

ERM-INV Model Solutions

Fall 2021

1. Learning Objectives:

1. The candidate will understand the ERM framework and process and be able to apply them to organizations.
4. The candidate will understand how the risks faced by an entity can be quantified and the use of metrics to measure risk.

Learning Outcomes:

- (1e) Propose ERM solutions or strategies that effectively manage risk under different real (case study) and hypothetical situations facing financial and non-financial organizations
- (4c) Analyze risks that are not easily quantifiable, such as liquidity, operational, and environmental risks

Sources:

Value-at-Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion
Ch. 13 Liquidity Risk (Except section 13.4) (LO 4)

SOA Monograph: A New Approach to Managing Operational Risk, Ch. 8 (LO 4)

Embedding Cyber Risk in Risk Management: An Insurer's Perspective (pp. 12-15 of
Cybersecurity: Impact on Insurance Business and Operations) (LO 4)

ERM-136-20: Managing Liquidity Risk: Industry practices and recommendations for
CROs (excluding section 4) (LO 4)

ERM-106-12: Economic Capital-Practical Considerations-Milliman (LO 4)

ERM-106-12: Economic Capital-Practical Considerations-Milliman (LO 1)

Commentary on Question:

This question applied the candidate's knowledge of liquidity and operational risk to the case study. Candidates performed well overall, as the answers generally were able to tie back to the case study and respond directly to the question asked.

1. Continued

Solution:

- (a) Big Ben considers improving its operational risk analysis by implementing one of the following:
1. Using five years of Big Ben's operational failure frequency and loss severity data, which is collected internally.
 2. Using five years of Big Ben's internal data combined with industry data.
 3. Using stress testing and scenario analysis.
- (i) Evaluate each of the three approaches.
- (ii) Recommend the most appropriate approach for Big Ben. Justify your response.

Commentary on Question:

Candidates performed well on this part of the question. Most were able to evaluate the three approaches. Recommendations sometimes only considered the accuracy of the approach in general and received partial credit as it was expected that the recommendation tie back to Big Ben's situation.

- (i) Approach 1: Using internal loss frequency and severity data is most relevant to Big Ben Bank. However, the 5 years of data may not be sufficient. The 99.5% VaR measurement requires the level of aggregate loss associated with a one in two-hundred year event. When the loss is heavy-tailed, 1000 years of relevant loss data may be required. For Big Ben Bank, the low frequency and high severity losses has not occurred before; using 5 years of internal data might result in very few data points which is not credible.

Approach 2: Combining internal and external data may allow Big Ben Bank to have sufficient data to model operational risks. When combining external data for frequency, data may need to be scaled for size. Since Big Ben Bank's primary product is wealth management for high net worth clients, using general banking industry's loss data might not be appropriate. Careful considerations need to be given when selecting the external data.

1. Continued

Approach 3: Stress testing and scenario analysis can be used when data are not sufficient or not available. It can also be used to assess other risks together like market risk, credit risk, where the information is sparse or non-existence in the tail. Big Ben Bank is considering the expansion of the Investment Banking and Asset Management businesses over next year, and expansion of the Commercial banking over next 3-5 years, it would be important for the Bank to understand how their risk landscape changes as the result of the strategic plan. Stress testing and scenario analysis is a flexible tool that is not over-reliant on historical data, but provide insights into what could possibly happen in the future for Big Ben Bank.

- (ii) It's recommended to use stress testing and scenario analysis for two reasons:
- This approach is relatively easier compared to the other two approaches. No additional resources are needed to gather external or industry data. It is also less complicated to model and calibrate.
 - The stress and scenarios can be adjusted quickly according to external environment and tailored towards company's strategic plan.

- (b) Big Ben is considering acquiring an online life insurance company.

Taylor, an actuarial student, suggests that Big Ben implement the following in its new Liquidity Assessment Program if Big Ben undertakes the acquisition:

1. Reflect the correlation between financial markets and insurance risks
2. Measure liquidity risk using liquidity ratio and excess/deficit of liquidity
3. Assess liquidity using 10 unique stress scenarios

- (i) Describe the key drivers of liquidity risk for Big Ben.
- (ii) Compare the liquidity risk profile between a life insurance company and Big Ben.
- (iii) Critique Taylor's suggestion.

Commentary on Question:

Most candidates performed well on this part. To receive full credit for subpart (i) it was expected that Big Ben's specific drivers according to information in the case study were addressed, however some were too general and only received partial credit.

1. Continued

- (i) Big Ben's on-demand cash is not enough to cover the on demand deposit due to banks, retails customers and corporate customers. And it's usually very difficult to raise new funds (such as new debt or new equity) when it's needed the most. Both Big Ben and its creditors might evaluate the likelihood of cash requests from debt or equities when the liquidity issue is industry wide. This will transform a small problem into a crisis.

Asset management is the main service Big Ben Bank provides, and Big Ben Bank is a world leader in the ETF market. Financial tech innovation, with an increasing share of electronic trading and use of ETFs is concern with respect to increased liquidity risk. This manifests through greater uncertainty, especially in times of heightened volatility when market makers have been observed to withdraw, just when liquidity is needed the most.

- (ii) At a high level, insurance policyholders have little incentive to surrender their policies during market turmoil and, as insurance liabilities are better matched with assets, the risk of forced asset sales is largely reduced. However, for Big Ben, liquidity might be a significant issue during market turmoil. "Bank Run" may occur, and its creditors might default on their debts. The risk of forced asset sales might increase significantly during market turmoil.

Insurance companies are much less interconnected than banks and by pooling a large number of risks and by retaining the bulk of the risks underwritten on their balance sheet, potential liquidity issues are likely to be idiosyncratic without industry wide impact. For Big Ben, the liquidity issue can be industry wide. In market turmoil, the market value of assets would decrease significantly, the bank might have limited access to external fund.

- (iii) Correlations: Since Big Ben is considering investing in an insurance company, it would be useful to consider the correlation between financial markets and insurance risks in the liquidity risk management framework.

Metrics to measure liquidity risk: Using multiple metrics consistently over time might provide more information on liquidity risk and can thus be beneficial. The use of a liquidity ratio (liquidity resources divided by liquidity needs, or vice versa) is the most common metric, followed by excess/deficit of liquidity (available liquidity minus liquidity needs).

1. Continued

Stress scenario and assumptions: Using scenarios can assess liquidity risk under normal and stress environments, considering multiple stress events together with additional stress assumptions for example: distressed financial markets; restrictions on internal flows of funds; credit rating downgrade. This is a good suggestion, but ten scenarios may be too many for Big Ben to evaluate.

- (c) Big Ben is evaluating its approach to managing its cyber risk given its strategy of creating a one-stop shop interface for its globally mobile clientele and its possibility of acquiring an online insurance company. Big Ben notes that cyber risk is gaining more attention given its increasing incidence rate and impact.

Big Ben's current cyber risk management framework includes:

- Hiring people with cyber risk expertise and providing training to employees
- Setting cyber risk limit using key risk indicators
- Real-time monitoring of internal, communication system, and social media data.

