ERM-INV Model Solutions
Spring 2015

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

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

Sources:
ERM 114-13: Introduction to Reinsurance, Rudolpho Wehrhahn (excluding all Annexes)

Commentary on Question:
The goal of the question is to test knowledge of reinsurance options. The candidate was expected to identify management considerations for selecting an appropriate reinsurance option.

Solution:
(a) Explain how reinsurance could be used to address Myers' breach in risk limits.

> **Commentary on Question**:
> *Full credit was awarded for responses that described the benefits of reinsurance specifically to address the concern given in the question. Credit was not given for features or benefits of reinsurance that would not address the breach in risk limits, although these were often included in candidate responses. While many candidate responses included the central point regarding risk transfer (point 1 below), fewer included points 2 and 3.*

1. Reinsurance is a risk management tool used to transfer risk from the insurer to the reinsurer.

2. Meyers could use reinsurance to transfer
   - Exposures in excess of its concentration limits by ceding a portion of all policies covering a defined risk (surplus reinsurance), or
   - Losses in excess of its concentration limits by using excess of loss reinsurance.

1. Continued

3. Use of reinsurance allows the insurer to participate in a larger diversity of risks using the same working capital by keeping a smaller portion of each risk. The reduction in concentration risk may diminish the volatility of annual results.

(b)   Compare and contrast surplus reinsurance with excess of loss reinsurance.

Commentary on Question:
A large number of candidates did not clearly identify the differences between the two forms of insurance.

Compare:
Both are risk management tools that transfer risk to the reinsurer. The capacity is the maximum amount that is reinsured.

Contrast:
- Excess of loss only covers losses in excess of priority so that small claims are not reinsured.
- Surplus reinsurance is quota share reinsurance that assigns or cedes a portion of each claim. Small claims are reinsured. The retention is the amount of sum insured retained by the insurer (for sum insured amounts $\leq$ retention plus capacity).

(c)   Calculate Myers' retained claim for the following scenarios. Show your work.

Commentary on Question:
Many candidates struggled with the surplus reinsurance calculations. In surplus reinsurance, the quota share reinsured is determined based on the sum insured. Then that quota share is ceded for each claim, regardless of claim size. Full credit answers generally included both a table and supporting calculations, although full credit was given for correct calculations with the retention amounts clearly indicated regardless of whether a table was included.

Retained Agreement I – Surplus Reinsurance:
A) Since the sum insured = $100 and retention = $60, the quota share ceded equals [1 − (retention/sum insured)] = [1 − (60/100)] = 40%. The capacity limit does not come into play. Alternatively, the retained share is (retention/sum insured) = (60/100) = 60%. So, the $20 claim is 60% retained. **Retention = 20 x 0.60 = $12**.
B) Sum insured = $300. Sum insured minus retention = $300 − 60 = 240 = capacity. Therefore, retained share = 60/300 = 20%. The $200 claim is 20% retained. **Retention = 200 x 0.20 = $40**.

1. Continued

Retained Agreement II – Excess of Loss Reinsurance:
A) Since the $20 claim is less than the $50 priority, it is **fully retained**.
B) The $200 claim is in excess of the $50 priority, so it is reinsured up to the $100 capacity. Ceded amount = Min [(claim – priority), capacity] = Min[(200-50), 100] = Min[150,100] = $100.
   Retention = $200 – 100 = $100.

Scenario	Sum Insured	Claim	Retained Claim I	Retained Claim II
A	$100	$20	**$12**	**$20**
B	$300	$200	**$40**	**$100**

(d) Outline the considerations that would factor into making a recommendation between the two reinsurance options.

Commentary on Question:
Any three of the following considerations resulted in full credit.

- Counterparty risk of each reinsurer (credit ratings, probability of default)
- The risk-return trade-off or the cost of each option
- The impact on the risk measures of each option, or how well each addresses the risk limit breach
- Regulatory issues such as whether reserve or capital credit would be allowed
- The level of risk sharing of each option
- The duration or renewability of each option
- The ease of doing business and/or existing relationship with the reinsurers
- Tax issues

2. **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.

(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.

Sources:
Financial Enterprise Risk Management, Sweeting, 2011
- Ch. 7 Definitions of Risk
- Ch. 16 Responses to Risk

Commentary on Question:
This question was designed to test a candidate's understanding of a variety of risks applied to specific situations, as well as how to mitigate those risks.

For sub-part (i) of each section, candidates needed to adequately describe the main risk within the context of the situation in order to receive full credit. For sub-part (ii) of each section, candidates needed to have two well-explained mitigation strategies in order to receive full credit.

For sub-part (ii), particularly in parts (a) and (b), some candidates suggested mitigation strategies that essentially involved not making the proposed change. Such responses received minimal credit, as the point of the question was how to manage the risk, given that the change was occurring.

