ERM-INV Model Solutions
Fall 2014

1. Learning Objectives:

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:

(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:

Understanding ORSA before Implementing It – Shapella and Stein

Commentary on Question:

In general, candidates performed well on this question, demonstrating adequate knowledge of ORSA requirements and ERM practices. Most of the candidates understood the benefits to Humber's risk management - part (b) - and many received full credit. Many candidates performed better in part (a) than in part (c).

Solution:

(a) Explain how Humber will need to adjust its current ERM practices in order to comply with the new ORSA requirements.

Commentary on Question:

The following list of three adjustments is an example of what would receive full credit for part (a). Some candidates stated the need to document but spent too much time providing details of the perfect or ideal ERM practice, rather than spending that time on explaining other adjustments that would be required. Some candidates stated that Humber would need to develop an economic capital model; however, an EC model is not an ORSA requirement, so an absolute statement to that effect did not receive credit. Candidates could receive credit for stating that Humber could look into developing an EC model.

1. Continued

(i) Humber will need to document the efficacy of its ERM functions. Humber will likely need to create a formal ERM function to look at the risks across the corporation; otherwise, it will be difficult to document sufficiently to get approval from regulators.

(ii) Humber may need to allocate additional resources to fully investigate the ORSA requirements - more regulatory reporting and more scrutiny.

(iii) Humber will need to conduct ORSA on a company-wide basis:
- Will need to aggregate risks at a company-wide level
- May require additional stress and sensitivity testing of balance sheet financials that the company doesn't now do corporate-wide

(b) Describe how complying with the ORSA requirements could benefit Humber's risk management.

Commentary on Question:
Candidates performed very well on this part and demonstrated that they understood the benefits. They received full marks if they provided two or more complete answers. The list below includes additional items for educational purposes.

- ORSA is meant to be qualitative as well as quantitative, so it is meant to foster a better Enterprise Risk Management framework. This would benefit Humber since the company may have blind spots given its current practices.
- Humber will be required to look at risks / issues important to or specific to the company.
- Humber will have increased awareness of the interrelationships between risks, especially between its two lines of business.
- Humber management will have increased understanding of the relationship between the overall risk exposure and the capital needed to support it and thus have increased capital efficiency.
- Humber management can integrate ORSA requirements into business decisions at the company level rather than just at the line of business level.

(c) Provide arguments for why Humber may not wish to purchase Horton's services.

Commentary on Question:
Below is a list of four arguments. Candidates received full marks if they provided three or more arguments with reasonable explanations. Other arguments besides those listed could receive points, if appropriate. A few candidates wasted time writing arguments in favor of the purchase, as opposed to only writing down arguments against.

1. Continued

1. ORSA will allow companies to implement according to the size and culture of their business.

- It allows a company like Humber to not necessarily have as full-blown a system as a large, internationally-active insurance company would have.
- Humber will incur additional costs and may require additional resources, but it will be in proportion to the size of their business.

2. ORSA will evolve over time and is not expected to be perfect immediately. Since Humber's risk management function will be new, on a group-wide basis, it will be able to evolve along with the evolution of ORSA requirements.

3. Companies do not necessarily need to have an EC model. Horton's package most likely includes an EC model designed for large companies, but Humber may not necessarily need to create this right away to satisfy the ORSA requirements.

4. Small companies like Humber do not need to compete with on the same basis as larger competitors.

- The cost of implementing ORSA should be commensurate with the riskiness of the business – group term products and individual term life products.
- Humber's ORSA should reflect the simplicity of its two primary lines of business.

2. 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:

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

(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.

(5c) Apply risk measures and demonstrate how to use them in capital assessment. Contrast regulatory, accounting, statutory and economic capital.

(5d) Propose techniques for allocating/appropriating the cost of risks/capital/hedge strategy to business units in order to gauge performance (risk adjusted performance measures).

Sources:

ERM-101-12: Measurement of Modeling of Dependencies in Economic Capital (Ch 3-5)

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

Commentary on Question:

The question was designed to test candidates' understanding of a company's general risk budget profile and various approaches to capital allocation. Candidates are expected to be able to explain risk concepts such as diversification, demonstrate how different capital allocation methods work, comprehend the impact of the capital allocation methods on a company's businesses, and make reasonable recommendations.

Overall, candidates struggled with this question.

Solution:

(a) Describe how diversification helps Simcoe's risk management.

2. Continued

Commentary on Question:
To properly answer this question, a candidate needs to describe how diversification applies to Simcoe and helps Simcoe's risk management practice. To simply describe what diversification means was considered a weak answer. Being able to correctly calculate the diversification benefit alone did not receive full credit. Most candidates were able to state what diversification does in general but few candidates were able to make clear the concept of diversification as applied to Simcoe's risk profile.

Diversification is used to mitigate risk and replies on different levels of correlation between risks to be most effective in the minimization of a company's overall risk exposure.

- Simcoe is in multiple lines of business that are exposed to different risks.
- Being in multiple product lines helps Simcoe find natural offsets to its risks.
- Some of Simcoe's product lines have low correlation to each other, resulting in risk diversification benefits.

(b)

(i) Explain what the Shapley Value allocation method tries to accomplish in risk allocation and the assumptions underlying the method.

(ii) Calculate all missing table values below using the Shapley Value Method:

Commentary on Question:
- In subpart b-i, the majority of candidates attempted to explain the method but gave no statement regarding assumptions.
- Explaining the use of game theory and that Shapley Value is an average of multiple methods in b-i would get full credit.
- In subpart b-ii some of the candidates did not show their work; as a result, even though the answers were correct, they could not receive full credit.
- Many candidates made errors with the first-in calculation in subpart b-ii. Candidates who did show their work were able to earn credits for the remainder of the calculation process, if done correctly.
- The Committee acknowledges that there is a minor typo in the table shown at the bottom of page 2, where the Unscaled Discrete Marginal Contribution for A should have shown as 40.9 rather than 41.0. One candidate noted this discrepancy.

2. Continued

(i) Explanation

Shapley Value uses a combination of Pro-Rata and Discrete Marginal to spread the diversification benefit. Each business benefits from the diversification of being part of a larger whole, but also shares the diversification benefit with the other businesses. (Note: Candidates can use the game theory to explain. Shapley is an average of multiple methods.)

Assumptions

- Assumes there is a coalition and everyone participating is in agreement.
- Needs a whole number of players.

(ii)

Business	1st In Contribution (Pro-Rata)	2nd In Calculations		Last In Contribution (Unscaled Discrete Marg)	2nd In Average	Average Shapley Values
A	40.4	53.84	43.7	41	48.77	43.39
B	24.26	23.77	37.66	21	30.72	25.33
C	48.5	51.76	48.04	35.1	49.9	44.5
Total	113.2	129.4	129.4	97.1	129.4	113.2

Note that the 2nd In Average column was not required to be completed to answer the question as stated in the exam. It is shown here to help explain the calculation that is done to obtain the final answer.