Taylor made the following suggestions:

- Big Ben should leverage its current infrastructure and available technologies. No new technology investment to address cyber risk should be made
- Big Ben should develop a contingency plan to cover additional financial losses that might occur
- No cyber risk insurance is necessary.

Evaluate Taylor's suggestions.

Commentary on Question:

Candidates typically received only partial credit for this part of the question as either not enough detail for each response was given, or the answer did not address Big Ben's potential acquisition of an online insurance company.

I disagree with Taylor's first suggestion. Big Ben should consider additional investment in new technologies, which can help identify the sources of cyber risk, prevent cyber attacks and maintain robustness of the internet system. New forms of cyber risk emerge every day, and technologies used to combat cyber risk evolves quickly. By investing in an insurance company, Big Ben may face new forms of cyber-attacks it has never experienced before.

1. Continued

Although experts would be hired and more training would be provided to its employees, if the infrastructure is not robust enough, the other measurements and controls would be less effective. Although new technologies may be expensive to use now, it is important to understand their functions and applications so that they can be adopted when it is economical and necessary to do so.

Taylor's second suggestion is good but can be improved. A contingency plan is critical to managing losses caused by cyber risk events. For Big Ben, having the contingency plan to cover financial losses might not be enough. It also needs to consider the potential damage to the bank's reputation. Investing in an insurance company would also expose the bank to additional scrutiny from the insurance industry. Personal data leaks from the insurance side might result in tightened regulatory requirements for the Bank. These should also be considered in the contingency plan. An action plan can help the company quickly respond to a cyber risk event such as a data breach and a system failure. It can help minimize business disruption and avoid being a headline on cyber security, or at least demonstrate the company's determination and capability to manage cyber risk.

For Taylor's third suggestion, cyber insurance is an option for Big Ben Bank to consider depending on its overall exposure. It can be used to transfer severe impact of cyber risk events to a counterparty. Cyber insurance adds an extra layer of protection to cover unexpected losses. However, having the cyber insurance might expose Big Ben to additional counterparty risk. Proactive cyber risk management is needed because cyber insurance does not cover all losses, and good cyber risk management can reduce the exposure to cyber risk and therefore get lower cyber insurance premiums.

- (d) Big Ben has hired Caerus to evaluate whether it should acquire an online life insurance company.
 - (i) Explain how the liquidity risk, operational risk, and cyber risk profiles might be impacted if Big Ben acquires an online insurance company.
 - (ii) Recommend whether Big Ben should consider acquiring an online life insurance company based on your response to part (i). Justify your response.

Commentary on Question:

Most candidates were able to explain how these risks would change.

Recommendations to acquire the company with some justification received partial credit.

1. Continued

- (i) Liquidity risk: After acquisition, due to the inverse product cycle of insurance business, the current liquidity situation might change. Big Ben might have adequate liquidity in the short term. However, life insurance liabilities are long-term in nature, the duration of assets in market might not be long enough to match the liability duration. Therefore, Big Ben might not have enough liquidity to cover long term liabilities.

Operational risk: According to Caerus, the current methodology is inadequate. Acquisition of the insurance company will increase Big Ben's exposure to operational risk. Big Ben will need to hire additional staff, provide trainings, and system testing and maintaining, which will increase operational risks. The additional operational risks need to be assessed and quantified using an updated approach before making the decision.

Cyber risk: Cyber risk will increase after acquisition. The volume of personal information collected from life insurance sector would significantly increase, which increases the exposure of cyber risk as Big Ben would face new forms of cyber attacks it's never exposed to before. The current cyber risk management needs to be improved before adding additional risk to it.

- (ii) I recommend not to acquire the insurance company. It's exposure to liquidity, operational, and cyber risk will all increase post acquisition.

Big Ben might not be able to acquire the insurance company as it has liquidity issues in the next a few years. In addition, Big Ben has plans to expand its Investment Banking and Asset Management business next year, and expand its Commercial Banking in 3-5 years. The excess capital might not be enough to fund both the acquisition, and the expansions of its current business, while maintaining the internal capital adequacy ratio of 140%.

Big Ben Bank should also consider the impact on the economic capital by acquiring the insurance company. Insurance risk will be added to the EC framework, and the diversification benefit should also be reconsidered.

2. Learning Objectives:

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

Learning Outcomes:

- (3f) Demonstrate an understanding of model and parameter risk
- (3g) Evaluate and select appropriate models to handle diverse risks, including models that use a stochastic approach

Sources:

Economic Scenario Generators: A Practical Guide, p. 7-17 (pp. 97-112 background only)

Parameter Uncertainty, CAS, CIA and SOA, 2017

Commentary on Question:

This question tests candidates' understanding of business use cases of Economic Scenario Generator and the ability to apply it to a small regional insurance company.

Solution:

- (a) PIC considers implementing an Economic Scenario Generator (ESG) to enhance its risk management capabilities. Your colleague Hunter commented, "since the purpose of using ESG is to manage risk, it is more appropriate to develop real-world scenarios".
 - (i) Describe three business uses demonstrating that an ESG could add value to PIC.
 - (ii) Critique Hunter's comment.

Commentary on Question:

To receive maximum credit, candidates needed to demonstrate understanding of how ESG could add value to a company, the differences between real-world and risk-neutral scenarios, and application of general knowledge to a specific company. Most candidates did well in subpart (i). Some candidates received partial credit as they did not comment on the use of ESG in managing its recently added variable annuity products in subpart (ii).

- (i) ESG could add value to PIC in the following business use cases:
 - Price variable annuity products with embedded options
 - Support Strategic Asset Allocation by evaluating financial risks and rewards under uncertain economic and capital market conditions
 - Support internal stress testing and regulatory cash flow testing

2. Continued

- (ii) Hunter's comment is partially correct.
- Hurter is correct that real-world scenario is more important for risk management purpose as real-world scenarios are concerned with forward-looking potential paths of economic variable and their impacts. These scenarios allow explorations of what-if analyses as it demonstrates the likelihood of future events and their business impact.
 - However, the recently issued variable annuities have dynamic policyholder behaviors and the exposures to many alternative investment products, which generates path-dependent cash flows that do not have closed formula to compute. In this case, risk-neutral scenario should also be used to price these cash flows.
 - A recommended approach could be use real-world scenario to assess overall risk and to measure the effectiveness of a hedging strategy, and risk-neutral scenarios projected forward from each current node of the simulation to price cash flows.

- (b) An Excel-based ESG model developed and used by the Investment Office (IO) may be leveraged for risk management purpose.

The primary use of the IO's ESG is to generate interest rate paths for PIC's fixed income assets, which constitute 93% of PIC's investment portfolio. This real-world scenario generator derives the term structure of interest rates using a Vasicek model with parameters calibrated to historical treasury rates from 1980 to 2019 using a regression approach.

You note the following modeling choices made as part of the parameterization process:

- Outliers are eliminated to generate a steady-state level
 - The underlying dynamics of interest rates are described using a long-term mean and standard deviation
 - The recovery path from initial condition to a steady-state level is calibrated to be consistent with historical experience. Due to long run-time, recalibration of parameters and assumptions is performed annually.
- (i) Assess the limitations of this ESG model for PIC based on the features of a comprehensive ESG.
- (ii) Describe two sources of parameter risk in the current interest rate parameterization process.
- (iii) Evaluate the appropriateness of this model for each of the three business uses you identified in part (a)(i).

