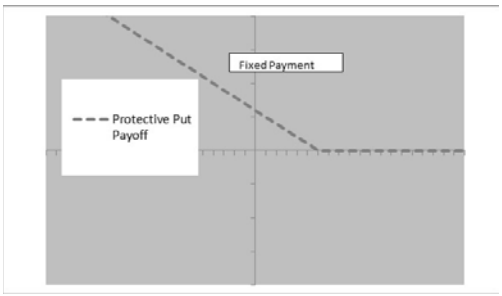


(ii)



8. Continued

(iii)



(c) Assess the merits of each of the three equity derivatives positions as a means for SLIC to gain passive exposure to the S&P 500 Index.

Commentary on Question:
Most candidates did not provide answers as to how these strategies would align with SLIC's objectives. Ideal answers noted that strategies (ii) and (iii) would not gain the appropriate positive exposure to S&P 500 for SLIC and that (iii) was a non-linear payoff.

(i) SLIC receives S&P 500 exposure in exchange for a fixed return with minimal upfront costs. This is an appropriate strategy for SLIC to gain positive exposure to S&P 500

(ii) This strategy earns negative symmetrical exposure for SLIC at a low upfront cost. This is not a suitable strategy for SLIC as it does not create positive exposure to S&P500.

(iii) This strategy requires upfront payment to buy the options, and creates negative exposure to the S&P500 that is asymmetrical (non-linear payoff). This is not a suitable strategy for SLIC.

(d) Explain the advantages and disadvantages of having the SLIC investment team gaining passive U.S. equity exposure synthetically versus through managing an index fund.

Commentary on Question:
Most candidates did well on this part, however many did not provide explanations with their answers.

Advantages:

Derivatives are more liquid investments than direct investment

Low up front cost required for swaps/futures

Disadvantages:

Derivatives add sophistication/ require additional expertise

Interest rate exposure added with the use of derivatives

8. Continued

(e) Determine the optimal allocation to each of the active U.S. equity managers and to the in-house passive team if a total U.S. equity portfolio TEV of 5% is the risk appetite constraint. Show your work.

Commentary on Question:
In general candidates struggled on this part, and some had difficulty in setting up the solution by deriving asset manager Information Ratios (μ/σ) to use in the given equation. Others correctly set up the problem, but did not recognize the resulting short position for the in-house allocation.

Another acceptable answer for (e) was noticing that both active managers had a TEV of 5%, so any allocation between the two managers could be acceptable based solely on a risk appetite of 5%. The optimal allocation under this reasoned approach would be 100% to Alpha Mgmt since their excess return is higher (2.5% vs 2%).

Need: $x_i\omega_i = IR_i[\omega_p/IR_p]$ for each i

Have: IR = μ/ω (from Case Study)
Manager Alpha Mgmt (A) has $TEV_A = \omega_A = 5\%$, $\mu_A = 2.5\%$, $IR_A = 2.5/5 = 0.5$
Manager Beyond Beta (B) has $TEV_B = \omega_B = 5\%$, $\mu_B = 2.0\%$, $IR_B = 2/5 = 0.4$
In-house passive team has $TEV_I = \omega_I = 0$, $\mu_I = 0$

$x_A\omega_A = IR_A[\omega_p/IR_p] = 0.5*[\omega_p/IR_p]$
$x_B\omega_B = IR_B[\omega_p/IR_p] = 0.4*[\omega_p/IR_p]$
So $5\%x_B = 0.8 * 5\%x_A$ or $x_B = 0.8 * x_A$

$\omega_P = \text{sqrt}(x_A^2\omega_A^2 + x_B^2\omega_B^2 + x_I^2\omega_I^2)$
$\omega_P = \text{sqrt}(0.0025x_A^2 + (0.8)^2(0.0025x_A^2) + 0)$
$\omega_P = \text{sqrt}(0.0041x_A^2)$
$\omega_P = 0.064x_A$

According to the risk appetite, the total portfolio TEV should be 5%:
$\omega_P = 5\% = 0.064x_A$; $x_A = 78\%$; $x_B = 0.8\ x_A = 62.4\%$; $x_I = 1 - x_A - x_B = -40.4\%$

(f) Determine the allocated principal and relative risk budget (in $000s) for each of the three U.S. equity managers under the optimal manager allocation, at a confidence level of 95%. Show your work.

Commentary on Question:
Most candidates did well on this part; however some used a TEV of 5% instead of 0% for the in house team.

8. Continued

For Alpha Mgmt:
Allocated principal = $40,000 * 78% = $31,200
Relative risk budget = $\alpha\sigma W$ = 1.645 * 0.05 * $31,200 = $2,566

For Beyond Beta:
Allocated principal = $40,000 * 62.4% = $24,960
Relative risk budget = $\alpha\sigma W$ = 1.645 * 0.05 * $24,960 = $2,053

For In-house passive team:
Allocated principal = -$40,000 * -40.4% = ($16,160)
Relative risk budget = $\alpha\sigma W$ = 1.645 * 0 * ($16,160) = 0