1st in Contribution:

1st in Business A = Diversified Total VaR * (Standalone VaR_A / Undiversified Total VaR) = 113.2 x (50 / 140) = 40.4

1st in Business B = 113.2 x (30 / 140) = 24.26

1st in Business C = 113.2 x (60 / 140) = 48.5

2. Continued

2nd in Calculations:
For Business A:

- Business AB Allocation - 1st in Business B = Total VaR Excl. Business C - Pro-Rata VaR_B = 78.1 - 24.26 = 53.84
- Business AC Allocation - 1st in Business C = Total VaR Excl. Business B - Pro-Rata VaR_C = 92.2 - 48.5 = 43.7

(Note: The 2nd in calculations can be done in a different order. For example, first take out Business A in the first column and then take out Business B in the 2nd column, so it's possible to get different totals in the two 2nd in columns. But the "2nd In Average" would still be the same.)

For Business B:

- Business BC Allocation - 1st in Business C = Total VaR Excl. Business A - Pro-Rata VaR_C = 72.3 - 48.53 = 23.77
- Business BA Allocation - 1st in Business A = Total VaR Excl. Business C - Pro-Rata VaR_A = 78.1 - 40.44 = 37.66

For Business C:

- Business CA Allocation - 1st in Business A = Total VaR Excl. Business B - Pro-Rata VaR_A = 92.2 - 40.44 = 51.76
- Business CB Allocation - 1st in Business B = Total VaR Excl. Business A - Pro-Rata VaR_B = 72.3 - 24.26 = 48.04

Shapley Value = Average (1st In Contribution, Last In Contribution, Average 2nd In Contribution).
Shapley Value for Business A = Average (40.4, 41, Average (53.84, 43.7)) = 43.39
Shapley Value for Business B = Average (24.26, 21, Average (23.77, 37.66)) = 25.33
Shapley Value for Business C = Average (48.5, 35.1, Average (51.76, 48.04)) = 44.5

(c)

(i) Summarize the results of your calculations for the two alternative capital allocation methods, I and II, for the CRO.

(ii) Explain how each line of business leader may react to the potential change in the risk budgeting approach.

2. Continued

Commentary on Question:
In subpart (i), the answer we were looking for related back to the risk budgeting process and how the alternative methods would impact that process. However, the wording just asked candidates to summarize the results – so any appropriate summary could receive credit.

In subpart (ii), however, the question did ask about reactions to the change in risk budgeting. Many candidates made an error by comparing the methods to each other rather than to the current risk budget amount.

(i) Certain lines of business may now be outside of the prior set risk budgets depending on the approach chosen:

- Pro-Rata:

LOB A: Getting allocated less capital now.
LOB B: Getting allocated approximately the same.
LOB C: Getting allocated more capital.

- Shapley Value:

LOB A: Getting allocated less capital now.
LOB B: Getting allocated approximately the same, slightly more.
LOB C: Getting allocated more capital.

(ii) The line of business leaders are concerned with the potential change in the risk budgeting approach and the impact to their businesses and current risk management processes.

- LOB B and C will most likely be accepting or indifferent to a change whereas LOB A will resist the change due to having less capital to deal with the same amount of risk as it had before. Less capital means more likelihood of exceeding its budget.
- Impacts compensation for the business lines if performance is linked to the risk management, so managers won't want to switch if their compensation has the potential to be negatively impacted.

(d) Recommend one of the three approaches to set risk budgets for Simcoe. Justify your answer.

Commentary on Question:
Candidates were expected to select Shapley or to continue with Discrete Marginal, with adequate justifications. Pro-rata is considered a sub-optimal method, but if candidates justified their decision some credit was given. Some candidates chose their methods without giving a justification or by simply stating that it's easy to calculate; these answers were considered insufficient.

2. Continued

For Shapley:

- Allows some sharing of the diversification benefit between each sub-portfolio.
  - Some lines will partially subsidize others.
- No scaling is required.

For Discrete Marginal:

- Allows some sharing of the diversification benefit between each sub-portfolio.
- Need to scale marginal contributions to get back to the total.
- Approximation for continuous marginal.

3. Learning Objectives:

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

Learning Outcomes:

(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.

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

(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.

(4i) Analyze the application of Asset Liability Management and Liability Driven Investment principles to Investment Policy and Asset Allocation.

Sources:

ERM-112-12: Revisiting the Role of Insurance Company ALM within a Risk Management Framework

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

Commentary on Question:

This question focused on whether candidates could apply and interpret Strategic Asset Allocation in the context of a Group Pension product line. Most candidates did not perform well on this question, indicating that they did not recall basic investment concepts such as Efficient Frontier and that they had not focused on this study material in their preparation.

Solution:

(a) Explain why the Approach 1 Efficient Frontier is above and to the left of the current portfolio.

Commentary on Question:

Many candidates stated the obvious conclusion of the graph rather than explaining the rationale.

Employing a broader set of investable asset classes in the expanded universe takes fuller advantage of the benefits of diversification to maximize portfolio efficiency as compared to the narrower asset universe of the current portfolio. New asset classes have higher potential returns as well as higher volatilities, but are not perfectly correlated with the other assets and thus can achieve higher excess portfolio return with lower volatility than the current portfolio

3. Continued

(b) Contrast the "bottom-up" approach used by the investment team in their SAA analysis to your holistic approach.

Commentary on Question:
Many candidates merely described the bottom up approach, but did not really contrast it to the holistic approach. Some candidates clearly did not know what was meant by the "holistic approach" as described in the study material and tried to answer the question based on the generic meaning of "holistic".

"Bottom up" focuses on assets backing reserves independent of surplus. Generally separate investment portfolios back reserves for each major liability type. These portfolios each have an objective of closely matching cash flows or duration of liabilities. The separate surplus portfolio is managed consistently with the goal of preserving capital.

"Holistic" considers the entire asset portfolio in aggregate, which includes assets backing liabilities plus segment surplus. This approach optimizes risk-adjusted returns within capital constraints and risk tolerance levels while simultaneously determining the most effective constraint for ALM.

(c) Construct a portfolio of zero coupon bonds that will replicate a $100 million Group Pension liability. Show your work.

Commentary on Question:
In general, candidates either answered this question very well, or not at all. The solution required more than $100 m in assets which meant that the company needed to borrow money. Many candidates mixed this up and talked about "lending" rather than "borrowing" and received less credit. Candidates could also receive full credit if they rebalanced the weights to eliminate the $15 million shortfall. A few candidates simply computed weights based on duration, which was not correct.