2. Continued

Commentary on Question:

This part of the question tests whether candidates could identify the weaknesses of an ESG based on descriptions of its design.

Most candidates were able to identify at least three limitations and receive full credit for subpart (i) based on information provided in the question stem. Some candidates did not receive full credit as they either listed generic limitations that are not applicable to the ESG described in the question stem or have inaccurate statements (e.g., Vasicek model should not be used in ESG).

Candidates did not do well in subpart (ii) as most candidates failed to identify the risk drivers in the parameterization process. Most candidates commented on the infrequent recalibration schedule, which is a proper risk but not a risk occurred during the parametrization process.

Most candidates received partial credit in subpart (iii) as conclusions were provided with minimal support. Full credit required an actual evaluation.

- (i) This ESG model has the following limitations:
 - It has limited capability of producing extreme but plausible scenarios as indicated by its parameterization approach, e.g., limited tail events during selected time period
 - This ESG model only simulates possible future paths of limited economic variables, i.e., interest rate and corporate bond (yield)
 - This Excel based ESG model has long run-time which indicates some computationally inefficient

- (ii) Parameter risk is the uncertainty as to whether the parameters are appropriate for the phenomenon that we are attempting to model. This uncertainty could be driven by the selected empirical treasury dataset is too short to reflect various characteristics of interest rate term structure, such as the high inflation period in the 1970s

The regression parameterization approach is not effective because the historical data for many economic variables violates one of the prime assumptions of these techniques: independent observations.

2. Continued

- (iii) **Price variable annuity products which have embedded options:** This ESG could not support this business use since it is a real-world scenario generator that contains a significant amount of expert judgement to determine the veracity of the scenarios that result from the parameterization process. Pricing embedded options requires to reproduce the prices of traded derivative instruments in order to determine comparable prices for derivative instruments and insurance contracts with embedded options that are not traded but that require market valuation

Support Strategic Asset Allocation by evaluating financial risks and rewards under uncertain economic and capital market conditions: This real-world ESG fits this intended use as it reflects company's view on future economic conditions and the parameterization process reflects consideration of the entire distribution of outcomes such as selecting a consensus type of steady level (i.e., outliers are treated); using mean/standard deviation as stylized facts.

Support internal stress testing and regulatory cash flow testing: This ESG model is not able to support this business use case. Even though it is a real-world scenario that reflects expert opinion on future economic performance; it has limited capability to generate extreme while plausible scenarios for stress testing purpose. For example, the model is not able to reflect impacts of tail events by treating outliers, using mean/standard deviation as key parameterization targets.

3. Learning Objectives:

1. The candidate will understand the ERM framework and process and be able to apply them to organizations.
3. 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 how the risks faced by an entity can be quantified and the use of metrics to measure risk.

Learning Outcomes:

- (1d) Assess the overall risk exposure arising from an organization's current and emerging risks
- (3a) Demonstrate how each of the financial and non-financial risks faced by an organization can be amenable to quantitative analysis
- (3b) Demonstrate organization-wide risk aggregation techniques that illustrate the concept of risk diversification by incorporating the use of correlation
- (3c) Evaluate and select appropriate copulas as part of the process of modelling multivariate risks
- (3d) Demonstrate the use of scenario analysis and stress testing in the measurement of current and emerging risks
- (3g) Evaluate and select appropriate models to handle diverse risks, including models that use a stochastic approach
- (4c) Analyze risks that are not easily quantifiable, such as liquidity, operational, and environmental risks

Sources:

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

Covid-19: implications for insurer risk management and the insurability of pandemic risk

Value-at-Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion
Ch. 18 Credit Risk Management

ERM-101-12: Measurement and Modeling of Dependencies in Economic Capital

ERM-119-14: Aggregation of risks and Allocation of Capital

Financial Enterprise Risk Management, Sweeting, 2017, Ch. 14 Quantifying Particular Risks

3. Continued

Commentary on Question:

The question tested the candidate's ability to understand, apply, and evaluate an economic capital framework, as well as assessing and applying aggregation techniques and stress testing. Credit was commonly lost by candidates that did not use all of the provided information in the question, such as not referencing or considering the product features of LifeCo or not critiquing or commenting on all recommendations in the question.

Solution:

- (a)
- (i) Evaluate LifeCo's approach to modeling EC for the three identified key risks.
 - (ii) Calculate credit risk EC and interest rate risk EC. Show all work.
 - (iii) Explain how you would incorporate lapse risk and reinvestment risk into LifeCo's EC framework.

Commentary on Question:

There was a wide range of performance by candidates on part (a).

Many candidates lost credit on subpart (i) as they did not relate the responses to LifeCo's product features and rather provided generic answers.

A common mistake in subpart (ii) was confusing forward rates with spot rates for the interest rate calculations. In addition, it was determined that there were multiple reasonable ways to estimate the discount rate and credit (up to full credit) was awarded for such approaches. Approaches that produced nonsensical results were not awarded credit. Finally, some candidates calculated the Credit Risk EC as the expected loss, forgetting to add 20%.

If the final answer in subpart (ii) was incorrect, partial credit was given for the variables that were calculated correctly, as well as for the correct formulas used.

In subpart (iii), many candidates discussed the considerations to setting lapse or reinvestment assumptions rather than recommending how an EC calculation would be designed/modeled.

3. Continued

(i) Credit:

- The historical data being used is out of date, and is missing the 2008 financial crisis which could materially impact the historic default rates.
- The model does not assume any changes in credit rating over the 3 years, which is not realistic.
- The 120% factor seems arbitrary. It would be more appropriate to set the EC using a specified risk metric (VaR, CTE) applied to a probability distribution with parameters that are market consistent.

Interest:

- The products have liability cashflows that vary with interest rates that also have guarantees which do not pass-through the downside risk to the policyholders. The interest rate risk should use a stochastic approach that also reflects the changes in liability cash flows as the interest rate changes.
- Rather than applying a deterministic spread between the base interest rates and the shocked interest rates, it is more appropriate to set the interest EC based on the VaR or CTE of many stochastic scenarios.
- The Ho-Lee model is more appropriate for modelling short rates but is not ideal for modelling full yield curves (30 years are used in the EC model).

Mortality:

- The RBC framework is a rules-based approach that may be reasonable but does not capture the specifics of LifeCo's mortality risk.
- Given LifeCo's Par block is closed with a high average attained age, it is likely that RBC does not accurately reflect LifeCo's risk, specifically the potential catastrophe risk.

(ii) Refer to Excel for calculation solutions.

(iii) Lapse – Deterministic

- LifeCo should test UL and Par separately to determine if they are lapse supported or lapse sensitive, and then apply EC shocks accordingly.
- LifeCo should determine shocks to lapse rates to represent a targeted risk metric. The shock should consider both internal and industry data.
- LifeCo should include a time zero mass-lapse shock.