First compute Weights: W(i) = duration/term length or D(i) / T(i), i = 1,2,3,4,5
W(1) = D(1)/T(1) = 0.2/1 = 0.20
W(2) = D(2)/T(2) = 0.6/3 = 0.20
W(3) = D(3)/T(3) = 1.5/5 = 0.30
W(4) = D(4)/T(4) = 4.0/10 = 0.40
W(5) = D(5)/T(5) = 1.5/30 = 0.05

The sum of these weights exceeds 100%, so the balancing cash weight W(0) is derived from: 1 = W(0)+W(1)+W(2)+W(3)+W(4)+W(5)
W(0) = 1 – 1.15 = -0.15 which is a $15 m shortfall

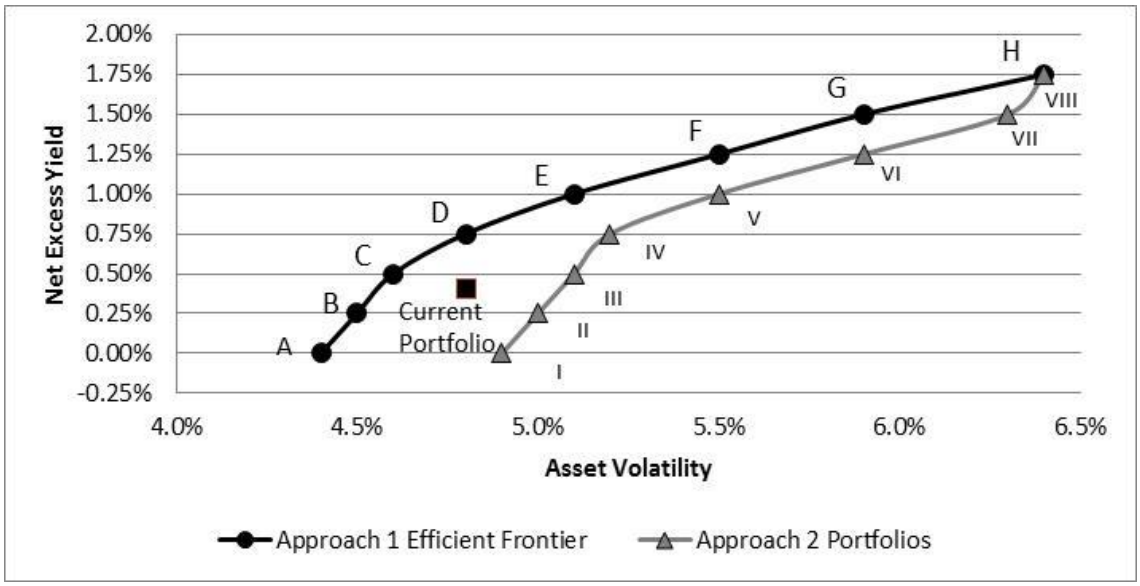
3. Continued

For $V = $100 million liability, invest $VW(i) in zero-coupon bonds maturing at 1, 3, 5, 10 and 30 years based on the weights above:
1-yr: $100(0.20) = $20 million
3-yr: $100(0.20) = $20 million
5-yr: $100(0.30) = $30 million
10-yr: $100(0.40) = $40 million
30-yr: $100(0.05) = $5 million

And finally, cash holding of $100(-0.15) = -$15 million, or short $15 million in cash, completes the liability replicating portfolio.

(d) Sketch approximately where you would expect the Approach 2 portfolios to fall on Chart 1 provided at the beginning of the question. Explain your sketch.

Commentary on Question:
In order to get credit the candidate needed to sketch Approach 2 relative to Approach 1. Many candidates lost points by sketching the graph without providing any explanation. Some candidates had Approach 2 above Approach 1, which was not correct. Some candidates did not follow the question direction (to use Chart 1) and instead changed the labeling of the x-axis to Surplus Volatility, which resulted in a loss of points.



In Chart 1, the risk metric is asset volatility; therefore, in this case the efficient frontier under Approach 1 outperforms Approach 2. Approach 1 is optimal since its efficient frontier was constructed to minimize portfolio asset volatility while Approach 2 minimizes surplus volatility.

3. Continued

(e) Recommend a new efficient portfolio to Yorkton management for each of (i) and (ii):

(i) Approach 1 Efficient Frontier, portfolios A through H

(ii) Approach 2 Efficient Frontier, portfolios I through VIII

Justify your recommendations.

Commentary on Question:
Candidates in general did very well on this question.

(i) While portfolios C through H have higher excess returns, of those, only portfolios C and D do not increase asset volatility risk. As portfolio D has the higher excess return of the two, portfolio D is the most efficient portfolio without increasing asset volatility risk.

(ii) While portfolios III through VIII have higher excess returns than the current portfolio, of those, only portfolios III and IV do not increase surplus volatility risk. As portfolio IV has a higher net excess than portfolio III, Portfolios IV is the most efficient asset mix that does not increase surplus volatility risk.

(f) Indicate how likely it is that each of Approaches 1 and 2 will meet risk management goals with respect to:

(i) Portfolio Risk

(ii) Surplus Risk

(iii) Economic Capital Requirement

(iv) Market Risk Diversification

Commentary on Question:
Candidates "overthought" this question and did not do very well. The question came almost directly from the source material, but candidates should have been able to reason to the answers if they didn't remember the source. In scoring this question, we looked for the candidate to specifically say something about Approach 1 and Approach 2 for each item. Note that the model answer explains "why" but the question does not ask for an explanation so no points were deducted if no reason was given.

3. Continued

(i) Approach 1 is more likely to meet the portfolio risk goal because it focuses on just the assets backing the product and is designed to minimize asset portfolio volatility. Approach 2 is less likely to meet a portfolio risk goal because it is focused on minimizing surplus volatility.

(ii) For the reasons given in (i), Approach 2 is more likely to meet the surplus risk goal than Approach 1. Approach 1 does not focus on surplus.

(iii) Approach 2 is more likely to meet the economic capital requirement goal. Approach 1 is not likely to meet the goal because it only looks at portfolio volatility.

(iv) Approach 2 is more likely to meet the market risk diversification goal than Approach 1, which has a goal of minimizing portfolio volatility. Approach 2 captures the market risk of the liabilities. Approach 1 may be more likely to meet diversification goals than the current portfolio, but not as well as Approach 2.

4. **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.

Learning Outcomes:

(2a) Demonstrate how each of the 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.

(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.

(2g) Analyze and evaluate model and parameter risk.

(2h) Construct approaches to managing various risks and evaluate how an entity makes decisions about techniques to model, measure and aggregate risks including but not limited to stochastic processes.

(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.

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

Sources:

Financial Enterprise Risk Management, Sweeting

- Ch. 14 Quantifying Particular Risks

ERM 104-12: Study Note on Parameter Risk, Venter and Sahasrabuddhe

Value-at- Risk: The New Benchmark for Managing Financial Risk, Jorion, 3rd Edition

- Ch. 18 Credit Risk Management

4. Continued

Commentary on Question:
The purpose of this question was to test the candidate's ability to identify risks in using a particular actuarial model for a given catastrophic event. Candidates were asked to demonstrate knowledge of a Poisson model, decide if it was appropriate for the situation, then determine how this distribution compared to other risk assessment approaches.

Most candidates scored well on either the calculation part or the analysis part of the question. Few candidates were able to score well on both aspects. Candidates who tied their answers back to the windmill farm scenario received more points.

Solution:
(a)

(i) Demonstrate that the Maximum Likelihood Estimator (MLE) for the λ parameter of the Poisson distribution is equal to the sample mean.

(ii) Calculate the MLE for the λ parameter relating to natural disasters.

Commentary on Question:
In subpart (i) most candidates provided a partial demonstration, then jumped to the given answer that the mean was to equal the variance. In this case, partial credit was given for the steps shown that were correct. Most candidates received full credit for the subpart (ii) calculation.

(i) The derivation follows:

$$L(\lambda) = \prod_{i=1}^{n} f(x_i;\lambda) = \prod_{i=1}^{n} \frac{e^{-\lambda}\lambda^{x_i}}{x_i!}$$

$$\ln L(\lambda) = \sum_{i=1}^{n} \left[-\lambda + x_i \ln\lambda - \ln(x_i!)\right]$$

The maximum likelihood estimator can be obtained by taking the derivative, setting it equal to zero, and solving.

$$\frac{d}{d\lambda}\ln L(\lambda) = \sum_{i=1}^{n}\left[-1 + x_i/\lambda\right] = -n + \frac{1}{\lambda}\sum_{i=1}^{n} x_i = -n + \frac{n\bar{x}}{\lambda} = 0$$

$$\hat{\lambda} = \bar{x}$$

(ii) $\hat{\lambda} = \frac{2}{160} = 0.0125$

4. Continued

(b) You have confirmed that the risk premium assumed in the hurdle rate did not explicitly consider the risk of natural disaster.

(i) Assess whether the potential for natural disaster alters the decision on whether to accept this investment. Show your work.

(ii) Identify the shortcomings of using a Poisson approach for modeling the risk of natural disaster for this investment.

Commentary on Question:
The subpart (i) question asked candidates to "assess" and "show your work". The intent was that candidates would complete calculations or do some type of analysis in order to make the assessment. Many candidates did not show their work or showed very little. Candidates who only offered an opinion on whether the decision should be altered, without any analysis to support their claim, did not receive any credit. Candidates who drew a reasonable conclusion from incorrect calculations received some credit.

In subpart (ii) at least two appropriate shortcomings were required for full credit.

(i) Probability of no loss by end of year 5 = $\{[e^{(.0125*5)}]*(.0125*5)^0\}/0! = .9394$
Adjusted Beginning of Year 6 Cash Flow = $1,650 * .9394 = $1,550
Adjusted IRR = 25.39%

25.39% vs. 26.97% IRR is not a material enough difference to lead you to change the investment decision. The IRR still exceeds the hurdle rate.

(ii) Shortcomings of Poisson approach:
Sampling Risk - observed sample different than actual natural disaster probability
Model risk - natural disasters may not follow Poisson distribution
Insufficient parameter risk - something other than a natural disaster causes ruin
Want to model frequency and severity, which Poisson cannot do

(c) Explain the analogy between your estimation of ruin relating to natural disaster and credit default risk assessment.

4. Continued

Commentary on Question:
This part asked candidates to show their understanding of ruin modeling by relating it to the more common credit default risk. It was intended to be straightforward, but, for the most part, candidates did not seem to know how to approach the question. Credit was given to a wide variety of answers, as long as some attempt was made to relate the two. Candidates who made valid comparisons between the scenario and the credit default risk assessment approach were awarded full points.

Default credit risk is the risk of default by a counterparty. It is analogous to the risk of ruin by natural disaster.
Default credit risk can be measured by probability of default. This is analogous to the probability of ruin by natural disaster.

(d) Compare and contrast your use of the Poisson distribution to the following default risk assessment approaches:

(i) Credit migration models

(ii) Structural credit risk models

(iii) Altman Z-score

Commentary on Question:
Most candidates were able to accurately define the three approaches. However, only providing a definition did not answer the question and resulted in a small amount of partial credit being awarded. Candidates who compared these approaches to the Poisson model scored more points. Candidates could also receive points for comparing these approaches in the context of the natural disaster scenario, although this was not required (and was not necessary to obtain full credit).

(i) Credit migration models - Use transition matrices to infer default probabilities. Models are significantly more complex than the Poisson model. Unlike the Poisson model, Credit migration models do not have an underlying distribution.
(ii) Structural credit risk models give the probability of default based on an underlying asset value. These models and the Poisson both model the probability of occurrence.
(iii) Altman Z-Score uses a firm's financial ratios to determine a score, which is used to assess whether or not a firm has a high probability of becoming insolvent. The Poisson model was used to estimate the probability distribution of a firm becoming insolvent.

5. Learning Objectives:

1. 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 the approaches for managing risks and how an entity makes decisions about appropriate techniques.

Learning Outcomes:

(1a) Explain risk concepts and be able to apply risk definitions to different entities.

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

(1c) Identify and assess the potential impact of risks faced by an entity, including but not limited to market risk, currency risk, credit risk, counterparty risk, spread risk, liquidity risk, interest rate risk, equity risk, hazard/insurance risk, inflationary risk, environmental risk, pricing risk, product risk, operational risk, project risk and strategic risk.

(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.

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

Sources:

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

Financial Enterprise Risk Management, Sweeting

- Ch. 16 Responses to Risk

Commentary on Question:

The goals of this question were

- *to understand, analyze, and address risks in a non-insurance company; and*
- *to understand, analyze, and apply different means of hedging, including financial derivatives.*

The five parts presented a range of difficulty: retrieval of information from the sources, analysis, and knowledge utilization. Most candidates successfully recalled information they had read, but as the question delved more deeply into applying those concepts to a real-life situation, the results were much more varied.

5. Continued

In the knowledge-utilization sections, there was no benefit to listing information from the sources that was indirectly related to the concepts involved; points were only awarded for demonstrating how the concepts related to the specific situation, and directly answering the specific question.

Solution:

(a) The CEO asks you to apply the PESTEL framework to identify the general environmental risks Poutine faces.

(i) Identify each of the risks considered in the PESTEL framework.

(ii) Provide an example for two of the risks identified above which are specific to Poutine.

Commentary on Question:
The PESTEL risks came directly from ERM 107-12. In subpart (ii), each example needed to tie an element of the list in (i) to an aspect of Poutine's situation in order to receive credit. Examples were needed for two risks to get full credit. The response below gives additional examples for educational purposes.

(i) Political, Economic, Social, Technology, Environmental, and Legal

(ii) Examples of answers for each risk:

1. Political issues:
   - Regulations intended to encourage use of "green" energy and discourage use of coal could make coal more expensive

2. Economic issues:
   - General economic conditions (interest rate, futures market, etc.) will affect Poutine's ability to trade

3. Social issues:
   - Protests about Poutine, since its business may pollute the environment around its factory, could lead to loss of business

4. Technological issues:
   - Another company adopts a new, cheaper technology to remove impurities in silver, and Poutine's customers choose to do business with companies using the new technology.

5. Environmental issues:
   - A natural disaster can greatly affect energy prices.

5. Continued

6. Legal issues:
   - Legal costs associated with lawsuits/potential breaking of laws will result in costs.

(b) Identify strategic risks Poutine faces if it implements the CEO's proposal.