3. Continued

Lapse – Stochastic

- LifeCo should determine the relationship between policyholder behavior (partial withdrawals and full lapse) and interest rates.
- Simulate withdrawals under a set of real-world economic scenarios and select the appropriate risk measure (VAR/CTE)

Reinvestment

- Generate real-world scenarios for reinvestment rates for fixed income assets backing the general fund
- Calculate liabilities under credited and discount rates derived from each scenario
- Select an appropriate risk metric (VAR/CTE) for required EC using liabilities obtained in the previous step

- (b) The following correlation matrix has been provided and is based on publicly available historical market data.

Correlation Matrix			
	Credit	Mortality	Interest Rate
Credit	1.00	0.03	0.30
Mortality	0.03	1.00	0.01
Interest Rate	0.30	0.01	1.00

- (i) Calculate LifeCo's aggregate EC using the given correlation matrix. Show all work.
- (ii) Compare and contrast the following aggregation methods as they pertain to LifeCo:
- Correlation
 - Copula.
- (iii) Describe the considerations for using copulas to aggregate risks in an EC framework.

Commentary on Question:

Candidates generally performed well on this part. A common mistake candidates made was further explaining what a copula is in subpart (iii) rather than describing specific considerations associated with using copulas.

3. Continued

(i) Refer to Excel for calculation solutions.

(ii) Correlation

- This approach is simple to apply and easy to understand. It is fairly easy to calibrate the correlations using company experience.
- This approach assumes that relationships between risks are linear throughout the distribution, which is generally not true in tail events. It is likely that the correlations between mortality and economic risks are higher in tail events.
- This approach assumes the distribution of each risk is normal, which is inappropriate for LifeCo, given there are guarantees on both products resulting in skewed loss distributions.

Copulas

- Copulas are better than the correlation approach at modelling tail dependencies. They do not require that each risk is assumed to follow a normal distribution, and can have changing relationships in the tail events, which is more accurate for modeling EC.
- Copulas are much more challenging to implement, operate and calibrate.

(iii)

- Identifying the appropriate marginal risk distribution for each risk.
- Selecting the appropriate copulas to aggregate the marginal risks.
- Consideration of the data availability and reliability to calibrate the parameters of the distributions and copula.
- Does LifeCo have the expertise and computational capacity to maintain and calculate EC using a copula?

(c) Management suggests using the following scenario and the correlation matrix provided in part (b):

Risk	Outcome
Credit	10% decrease in recovery rates (e.g. from 70% to 60%)
Mortality	5% increase in liability claim payments for all durations
Interest rate	10 bps decrease in base discount rates for all years

3. Continued

- (i) Recalculate the total required EC under the pandemic scenario. Show all work.
- (ii) Critique LifeCo's management's suggestion.

Commentary on Question:

Candidates generally performed well on this part. Credit was lost in subpart (ii) for not critiquing each recommended change to the EC framework, not understanding how the EC calculations are impacted by the recommended changes, or not understanding what reasonably expected impacts of COVID-19 are.

Like question b(ii), if the final answer in subpart (i) was incorrect, partial credit was given for the variables that were calculated correctly, as well as for the correct formulas used.

(i) Refer to Excel for calculation solutions.

(ii) Interest

- A shock to base discount rates has a minimal impact on EC because the spread between the base and shocked is not changed from 50bps. It would be more appropriate to increase the spread between base and shocked.
- The decrease in interest rates is not expected to be permanent, it would be more appropriate to shock discount rates in the short term with long term rates reverting back to expected.

Credit

- Although recovery rates may decrease, it is likely that default rates will also increase.

Mortality

- A permanent increase in mortality rates is likely excessive. It would be more appropriate to shock mortality rates in the short-term only.
- Due to the effects of COVID-19, it would be more appropriate to apply different mortality shocks for different age bands.

Correlation

- The correlations with mortality of 0.03 (credit) and 0.01 (interest) will understate the impact, given that COVID-19 resulted in a scenario where mortality was impacted as well as the economic environment. Significantly higher correlations would be more appropriate.

4. Learning Objectives:

1. The candidate will understand the ERM framework and process and be able to apply them to organizations.
3. 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 how the risks faced by an entity can be quantified and the use of metrics to measure risk.
5. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

Learning Outcomes:

- (1a) Recommend an appropriate framework for an organization's enterprise risk management and an acceptable governance structure
- (1c) Demonstrate how to articulate an organization's risk appetite, desired risk profile, quantified risk tolerances, risk philosophy and risk objectives
- (3a) Demonstrate how each of the financial and non-financial risks faced by an organization can be amenable to quantitative analysis
- (4a) Determine risk exposures using common risk measures (e.g., VaR and TVaR) and compare the properties and limitations of such measures
- (5c) Demonstrate the use of controls for retained and residual risks
- (5f) Demonstrate the use of tools and techniques for identifying and managing credit and counterparty risk

Sources:

Risk Appetite: Linkage with Strategic Planning Report

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

Value-at- Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion
Ch. 18 Credit Risk Management

Exploring the Black Box: Working with inherent and residual risk.

Commentary on Question:

Overall, most candidates did well on this question. Parts (a) and (b)(iv) of the question are where candidates struggled the most. Most candidates did very well on the Excel calculation portion of the question as well as part (c).

4. Continued

Solution:

(a)

- (i) Describe two primary benefits of having a well-defined risk appetite framework for key organizational risks.
- (ii) Explain how risk appetite can be reflected in each of the following:
 - Asset Allocation
 - New Business Budgeting
 - Performance Measurement.

Commentary on Question:

Most candidates didn't understand what was being asked in subpart (i) and instead described what a risk appetite framework was rather than what the benefits were. Most candidates got at least partial credit on subpart (ii), struggling primarily with the "Performance Measurement" part of the question.

- (i)
 1. Protecting and creating value for the business. Risk appetite describes risk with quantitative measures and facilitates the analysis of the risk/return trade-off. This helps senior management make informed decisions to maximize the risk-adjusted return for the shareholder.
 2. Ensuring the consistency between risk appetite and risk limits. Both rating agencies and investors are concerned about whether risk appetite is properly aligned with the risk limits being set for business operations.
- (ii) Asset Allocation: Strategic asset allocation (SAA) is used to determine a long-term policy portfolio reflecting the desired systematic risk exposure. Asset allocation objectives should incorporate key aspects of a company's risk appetite framework to guide decision-making and to monitor outcomes.

New Business Budgeting: Insurance companies normally prepare new business budgets of certain return or value measures each year while clients, shareholders, employees, and regulators are interested in understanding the amount of risk the company will take in the future. These return/value measures do not fully and accurately consider the level of risk being taken; therefore, other measures need to be used to explain the impact of the new business on the future risk profile.

4. Continued

Performance Measurement: Including appropriate key performance indicators (KPIs) regarding risk appetite in managers' performance scorecards would encourage employees to think in terms of both return and risk when making business decisions, which promotes alignment between the objectives of key stakeholders and the enterprise risk tolerance (i.e. RAROC, risk-adjusted value).

- (b) The details of the entire three-asset portfolio you have been asked to evaluate are given below. The CRO wants to evaluate risk metrics for monitoring the block and suggests that a 95% VaR may be an appropriate threshold.