Commentary on Question:
For full credit, at least two distinct risks needed to be identified. Candidates were not required to "explain", but they needed to provide enough description that it was clear what the risk was. The solution shows more risks than would be required for full credit.

- Poutine will still face fixed costs if it stops production, which would cause financial problems for the company.
- Competitors may seize the opportunity to become dominant players, known for serving their customers "in good times and bad".
- Restarting production could be expensive.
- There's no guarantee that the coal costs would later be less than the fixed refining fee, so Poutine may be out of its core business indefinitely.

(c) Explain how the CEO's strategy can be described as a financial derivative.

Commentary on Question:
Many candidates had trouble with this part of the question. For full credit, it was necessary to use the analogy of a call or a put, making a clear connection between the instrument and Poutine's specific situation.
The answer could be expressed in terms of a call, because Poutine would buy the coal only when the price was in the acceptable range, or a put, because Poutine would only provide its services when the cost of coal was in an acceptable range. Either approach was acceptable if the connection was explained well.

Very few candidates were awarded full credit for this question.

Income can be described as

- Revenue – Expenses = Fee Charged – Coal (variable) costs – Fixed Costs

When their coal costs are greater than the current cost / fee assessed for refining silver, the company shuts down production. Poutine will still incur its fixed costs when not in production and will need to make this up in the long run in order to stay viable. The strategy is similar to a call option on the Poutine fee with the strike price being the price of coal. The fixed costs are analogous to selling a bond.

5. Continued

(d)

(i) Describe how Poutine could hedge its risk exposure to changes in the price of coal with forward contracts.

(ii) Describe how Poutine could hedge its risk exposure to changes in the price of coal with futures contracts.

(iii) Explain whether you would recommend using futures or forward contracts as a hedging strategy. Justify your answer.

Commentary on Question:
For full credit, it was necessary to demonstrate knowledge of the difference between futures and forwards, make a clear connection to this specific situation, choose between futures and forwards, and justify that choice. Forwards were considered the preferred choice, but points were also given for futures if the reason was well-supported.

(i) Poutine could estimate the amount of coal it will need at a future date and contract with another party to sell Poutine that coal at a predetermined price. Poutine would then know ahead of time not only the cost of the coal but also the cost of the hedge, and could price its product accordingly. Forwards are non-exchange contracts, so they can potentially be customized to match Poutine's underlying assets and timing needs.

(ii) Poutine could estimate the amount of coal it will need at a future date and buy coal futures contracts on an exchange; knowing the future cost as well as the cost of the hedge would enable Poutine to price its product accordingly. There is generally more basis risk under futures, due to trying to fit contracts that are on the market to one's specific needs.

(iii) Forward contracts would be recommended, since the forward can be exactly customized to the risk (size, delivery date, etc.); futures contracts have virtually no flexibility and thus can result in a higher level of basis risk. Poutine needs this since they will not want cash settlement, and they have target dates and order sizes they will want to mitigate.

Alternative answer: Reasons for choosing futures over forwards:
There are administrative costs to set up and track forward contracts and additional costs of settling contracts and making changes to the forward contracts. Forwards involve more counterparty risk.

5. Continued

(e) You are asked to assess the CEO's shutdown strategy versus the CFO's hedging strategy.

(i) Identify the factors you would consider in choosing between the two.

(ii) Explain how these factors will inform your decision.

Commentary on Question:
Full credit was awarded for 3 well-described factors for which both the application to the specific situation and the role the factor would play in making the decision were well explained. The response below includes more factors than required for full credit.

(i) Production costs: the cost associated with stopping and starting the production process periodically

Price volatility: Is the volatility expected to continue or is it a rare occurrence?

Strategic risks associated with stoppage: loss of customers, employee morale

Hedging costs: will the hedging have any additional costs or require additional resources/expertise that would have to be incorporated into future pricing?

Reputational risk: stopping and starting could make customers think the company is in trouble, or at least undependable, employee morale

(ii) In making the decision, some factors can be quantified, such as production costs for start-up, hedging costs, and price volatility. Others need to be evaluated qualitatively and will have to be weighed based on the company's assessment of their importance. The strategic and customer risks should be given careful consideration as those could sink the company permanently.

6. Learning Objectives:

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

Learning Outcomes:

(1a) Explain risk concepts and be able to apply risk definitions to different entities.

(1c) Identify and assess the potential impact of risks faced by an entity, including but not limited to market risk, currency risk, credit risk, counterparty risk, spread risk, liquidity risk, interest rate risk, equity risk, hazard/insurance risk, inflationary risk, environmental risk, pricing risk, product risk, operational risk, project risk and strategic risk.

Sources:

Financial Enterprise Risk Management, Sweeting

- Ch. 7 Definitions of Risk (primary source);

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

Commentary on Question:

This question tested whether candidates understood the various risk categories and could apply them to the given situation. Most candidates did well on this question.

Solution:

(a) Classify each of the ten risk categories as High, Medium, or Low Importance for Yonge Life. Justify your choices.

Commentary on Question:

Most candidates did very well on part (a) of this question. The most commonly misunderstood risk was systemic risk. For full credit, candidates needed to classify each risk and justify the classification. All reasonable classifications with adequate justification were given full credit. The solution below is only an example of appropriate answers.

<u>High Importance:</u>

- Interest Rate Risk – High-yield bonds are sensitive to interest rates
- Liquidity Risk – High-yield bond exposure could pose problem if there is a market disruption and the company needs liquid funds
- Demographic Risk – Significant mortality exposure on term and recent experience has been poor; company has a large exposure to the US market

6. Continued

Medium Importance:

- Systemic Risk – Company is very dependent on US environment; risk could impact investments and reinsurance
- Credit Risk – Reliance on reinsurance where the single reinsurer could default; high-yield bond holdings may default
- Strategic Risk – Consistent management in place; Consistent strategy for multiple years that has been successful, but may indicate that strategy needs to be reviewed and updated

Low Importance:

- Market and Economic Risk – No real exposure to equities
- Non-Life Insurance Risk – Not applicable here due to being only in life insurance business
- Operational Risk – State-of-the-art technology, low turnover, and audited externally with no issues
- Foreign Exchange Risk – No direct exposure as all investments are domestic bonds

(b) Identify which risk categories would be of High Importance if Yonge Life makes the acquisition. Justify your choices.

Commentary on Question:
Many candidates performed well on part (b), but many did not provide justifications worthy of the full 2 points. For full credit, candidates were required to identify increases to strategic, operational, and foreign exchange risks as well as impacts to risks that had already been categorized as high in part (a).

Existing Risks
Investing in Chinese bonds continues to cause interest rate and liquidity risks. These bonds may not be as stable as the domestic US bonds.

Demographic risk continues to be high even though there is more geographical diversification, due to Yonge's inexperience with Chinese mortality.

Operational Risk
There is a completely new company to bring into Yonge's business operations: new people, processes, and technology to integrate. This will require a lot of due diligence and resources to ensure this happens without incident.

Strategic Risk
This is a big change in strategic direction. There are unfamiliar markets that may or may not be a good fit.

6. Continued

Foreign Exchange Risk

The company is incorporating management of new foreign assets and has little to no prior experience doing this. Additionally, profit and loss values will be affected by foreign exchange when Yonge brings the amounts into its financial results.

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.

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:

(2a) Demonstrate how each of the 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.

(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.

(5b) Define the basic elements and explain the uses of economic capital. Explain the challenges and limits of economic capital calculations and explain how economic capital may differ from external requirements of rating agencies and regulators.

Sources:

Financial Enterprise Risk Management, Sweeting

- Ch. 16 Responses to Risk

ERM-106-12: Economic Capital – Practical Considerations

Value-at- Risk: The New Benchmark for Managing Financial Risk, Jorion, 3rd Edition

- Ch. 5 Computing VaR
- Ch. 13 Liquidity Risk
- Ch. 18 Credit Risk Management

7. Continued

Commentary on Question:
This question tests candidates' understanding of the differences between various capital metrics, as well as knowledge of the two types of liquidity risk. Candidates were asked to apply that knowledge to different liability profiles and stress scenarios. The question was divided into four parts, each testing a different concept. Almost half of the question consisted of computation, with the remainder requiring explanation and analysis.

The question asked candidates to look at results from the standpoint of Hamsik, a reinsurance company, and it was continually made clear throughout the question that we wanted an evaluation from Hamsik's perspective. However, some candidates responded in terms of the ceding company rather than the reinsurer; they did not receive credit for those answers.

Solution:

(a) Explain why it is important for Hamsik Re to consider each of the three standalone capital measurements in its assessment of these contemplated transactions.

Commentary on Question:
Full credit on part (a) required an explanation of the purpose of each of the three standalone capital measurements, as well as recognition that Hamsik can't use a single one as the basis for its capital. Overall, candidates did well explaining each of the three measures, but in most cases they did not make the connections needed to tie them all together.

The three capital metrics serve different purposes. Hamsik must consider all of them in order to meet regulatory requirements, maintain its desired credit rating, and feel comfortable that it is holding enough capital for its risks, based upon its internal modeling.

RBC Capital reflects the minimum capital requirement the US regulator will require Hamsik to hold.

S&P Capital reflects the minimum capital required to obtain/maintain a desired credit rating (which is an important criteria used by Hamsik's counterparts to assess whether or not they want to enter into transactions with Hamsik).

Economic capital is a self-assessed capital level developed by Hamsik, reflecting the capital required to support a block of business with a given probability of default.

The capital required to support the contemplated transactions needs to reflect the greatest of these three metrics.

7. Continued

(b)

(i) Determine the value of ρ which equates the aggregate capital required under methods I and II.

(ii) Explain why this same ρ might not equate the aggregate capital required under methods I and II if S&P AA level capital were used rather than economic capital.

Commentary on Question:
To get full credit on part (b-i), candidates were required to set up the equation listed below and solve using the quadratic formula. While a number of candidates got all the way to the correct answer of 38.86%, many made minor setup and/or math errors. Partial credit was given in these situations. Regarding part (b-ii), candidates had difficulty giving a sufficient explanation.

(i) Method I: Aggregate Capital = sqrt(170^2 + 325^2 + 2*(-ρ)*170*325)
Method II: Aggregate Capital = (170+325)*(1-ρ)

Setting them equal:
sqrt(170^2 + 325^2 + 2*(-ρ)*170*325) = (170+325)*(1-ρ)
sqrt(134525 - 110500ρ) = 495 - 495ρ
134525 - 110500ρ = 245025 - 490050ρ + 245025ρ^2
245025ρ^2 - 379550ρ + 110500 = 0

Using the quadratic formula, ρ = 38.86% or 116.04%.
116.04% is not a reasonable value for ρ.
Therefore, ρ = 38.86%.

(ii) The correlation coefficient assumes linear dependence, which is not necessarily the case. The use of one correlation coefficient to equate different levels of required capital assumes that correlation is the same at all levels for which required capital may be set. However, risks may be more or less correlated at the different levels for which required capital may be set. As such, a correlation coefficient which would be appropriate when equating capital at a given level (say VaR(99.5%)) may not be appropriate at some other VaR level. We are not told the level used for the S&P capital or for Hamsik's internal economic capital, and they could well be different.

7. Continued

(c)

(i) Assess the liquidity risk profile associated with each block (i.e., Block A and Block B) from Hamsik Re's perspective.

(ii) Identify the more favorable of the two blocks from a liquidity risk profile perspective. Justify your response.

Commentary on Question:
To achieve full credit on part (c), the answer needed to contain an assessment of both asset (market) liquidity risk and funding liquidity risk. The majority of candidates provided a strong answer for asset liquidity risk. A much smaller number described the funding liquidity risk for each block.

(i) Block A:
Funding Liquidity Risk: This block is susceptible to policyholder cash demands (loans/withdrawals/surrenders), so risk is significant.

Asset Liquidity Risk: Assets are heavily weighted to private placements, which are more thinly traded, increasing liquidity risk.

Block B:
Funding Liquidity Risk: Relatively low given no ability for policyholder to accelerate payment of funds.

Asset Liquidity Risk: Assets are concentrated in Treasuries and high-quality Corporates, which reduces asset liquidity risk.

(ii) Funding Liquidity Risk: Block A has higher risk due to policyholder options to demand funds.

Asset Liquidity Risk: Given mix of asset classes described above, Block A has the worse profile. However, the relatively low economic reserve level relative to the statutory reserve may mitigate this risk to a large extent.

On balance, Block B has the better overall liquidity risk profile.

(d)

(i) Determine which of the two blocks would produce the more favorable LRR. Show your work.

(ii) Explain the shortcomings of Hamsik Re's approach to liquidity risk management.

(iii) Propose improvements to Hamsik Re's LRR approach.

7. Continued

Commentary on Question:
Part (d) was broken up into (d-i), which was largely a computational question, and parts (d-ii) and (d-iii), which required explanation. Regarding (d-i), candidates did very well, calculating the correct LRRs and coming to the right conclusion, that Block B produces the more favorable LRR. Results were mixed for (d-ii) and (d-iii). While most candidates explained several shortcomings and proposed multiple improvements, many of those responses did not address LRR or Hamsik's approach to liquidity risk management and therefore didn't relate directly to the question.

Answers shown below for (d-iii) in particular are examples and other appropriate responses received credit. For full credit in (d-ii) and (d-iii), more than one well-explained shortcoming and more than one well-developed improvement needed to be provided.

(i)

	BV_A	BV_B	Liquidity Haircut		A	B
- Private Placements	412	63	30%		288	44
- Treasuries	84	424	0%		84	424
- Corporates AAA	211	678	5%		200	644
- Corporates AA	134	233	10%		121	210
- Corporates A	99	144	15%		84	122
- Corporates BBB	155	152	25%		116	114
				(a)	894	1,558
				(b)	1,095	1,694
				LRR	82%	92%

Block B (92% LRR) produces a more favorable LRR than block A (82% LRR).