A	4%	\$20	6%	40%
B	6%	\$50	3%	60%
C	8%	\$30	10%	10%

- (i) Calculate, net of recovery, the expected loss and the variance over a one-year time horizon. Show all work.
- (ii) Calculate the 95% VaR using the results from (i) assuming that portfolio losses are normally distributed. Show all work.
- (iii) Determine the empirical 95% VaR based on the distribution of potential portfolio losses calculated in (i). Justify your response.
- (iv) Describe one key shortcoming for each metric calculated in (ii) and (iii) that should be considered when selecting an appropriate risk measure for QPT's risk appetite statement.

Commentary on Question:

Candidates performed well on subparts (i)-(iii). If the final answer in subparts (i)-(ii) was incorrect, partial credit was given for the variables that were calculated correctly, as well as for the correct formulas used. For subpart (iii) full credit was awarded for a value between 20-27 with justification. Most candidates struggled with subpart (iv) and provided general answers, such as issues of coherency.

- (i) Model Solution is in Excel file attached
- (ii) Model Solution is in Excel file attached

4. Continued

(iii) Empirical VaR95 based on distribution is 27 since there is at least a 95% probability that cumulative losses will fall below this value.

(iv) VaR 95 as calculated in b(ii):

- Actual distribution of potential net losses is deterministic and right skewed, thus the assumption of normality is violated.

VaR 95 as calculated in b(iii):

- 95th percentile may not be well defined (as seen in example), QPT would need to decide on whether a range is appropriate or rationalize their choice for a single value.

(c) QPT's CRO is planning a discussion with the internal audit department regarding risk assessment on credit risk in an inherent risk control matrix.

(i) Identify and describe three *key* questions that should be considered during the risk assessment phase.

(ii) Recommend the most effective action to mitigate the credit risk for the portfolio in part (b). Justify your response.

Commentary on Question:

Candidates performed very well on both subparts (i) and (ii). Alternate answers were awarded full credit based on their merit.

(i) 1. How vulnerable are you now to a certain risk? Considering the risk would occur, how vulnerable are you to this risk? In an extreme situation, you are entirely exposed to a risk.

2. How exposed are you? How often do risk events happen? The answer can be highly exposed on the one end and not or barely exposed on the other.

3. If the risk occurs and mitigation fails, what will be the impact? What happens when disaster strikes? What happens when all defenses are breached? What if all controls or systems fail? What will be the worst possible outcome? The answer can be catastrophic or may be immaterial.

(ii) Increase the number of issuers of the bonds holding. This would allow us to diversify the credit risk that are company specific. We could also select issuers among different sectors, and bonds of different credit ratings and duration.

5. Learning Objectives:

1. The candidate will understand the ERM framework and process and be able to apply them to organizations.
2. The candidate will understand the types of risks faced by an entity and be able to identify and analyze these risks.

Learning Outcomes:

- (1a) Recommend an appropriate framework for an organization's enterprise risk management and an acceptable governance structure
- (1e) Propose ERM solutions or strategies that effectively manage risk under different real (case study) and hypothetical situations facing financial and non-financial organizations
- (2a) Describe different definitions and concepts of risk
- (2c) Identify and analyze specific risks faced by an organization, including but not limited to: financial, environmental, operational, legal, reputational and strategic risks

Sources:

ERM-131-18: Leveraging COSO Across The Three Lines Of Defenses

Financial Enterprise Risk Management, Sweeting, 2017, Ch. 8 Risk Identification

Embedding Cyber Risk in Risk Management: An Insurer's Perspective (pp. 12-15 of Cybersecurity: Impact on Insurance Business and Operations)

ERM-133-19: Emerging Risks and Enterprise Risk Management

IAA Paper: Importance of Climate-Related Risks for Actuaries

ERM-107-12: Strategic Risk Management Practice, Anderson and Schroder, 2010 Ch. 7 Strategic Risk Analysis

Commentary on Question:

The goal of this question was to test candidates' understanding of the role of ERM for a non-financial institution and extending to key risks such as cyber risk and climate change.

5. Continued

Solution:

(a) For Section I - The Three Lines of Defense:

- (i) Summarize the function of the 2nd line of defense.
- (ii) The CFO of Energetix has proposed that the new ERM team should report to the Manager, Engineering.

Assess this proposal.

Commentary on Question:

This part was generally answered well. There were many possible answers that candidates could answer to receive full credit.

- (i) The 2nd line of defense reports to senior management, and includes but is not limited to risk management, compliance and other oversight functions. It provides expertise to 1st line management, providing assurance on risk control and limit setting. In addition, it also prepares risk reporting and disclosure to senior management to help better identify overall risk exposure and company risk profiles. There is a segregation of duties with first line of defense which owns the risk.
- (ii) This proposal is not appropriate, as the Manager, Engineering is in the first line of defense and should not supervise the 2nd line ERM function, because it would compromise the objectivity. Also, this structure would likely limit the scope to operational risks, whereas ERM should also assess all other risks, including financial and strategic.

It would be better for the ERM team to report to a Chief Risk Officer (senior management). The CRO will be the one to share and help the Board understand the risk profile during their meetings. Based on the case study, it seems that Energetix does not currently have a CRO; they should hire one.

(b) For Section II - Risk Identification:

Propose four risk identification tools and/or techniques for Energetix and explain how Energetix could use them.

5. Continued

Commentary on Question:

Most candidates were able to adequately explain four identification tools or techniques, but few explained how the tools were suitable for Energetix which was a key part of the question. The answers shown below are a subset of those that would have received credit. Roughly half the credit for each tool or technique was given for explaining the tool, and half for connecting it to Energetix.

Risk prompt lists - Use a Risk Prompt List such as PESTEL as a tool to identify macro-level environmental factors surrounding Energetix. For example, identifying the trends in the environment, then zoom in to industry specific and company specific factors. Focus on what other companies are doing in the industry, any trends in customer demands, regulatory changes, etc.

Case study - is a tool that looks at other cases in the industry of risks and helps Energetix to compare their risks to others. The tool would be used to identify key risks in the industry and how Energetix stands out or aligns with the industry. This could help them to specify their risk appetite and strategic initiatives. Learnings could feed both surveys and interviews.

Surveys are techniques to gather information from a range of sources and gather feedback into a repository, especially useful for a large company. The challenge with surveys is how Energetix frames the question, but it should still capture all potential risks if they survey all areas of the company. They can use the survey to propose key risks for Energetix to focus on, in order to prioritize risk management efforts.

Interviews - Energetix could perform interviews with different heads of the three main operating business segments to determine the risks that they face in each department. Senior leaders would be able to give detailed information and be able to answer questions right away (advantage compared to surveys).

- (c) For Section III - Emerging Risks:
- (i) Explain how Energetix is exposed to cyber risk.
 - (ii) Identify four risk management strategies for cyber risk for Energetix.
 - (iii) Identify two emerging risks, other than cyber risk, faced by Energetix. Justify why they are emerging risks.
 - (iv) Propose a methodology for monitoring early warning signals for each of the two risks identified in part (iii).

5. Continued

Commentary on Question:

Subparts (i) and (ii) were answered consistently well. The quality of the responses on subpart (iii) responses was uneven, with many candidates failing to properly justify their responses. Simple identification of a risk received no credit; the candidate had to explain the risk for partial credit and discuss why it was emerging for full credit. Subpart (iv) was not answered well, with very few candidates providing suggested metrics or indicating how the information could be of use.