(ii)

- LRR is a function of the statutory reserve, which may be a measure of exposure but does not reflect funding liquidity risk.
- LRR ignores assets backing capital.
- LRR ignores the economic reserve, which is much lower than the statutory reserve for the UL block and is a better reflection of the policyholder liability.
- Finally, without additional management information, LRR is not an actionable metric in its current form.

7. Continued

(iii)

- A ratio should be constructed that is based on the stressed cash obligation over a period of time, as opposed to a percentage of the statutory reserve.
- Thresholds should be set to indicate when the liquidity profile is sub-optimal, as well as what corrective action should be taken when these thresholds are breached.
- The LRR should be supplemented with other metrics, such as a VAR based measure of realized losses upon accelerated disposition of assets assuming stressed market conditions.

8. **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.

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

Learning Outcomes:

(1a) Explain risk concepts and be able to apply risk definitions to different entities.

(2h) Construct approaches to managing various risks and evaluate how an entity makes decisions about techniques to model, measure and aggregate risks including but not limited to stochastic processes.

(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.

(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.

8. Continued

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

Sources:
ERM-318-14: Longevity Hedging 101: A Framework for Longevity Basis Risk Analysis and Hedge Effectiveness

Value-at- Risk: The New Benchmark for Managing Financial Risk, Jorion, 3rd Edition
- Ch. 7 Portfolio Risk: Analytical Methods

Commentary on Question:
The purpose of this question was to test candidates' understanding of longevity hedging techniques and their ability to apply these concepts to a particular company's needs. Candidates who did well demonstrated a thorough understanding of longevity hedges based on Study Note ERM-318-14. Those candidates who did poorly on this question generally gave more generic answers that didn't demonstrate knowledge of this specific type of hedge. These candidates had the most trouble properly applying the relevant concepts to SLIC in parts (b) and (e).

Solution:
(a)

(i) Define longevity basis risk with respect to implementing a longevity hedge.

(ii) Identify alternative metrics to the SPIA annuity values that could have been used for the hedge objective.

(iii) Explain whether the SPIA annuity values metric is better than the alternative metrics you identified in (ii).

Commentary on Question:
Many candidates defined longevity risk instead of longevity basis risk for subpart (i). Full credit did not require the examples provided in the sample solution below but did require an explanation that the risk arises due to mismatches between the populations.

In subpart (iii), the expected answer is that annuity values are the best choice of metric. However, it was acceptable if candidates chose the alternative of "annuity liability cashflows", as long as their reasoning was explained. The other possible alternative metrics do not directly relate to the monetary impact of the hedge and therefore are not as useful.

(i) Longevity basis risk is the risk of a mismatch in demographics between the exposed population (the SPIA annuitants) and the population tracked by the hedging instrument.

8. Continued

Basis risk can emerge from factors such as different proportions of males and females (gender basis), different age distributions (age basis), mismatches in mortality between the national population and a specific subpopulation (subpopulation basis) or mortality differences between different countries (country basis).

(ii) Possible alternative metrics include:

- Mortality rates (crude or graduated)
- Mortality improvements
- Survival rates
- Life expectancies
- Liability cashflows

(iii) Annuity values are the best choice of metric for the hedge objective.

Mortality rates, mortality improvements, survival rates and life expectancies are all useful metrics to analyze but don't correspond directly to liability value or benefit payments, which are the items that Danielle Wolfe would be most interested in.

Liability cashflows are a relevant metric but contain more volatility than annuity liability values. Since the objective is to hedge the risk over an extended period of time it is better to focus on the more stable metric.

Annuity values are easily obtained for the annuities and can be calculated for the index population using the SPIA valuation model. Since this metric directly reflects the monetary impact of basis risk it is appropriate for evaluating the effectiveness of longevity hedges.

(b) Explain to Danielle Wolfe which of the two available longevity indices would minimize the longevity basis risk in the hedge relative to the SPIA product by referencing key observations from Chart A and Chart B.

Commentary on Question:
Full credit for this section required the candidate to recognize that LL closely tracks company experience while VB diverges significantly from the trend experienced by the company's SPIAs. Candidates who did not understand hedge calibration and focused on the SPIA/VB ratio being close to 1 near the end of the experience period scored poorly.

8. Continued

VitaBrevis Longevity Index (VB) is not appropriate as a hedge index. Chart A shows that there has been an unstable relationship between the SPIA and VB annuity values over time, with the VB value starting off below the SPIA value and ending up higher. Chart B clearly demonstrates the significant change in the ratio over the experience period as the ratio decreases from almost 1.2 to a final value of around 1.0. Using VB would introduce substantial basis risk since its experience is poorly correlated with that of the company.

The LongLife Longevity index (LL) is an appropriate choice for a hedge index. Chart A shows that the annuity values for the SPIA block and LL have moved in parallel over the experience period while Chart B shows a fairly constant ratio of annuity values over time. Since the ratio is not equal to 1 it will be necessary to calibrate the hedge to account for the absolute difference in annuity values. A properly calibrated index hedge using LL would minimize basis risk.

(c) Estimate the relative risk reduction of using the longevity hedge based on applying the 95% VaR risk metric to your histogram results.

Commentary on Question:
Most candidates did well on this part of the question. Candidates not receiving full credit generally made errors reading the chart or with the VaR formulas.

Greater longevity will produce higher annuity values so we will look at the right tail. Since we want the 95% VaR results and there were 2,000 scenarios run we will analyze the $(2000)(.05) = 100^{th}$ worst scenario.

For the unhedged SPIA the annuity value is \$12.6, so the relative VaR is 12.6 – 10.2 = \$2.4. For the hedged SPIA the annuity value is \$10.6 so the relative VaR is 10.6 – 10.2 = \$0.4.

Relative Risk Reduction = 1 – VaR(Hedged SPIA) / VaR(Unhedged SPIA) = 1 – 0.4/2.4 = 83%

(d) Calculate the diversification benefit that currently exists for SLIC's annuity and insurance mortality risk exposure, assuming a correlation of -60% between annuity and life insurance mortality risks.

Commentary on Question:
Most candidates scored very well on this part. Candidates who lost credit most often had minor errors in their formulas or made math errors.

8. Continued

Combined 99% VaR = sqrt{ $VaR(Ann)^2 + VaR(Life)^2 + 2\rho VaR(Ann) VaR(Life)$}

= sqrt{ $48.5^2 + 134.7^2 – 2(0.60)(48.5)(134.7)$ } = sqrt{12,656.8}
= 112.5

Sum of VaR = 48.5 + 134.7 = 183.2

Diversification Benefit = 183.2 -112.5 = $70.7 million

(e) Recommend to Danielle Wolfe whether or not to pursue a static hedge based on a longevity index. Justify your recommendation.

Commentary on Question:
Many candidates did poorly on this section because they failed to incorporate the results determined in (c) and (d). Full credit required comparing the risk reduction results from the hedge to the existing natural hedge from the life block. Candidates who answered this section based on general risk management concepts without showing an understanding of longevity hedges and without relating the answer to the specific example of SLIC received very little credit.

A static hedge based on a longevity index should not be pursued. Although an appropriate index-based longevity hedge is available, there is a naturally existing hedge to this risk resulting from the negative correlation of the SPIA and life insurance blocks. Since the diversification benefit of $70.7 million is higher than the annuity's standalone VaR of $48.5 million, fully removing the SPIA longevity risk would actually increase the overall mortality VaR by 70.7 – 48.5 = $22.2 million.

9. Learning Objectives:

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

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:

(1c) Identify and assess the potential impact of risks faced by an entity, including but not limited to market risk, currency risk, credit risk, counterparty risk, spread risk, liquidity risk, interest rate risk, equity risk, hazard/insurance risk, inflationary risk, environmental risk, pricing risk, product risk, legal risk, operational risk, project risk and strategic risk.

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

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

(4i) Analyze the application of Asset Liability Management and Liability Driven Investment principles to Investment Policy and Asset Allocation.

Sources:

ERM-315-14: LDI in a Risk Factor Framework

Value-at- Risk: The New Benchmark for Managing Financial Risk, Jorion, 3rd Edition

- Ch. 7 Portfolio Risk: Analytical Methods

Commentary on Question:

This question was designed to test candidates' understanding of how the risk factors underlying the asset allocation of a pension plan can be quantified and the use of metrics to measure the risks.

Solution:

(a) For each of these four selected risk factors:

(i) Describe the nature of the risk exposure in general.

(ii) Identify both the long position and the short position of the Factor Mimicking Portfolio (FMP) that would be used to model the risk.

9. Continued

Commentary on Question:
Most candidates did well on subpart (i) by showing their general knowledge of the four risk factors, but few did well on subpart (ii). The answer is based on a chart in the reading material. Candidates could have answered either from memory of the chart or by reasoning to an appropriate position.

Risk Factor	Description	FMP Long Position	FMP Short Position
I. Economic Growth: Equities	Economic growth uncertainty	Diversified equity index	1-month T-bills
II. Economic Growth: Credit	Risk of default and uncertainty of recovery	Corporate bond portfolio	Duration-matched treasury portfolio
III. Real Rates	Risk of bearing exposure to uncertainty in real interest rates	Inflation-linked treasury portfolio	1-month T-bills
IV. Inflation	Risk of changes in nominal prices	Nominal treasury bond portfolio	Maturity-matched inflation-linked treasury portfolio

(b) Explain how AHA's Plan liabilities are or are not exposed to each of the four selected risk factors, I through IV.

Commentary on Question:
*Generally candidates did well on this part of the question. However, this question is about AHA's Plan **liabilities**. Some candidates missed the points by talking about Plan asset investments only.*

I - Economic Growth: Equities
No. Pension liabilities are not directly exposed.

II - Economic Growth: Credit
Yes. If nominal liability cash flows are discounted using a corporate bond-derived discount curve, the liabilities will additionally gain exposure to the credit spread risk factor.

III - Real Rates
Yes. Pension liabilities are impacted by experienced inflation, e.g., Salary inflation.
The present value of inflation-linked cash flows has exposure to real rates.

9. Continued

IV – Inflation
Yes. Pension liabilities impacted by experienced inflation are similar to nominal bonds. The value of nominal cash flows has exposure to both real rate risk and inflation risk. In addition, actuarial assumptions include a CPI assumption.

(c) Calculate and allocate the surplus expected dollar return to each of the three risk factors to the nearest $ million. Show your work.

Commentary on Question:
Candidates did not do well on this part of the questions. Common mistakes were

- *Didn't use actual asset and liability and assumed them equal*
- *Only calculated asset side with liability side missing*
- *Only calculated total return and didn't allocate to each of the risk factors*

$E(\$R_{F1})$ = (65% × \$169.3) × (2 × 5.0%) (equity) + 0 (bond) – 0 (liability)
= \$11 million
$E(\$R_{F2})$ = 0 (equity) + 35% × \$169.3 × 0.6 × 1.0% (bond)
- \$192.9 × 1.2 × 1.0% (liability)
= -\$2 million
$E(\$R_{F3})$ = 0 (equity) + 35% × \$169.3 × 0.6 × 2.5% (bond)
- \$192.9 × 1.2 × 2.5% (liability)
= -\$5 million
$E(\$R_{SURPLUS}) = E(\$R_{F1}) + E(\$R_{F2}) + E(\$R_{F3})$ = \$11 - \$2 - \$5 = \$4 million

(d) Calculate the volatility of the surplus portfolio expected dollar return.
Show your work.

Commentary on Question:
In general, candidates did not do well on this part. Candidates could earn credit based on incorrect answers from part (c) if the formula setup was correct, and the calculation based on results from (c) was done accurately.

Surplus Variance =

$$\begin{bmatrix}11 & -2 & -5\end{bmatrix} \times \begin{bmatrix}2.6\% & 0.4\% & 0.5\% \\ 0.4\% & 0.3\% & -0.2\% \\ 0.5\% & -0.2\% & 2.0\%\end{bmatrix} \times \begin{bmatrix}11 \\ -2 \\ -5\end{bmatrix}$$

= 2.892
Surplus Volatility = $2.892^{0.5}$ = 1.7 million

9. Continued

(e)

(i) Explain the implications of positive and negative surplus returns and positive and negative surplus variances.

(ii) Assess the impact of each of the three key risk factors on the AHA Plan surplus.

Commentary on Question:
Generally candidates did well on this part of the question.

(i) Positive surplus return implies that exposure to this risk factor is expected to be rewarded, due to increasing the surplus, or that there is a cost to remove a risk factor exposure to actuarial risk. Negative expected surplus returns imply that the risk factor is lowering the surplus. Positive surplus variance implies the factor is increasing the surplus risk. Negative surplus variance implies that the risk factor is reducing risk.

(ii) F1 - Economic Growth: Equity
Largest risk exposure and largest return contributor

F2 - Economic Growth: Credit
Net short credit exposure of Plan produces drag on returns, but also lowers volatility, diversifying risk

F3 - Real rates and inflation
Second largest risk exposure – long duration nominal rates. Plan has negative surplus return exposure, and high volatility to this factor due to large duration mismatch.

(f) Recommend to the Pension Committee changes to the bond/equity mix that would improve the Plan's surplus risk/return profile. Justify your response.

Commentary on Question:
Candidates generally did not do well on this part. Candidates needed to make a specific recommendation and explain why it would improve the risk profile for full credit.

The following are sample answers only.

Answer 1 - Reduce exposure to Equity and increase exposure to other return drivers, like credit, real rates & inflation to diversify this exposure. This would ensure a more robust return generation across economic environments.

9. Continued

Answer 2 - Reduce the Plan's negative exposure to real rates and inflation (caused by large duration mismatch between assets and liabilities). This would increase the Plan's expected surplus return and decrease the Plan's surplus volatility.