- (i) Energetix is exposed to cyber risk through the possibility of cybersecurity attacks. These attacks could not only disrupt operations at the company but steal consumer data. Energetix likely has important data on wholesale and retail consumers and the release of such data, as well as potential service disruptions, would create legal and reputational issues for Energetix.
- (ii) IT controls – keep technology current
Training – provide ongoing cyber risk training to employees
Outsource to a cyber specialist
Cyber insurance – transfer severe impact to a counterparty
- (iii) Climate risk – this is an extremely pertinent risk as climate change is increasing the frequency of natural disasters, which could impact Energetix operations and create extreme losses. Although climate risk is present today, it is also an emerging risk because it is difficult to predict the evolution of this risk and its potential impact in terms of frequency and severity.

Technology risk – New technology may be developed which changes the business model for Energetix’s operations. This is emerging because it is unknown what technology may develop, how quickly it may become dominant, and how/when it will impact either Energetix or the energy usage of its customers.

- (iv) Monitoring for climate risk - read publications, monitor trend of weather-related damages in relevant jurisdictions; establish a key risk indicator with thresholds for action such as strengthening distribution networks

Monitoring for technology risk - assign resources to read publications, attend conferences to remain aware of emerging technologies and new applications; incorporate knowledge of technological evolution into strategic planning

5. Continued

(d) For Section IV - Strategic Risk:

- (i) The CFO has noted that climate-related damage to facilities and distribution channels may lead to service disruptions.

Provide three additional examples of how climate risk may impact the strategic planning for Energetix.

- (ii) Assess which of the three categories of climate risk (physical, transition or legal and reputation) is the most impactful on Energetix.

Commentary on Question:

For subpart (i), many candidates failed to receive credit because they pointed to physical risk which was already in the question stem. Any other climate-related risk was given credit as long as it was explained clearly. The biggest shortfall in responses was a lack of connection between the risks listed and strategic planning, such as increased costs, decrease or increase in customer demand (revenue reduction or potential supply issues respectively). Without that connection, no more than half the credit was awarded. For subpart (ii), which called for an opinion, any response earned full credit as long as reasonable justification was provided and the other two categories were also discussed to explain why they were not the primary choice.

- (i) Reputation: since Energetix provides gas utilities, it will be the subject of public discussion with respect to its impact on climate change. Groups and individuals will target the company if a move towards other power sources is not moving quickly enough, affecting its reputation. This will lead to reduced business and lack of ability to reach goals if reputation is significantly affected.

Legal: if Energetix does not do its part following government regulation (50% of all electricity in the state must be generated from renewable resources in the next 20 years), it will be subject to fines and legal costs as a result. This would affect Energetix's revenue and ability to continue to advance its business.

Transition risk: transition risk is related to the work and risk involved in moving towards more green energy. Energetix depends heavily on gas utilities for revenue. Converting to green energy will require significant costs and the development of new technologies to be able to capture these different energy sources. This makes it difficult for Energetix to work towards its other strategic goals.

5. Continued

- (ii) Physical risk is certainly the most immediate risk which can impact Energetix. As the CFO noted, physical damages due to climate risk could halt business activities and impact all of Energetix's clients. This risk is present today; because of the immediacy of this risk and the significant cost and reputation issues which could result from it, it is the most impactful of the three categories.

Both transition and legal are important but less impactful, as they are likely to be felt later in the future as the transition to a greener economy picks-up. Moreover, legal/reputation are risks that would also follow the business disruption from physical risks or the failure to prepare for transition risks.

6. Learning Objectives:

2. The candidate will understand the types of risks faced by an entity and be able to identify and analyze these risks.
5. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

Learning Outcomes:

- (2c) Identify and analyze specific risks faced by an organization, including but not limited to: financial, environmental, operational, legal, reputational and strategic risks
- (5b) Demonstrate application of the following responses to risk, including consideration of their costs and benefits: avoidance, acceptance, reduction without transfer, and transfer to a third party
- (5f) Demonstrate the use of tools and techniques for identifying and managing credit and counterparty risk
- (5g) Analyze how ALM and other risk management principles can be used to establish investment policy and strategy, including asset allocation
- (5i) Choose appropriate techniques to measure, model and manage various financial and non-financial risks faced by an organization

Sources:

Financial Enterprise Risk Management, Sweeting, 2017 Ch. 16 Responses to Risk

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-122-14: Chapter 1 of Captives and the Management of Risk, 3rd Edition, Kate Westover

Commentary on Question:

The question tested candidates' understanding of different risks and mitigation strategies. Candidates were asked to identify risks/risk responses, compare/contrast, and describe advantages of different risk management tools.

6. Continued

Solution:

- (a) The company has taken the following risk mitigation steps:
- Moved from entering into over-the-counter swaps to using exchange-traded interest rate futures
 - Signed new YRT treaties to cede death claims of UL policies to a reinsurance company
 - Implemented a data analytics system to help detect claim fraud.
- (i) Identify the risks being addressed in each step shown above.
- (ii) Identify the category of risk response for each risk mitigation.
- (iii) Explain what risks are created by taking each mitigation step.

Commentary on Question:

In general, candidates did well in identifying different types of risks before and after the risk mitigation actions. Candidates did not do well in identifying the type of risk responses. Partial credit was awarded for subpart (iii) if candidates correctly identified some of the risks but not all them.

- (i)
- Moved from entering over-the-counter OTC swaps to using exchange traded interest rate futures
Risk being addressed - Counterparty credit risk
 - Signed new YRT treaties to cede death claims of UL policies to a reinsurance company
Risk being addressed - Mortality(insurance) risk
 - Implemented a data analytics system to help detect frauds
Risk being addressed - Operational risk
- (ii)
- Moved from entering into over-the-counter OTC swaps to using exchange traded interest rate futures
Category of risk response - Risk removal
 - Signed new YRT treaties to cede death claims of UL policies to a reinsurance company
Category of risk response - Non-capital market mortality risk transfer

6. Continued

- Implemented a data analytics system to help detect frauds

Category of risk response - Risk reduction through more robust systems/processes

(iii)

- Exchange traded interest rate futures: basis risk. Future contracts are standardized; therefore they may not provide an exact hedge.

- Reinsurance: counterparty risk. Reinsurer may fail to honor its financial obligations.

- Data analytics system: technology risk, data risk.

(b) ABC Life has a wholly owned captive for its UL business. It is considering other risk transfer options because it believes the captive is too resource intensive.

- (i) Compare and contrast traditional reinsurance, securitization and use of a captive.

- (ii) Describe the advantages of each option for ABC Life.

Commentary on Question:

Candidates did well in describing the differences among the three risk transfer options. However, many candidates had difficulty describing the advantages of each option. Partial credit was awarded on each subpart if candidates described correctly some differences between the risk transfer options and/or some advantages of the options.

(i)

- They are all risk transfer risk management tool

- Commercial reinsurance is a form of non-capital market risk transfer - paying premium to another firm in exchange for protection from a risk.

- Wholly owned captive is also a non-capital market risk transfer – company self-insures itself by creating captive and transfer risk to captive.

- Securitization is a way of turning risk exposure into investment that can be sold to investors in capital market. It's a capital market risk transfer.

6. Continued

(ii)

- Captive: improving ABC's control over the purchase of insurance; tax benefits.
- Commercial reinsurance: increasing underwriting capacity; supporting entry into/exit from insurance markets.
- Securitization: market price can be determined for risks securitized; quicker way of raising capital to cover risks than issuing equity.

7. Learning Objectives:

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

Learning Outcomes:

- (4h) Demonstrate possible risk management strategies for non-financial risks
- (4i) Choose appropriate techniques to measure, model and manage various financial and non-financial risks faced by an organization

Sources:

ERM-620-21: The Evolution of LDI and Role of a Completion Manager (INV)

ERM-621-21: Liability Driven Investment Explained (INV)

Commentary on Question:

Overall, candidates did well on the analysis parts of the question but had some challenges when it came to answering other parts of the question. It is possible that many candidates did not focus on the specific prompts in the question when responding.

Solution:

- (a) SLIC's current pension plan portfolio shows the gap between the total liability benchmark and the current assets. SLIC is considering working with a completion manager.
 - (i) Determine where SLIC may encounter structural challenges when implementing the de-risking strategy.
 - (ii) List three potential benefits of a completion portfolio.

Commentary on Question:

Most candidates received at least partial credit on this part of the question. Based on responses, many candidates did not seem to know the definition of a completion portfolio.

7. Continued

- (i) **Portfolio structure:** Many plans distribute their fixed income allocation across several managers with different benchmarks. This approach provides the potential for a diversified alpha. Still, it can make it more difficult to identify where to take action when opportunities arise while managing potential basis risk as the hedging allocation grows.

Plan governance: Pension plans may have formal approval processes for adjusting investment strategy or introducing new instruments such as derivatives. In a market environment of reduced liquidity and rapid shifts in valuation, some plans may have seen periods of higher rates or wider credit spreads come and go before they are able to evaluate and act on the potential opportunity.

- (ii) **Improved asset/liability match:** The completion portfolio is designed to reduce the risk of mismatches between existing assets and liabilities

Capital efficiency: The completion portfolio can use leverage to hedge liability risks, reducing overall funded-status volatility while preserving the return potential of existing allocation to equities and other return-seeking assets

Opportunistic de-risking: Plans can use the completion portfolio to make nimble, opportunistic adjustments to duration, credit or other risks

Endgame management: The completion portfolio can be a vehicle for managing the overall plan toward lump-sum offerings and annuitizations where applicable

- (b) Max Hawke, SLIC's CIO, stated that liability matching using government and corporate bonds is simpler and more effective than using swaps.

Critique Hawke's statement.

Commentary on Question:

Candidates did well on this part. The model solution below contains more responses than required for full credit, but additional detail was provided to demonstrate a range of appropriate responses.

7. Continued

- CIO's statement is incorrect.
 - Certain bonds can be scarce. The issuance of government bonds is subject to the needs of the government to raise capital. Therefore, the supply is unpredictable. The maturity spectrum of the corporate market is skewed such that the majority of bonds have relatively short maturities. Corporate bonds also introduce credit risk.
 - Most importantly, the pension plan needs to raise cash by moving out of growth assets. But many plans cannot afford to relinquish their growth asset holdings in favor of bonds.
 - In contrast, swaps are available over virtually any maturity of up to 50 years, making them an excellent match for long-term liabilities.
 - They are also not restricted by physical supply determined by a government's financing requirements.
 - Therefore, the swaps are better to match liabilities since they are considerably more flexible.
- (c) Explain how real rate swaps could be implemented to help SLIC achieve this objective.

Commentary on Question:

Candidates did reasonably well on this part. The majority of candidates knew that the real rate swaps could be implemented to hedge inflation. However, few candidates knew the details as how to implement, i.e. receiving a fixed and paying variable.

- Real rate swaps are available that combine the interest rate and inflation elements in one contract.
- SLIC would receive a fixed real rate of interest and pay a variable rate of interest.
- By doing so, SLIC can hedge the interest rate from the interest rate swap portion and the inflation risk from the inflation swap portion.
- However, transacting separate interest rate and inflation swaps as it is usually more cost-effective to do so, and provides for greater futures flexibility.

7. Continued

- (d) Max Hawke asks you to evaluate the use of swaps to manage risk in the Plan. To simplify the analysis, you use an estimated benefit payment of \$1,000,000 ten years from now. Interest rates are expected to be 4% per annum on average over ten years. A 10-year zero coupon bond is used for the analysis.
- (i) Calculate the swap notional if a zero coupon interest rate swap is used to hedge the interest rate risk.
- (ii) Complete the following current balance sheet for this analysis.

Assets (when a bond is used)		Liabilities	
Cash	(A)=	Plan Liability	(C)=
Bond	(B)=		

Assets (when a swap is used)		Liabilities	
Cash	(D)=	Plan Liability	(C)=
Swap	(E)=		

You decided to shock interest rates instantaneously to 5% for a sensitivity analysis.

- (iii) Complete the post-shock balance sheet for this analysis.

Assets (when a bond is used)		Liabilities	
Cash	(A')=	Plan Liability	(C')=
Bond	(B')=		

Assets (when a swap is used)		Liabilities	
Cash	(D')=	Plan Liability	(C')=
Swap	(E')=		

Commentary on Question:

Most candidates earned at least partial credit on this part. Some used continuous effective interest rate for discount as opposed to annual effective rate, but they did understand the concept.

7. Continued

- (i) The notional should be equal to the present value of the liability.
 $1,000,000/(1+0.04)^{10} = 675,564$
- (ii) $(C) = 675,564$ as calculated in (i).
Since SLIC needs to purchase the same amount of bonds $(B) = 675,564$.
There is no cash involved. Therefore, $(A) = 0$.
When a swap contract is used, there is no swap value at the initiation.
Therefore, $(E) = 0$.
The corresponding cash will remain in the cash account. Hence,
 $(D) = 675,564$.
- (iii) When interest rates rise to 5%, the present value of the liability is
 $1,000,000/(1+0.05)^{10} = 613,913$ Therefore, $(C') = 613,913$
Bond $(B') = (C') = 613,913$
Also, there was no cash involved. $\therefore (A') = 0$.
Cash account when a swap contract used remains the same. $\therefore (D') = 675,564$
A swap contract value is changed from 0 to
 $(E) = 613,913 - 675,564 = -62,651$
- (e)
- (i) Determine the amount SLIC needs to pay to the counterparty (or receive from the counterparty) at the initiation.
- (ii) Determine the amount SLIC needs to pay to the counterparty (or receive from the counterparty) in 10 years assuming the CPI is 170 at that time.

Commentary on Question:

Commentary on part (e), if appropriate. Click here to enter text.

Model Solution to part (e), a form that fully answers the question at a level that would earn full credit, uses sentences or phrases appropriate to the cognitive level of the question, is a model of good communication. Click here to enter text.

- (i) There is no cash exchange at the initiation. Therefore, the amount is 0.
- (ii) At maturity, SLIC pays $1,000,000 \times (1+0.02)^{10} = 1,218,994$, and SLIC receives
 $1,000,000 \times 170/138 = 1,231,884$.
The actual payment is netted, and SLIC receives
 $1,231,884 - 1,218,994 = 12,890$.

8. Learning Objectives:

2. The candidate will understand the types of risks faced by an entity and be able to identify and analyze these risks.
4. The candidate will understand how the risks faced by an entity can be quantified and the use of metrics to measure risk.
5. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

Learning Outcomes:

- (2c) Identify and analyze specific risks faced by an organization, including but not limited to: financial, environmental, operational, legal, reputational and strategic risks
- (4a) Determine risk exposures using common risk measures (e.g., VaR and TVaR) and compare the properties and limitations of such measures
- (4b) Analyze quantitative financial and non-financial data using appropriate statistical methods to assist in quantifying risk
- (5h) Demonstrate possible risk management strategies for non-financial risks
- (5i) Choose appropriate techniques to measure, model and manage various financial and non-financial risks faced by an organization

Sources:

Value at Risk, Jorion, Chapter 8, Multivariate Models
ERM-613-17: Managing Investment Portfolios, Maginn and Tuttle 3rd Edition, Chapter 6, Fixed-Income Portfolio Management, Sections 4-5 only

Commentary on Question:

This question tested candidates' knowledge of fixed income portfolio management techniques in a liability-aware framework.

Solution:

- (a) The CFO proposes investing in corporate bonds, rather than government bonds, to implement the cash flow matching strategy.

Critique the CFO's proposal.

Commentary on Question:

Many candidates were able to receive full credit by discussing the credit/default risk implications of using corporate bonds in a cash flow matching strategy. To receive full credit, candidates needed to make reference to credit or default risk in particular, not just "risk" in general.

8. Continued

Corporate bonds may yield higher returns compared to government bonds. However, corporate bonds are subject to default, and the cash flow matching framework in theory assumes a default-free world. The lower the rating on the corporate bonds, the higher the probability that the cash flow matching assumption will not hold.

- (b) State the three main characteristics of classical immunization.

Commentary on Question:

Candidates did well on this part. Reasonable responses not shown in the model solution below were acceptable for full credit. For example, candidates who discussed the required relationships between asset and liability duration, convexity, and deviation of cash flows received full credit.

The three main characteristics of immunization are:

- Specified investment time horizon
- Assured rate of return during the holding period to a fixed horizon date
- Insulation from the effects of interest rate changes on the portfolio value at the horizon date

- (c) Explain one advantage and one disadvantage of using cash flow matching instead of immunization.

Commentary on Question:

Candidate performance was mixed on this part. Many candidates were able to explain the practical challenges associated with cash flow matching compared to immunization. However, many candidates failed to explain that cash flow matching strategies can protect against changes in the shape of the yield curve, whereas immunization can only protect against small parallel yield curve changes.

- Advantage: protection against changes in the shape of the yield curve, rather than only parallel shifts in the yield curve
- Disadvantage: more challenging to implement from a practical perspective; bonds typically available for cash flow matching strategies will generally not exactly match liability schedules

- (d)
- (i) Calculate X% and Y% so that both Portfolio I and Portfolio II immunize the liability.
 - (ii) Calculate the VaR of returns for each of Portfolio I and Portfolio II at the 95% confidence level, using the values of X% and Y% obtained in part (i). Assume returns are normally distributed and expected returns are 0.

8. Continued

Commentary on Question:

Candidate performance was relatively strong in this part.

Many candidates were able to receive full credit in (i) by recognizing that duration-matching is necessary, and correctly solving for the portfolio weights.

In subpart (ii), most candidates demonstrated adequate understanding of the standard deviation and VaR calculations required. Candidates who solved for incorrect portfolio weights in subpart (i) could still receive full credit in subpart (ii) if all steps were carried out correctly based on the incorrect weights. Common errors included confusing variance with standard deviation, and minor mistakes in the standard portfolio deviation formula. Candidates who made minor calculation/formula errors but demonstrated clear and logical steps received significant credit.

Duration matching is a necessary condition for immunization. The duration of a zero-coupon bond is equal to its maturity. Therefore, duration matching implies:

$$8x + 10(1 - x) = 9$$

$$2y + 30(1 - y) = 9$$

$$\text{Yielding } X\% = 50\% \text{ and } Y\% = 75\%.$$

The standard deviation of Portfolio I is as follows:

$$\sigma_{Port 1} = \sqrt{x^2 * \sigma_{8yr}^2 + (1 - x)^2 * \sigma_{10yr}^2 + 2x(1 - x) * \sigma_{8yr} * \sigma_{10yr} * \rho_{8yr,10yr}}$$
$$\sigma_{Port 1} = \sqrt{(0.5)^2 * (0.02)^2 + (0.5)^2 * (0.05)^2 + 2(0.5)(0.5) * (0.02) * (0.05) * (0.98)} = 3.49\%$$

The VaR at 95% confidence level may then be calculated as:

$$VAR(95\%) = \alpha \sigma_{Port 1} = 1.645 * 3.49\% = 5.73\%$$

The standard deviation of Portfolio II is as follows:

$$\sigma_{Port 2} = \sqrt{y^2 * \sigma_{2yr}^2 + (1 - y)^2 * \sigma_{30yr}^2 + 2y(1 - y) * \sigma_{2yr} * \sigma_{30yr} * \rho_{2yr,30yr}}$$
$$\sigma_{Port 2} = \sqrt{(0.75)^2 * (0.01)^2 + (0.25)^2 * (0.08)^2 + 2(0.25)(0.75) * (0.01) * (0.08) * (0.72)} = 2.59\%$$

The VaR at 95% confidence level may then be calculated as:

$$VAR(95\%) = \alpha \sigma_{Port 2} = 1.645 * 2.59\% = 4.27\%$$

- (e) Recommend which of Portfolio I or Portfolio II is more suitable to address the CFO's concerns. Justify your response.

8. Continued

Commentary on Question:

Candidates generally performed poorly on this part. To receive full credit, candidates were required to correctly identify the bullet/barbell portfolio distinction, coherently explain the implications of a yield curve steepening, and recommend Portfolio I based on logical reasoning. Stronger candidates were able to identify the bullet/barbell distinction. However, very few candidates were able to provide a detailed explanation of the relative performance of bullet and barbell portfolios in a yield curve steepening environment. Candidates who simply recommended a portfolio without explanation received no credit.

Recommend Portfolio I:

- Portfolio I is a bullet portfolio, as the portfolio cash flows are close to the horizon date of 9 years.
- Portfolio II is a barbell portfolio, as portfolio cash flows are more dispersed around the horizon date.
- In the event of a yield curve steepening, short yields decline and long yields increase.
- In this scenario, a barbell portfolio such as Portfolio II is exposed to the lower reinvestment rates for longer.
- Furthermore, more of Portfolio II would be outstanding at the end of the investment horizon, meaning that the increase in long yields will result in a more adverse capital loss for Portfolio II.
- Therefore, Portfolio I is less adversely impacted by a yield curve steepening scenario and has lower immunization risk.