Overall, candidates did well on this question.

Solution:
(a)
      (i) Describe the main risk that would be introduced by the simplified underwriting product.

      (ii) Propose strategies to manage the risk identified.

2. **Continued**

Commentary on Question:
Candidate performance was mixed on this portion of the question.
- *For sub-part (i), to receive full credit candidates needed to explain that unhealthy individuals would be drawn to this type of product. Simply identifying the risk of adverse mortality experience only received partial credit.*
- *For sub-part (ii), the solution shown is an example of a good answer; many other valid answers were given, which also received credit.*

(i)   **Adverse selection** is the main risk introduced. It arises as a result of information asymmetry. In this situation, due to limited underwriting, the individual knows considerably more about his health than the insurance company.

Healthy individuals will likely choose to purchase traditional term products, because they will receive lower premium rates. Unhealthy individuals will gravitate towards the simplified issue product, since a medical examination is not required.

(ii)   **Risk transfer** – Calusa could enter into a YRT or Coinsurance arrangement. This would transfer mortality risk to the reinsurer and give Calusa time to develop mortality experience for the simplified issue product.

Risk reduction - Calusa could limit the sales of the simplified issue product, in order to reduce the mortality exposure until Calusa becomes comfortable with the mortality experience of the new product.

(b)
(i)   Describe the main risk that would be introduced by the COLA feature.

(ii)   Propose strategies to manage the risk identified.

Commentary on Question:
Candidate performance was mixed on this portion of the question.
- *For sub-part (i), some candidates assumed the COLA adjustment was a fixed percentage, instead of a floating rate. Since the question did not specifically state that the COLA was tied to the CPI, candidates were not penalized for making this assumption.*
- *For sub-part (ii), the solution shown is an example of a good answer; many other valid answers were given, which also received credit.*

2. Continued

      (i)   **Interest Rate Risk** – The COLA rider introduces indirect interest rate risk to Calusa. Calusa is now obligated to make inflation-linked payments to purchasers of this rider. The result is that Calusa no longer knows the amount of the payments it is obligated to make in the future.

      (ii)   **Cash Flow Matching** - Calusa can invest in bonds which have coupon payments and redemption amounts that are tied to the Consumer Price Index (e.g., TIPS). By carefully implementing this strategy, Calusa can closely match its future asset and liability cash flows.

           Swaps - Interest rate swaps could be purchased. Calusa would agree to pay a fixed interest rate, in exchange for floating interest rate payments, linked to the CPI. Swaps would have to be entered into at various durations, in order to mimic the liability cash flows.

(c)

      (i)   Describe the main risk associated with Calusa's personnel practices.

      (ii)   Propose strategies to manage the risk identified.

Commentary on Question:
Candidates generally did well on this portion of the question.
- *For sub-part (i), many terms were used to name the risk. It was not important to get the correct term; candidates could still receive full credit using a different term than "People risk" but adequately explaining the risk.*
- *For sub-part (ii), the solution shown is an example of a good answer; many other valid answers were given, which also received credit.*

      (i)   **People risk** - People risk can encompass a variety of things, and it starts with the risk that the wrong people are employed. Employees in the claims department need proper training and skills to ensure claims are processed accurately and efficiently.

           High turnover in the P&C division could also lead to:
- Loss of intellectual capital
- Increased recruitment and training costs
- Decreased morale of remaining employees
- Low customer satisfaction if errors occur

      (ii)   **Hire the right employees** - Employees need to have the appropriate skills to work in the claims department.
- Employ a quality human resources department to find people with the right skills

2. Continued

- Implement training procedures for new and temporary employees
- Professional temporary employment agencies could be used to identify quality candidates

Retain the right employees
- Review performance on a regular basis to identify high performing and poor performing employees
- Provide competitive pay and working conditions
- Provide advancement opportunities

(d)

(i) Describe a significant risk associated with the new claims administration system.

(ii) Propose strategies to manage the risk identified.

Commentary on Question:
Candidates generally did well on this portion of the question. This portion of the question was intentionally worded differently, asking candidates to describe "a significant risk" instead of "the main risk". Therefore, alternative answers could receive full credit, but most candidates answered similarly to the solution below.

(i) **Technology Risk**
- An internet-based claims system hosted on third party servers exposes Calusa to unintended loss or disclosure of confidential information
- Remote access also increases security risks
- Loss of confidential data could damage Calusa's reputation
- By using a third party administrator Calusa has to rely on a resource it does not control

(ii) **Keep security up to date** - Security patches should be implemented as soon as they are available in order to minimize potential loss of confidential information. Calusa should take appropriate measures to restrict access to the internet-based claims system, such as weekly password resets.

Back up data regularly – Back up servers daily and store backup data at another site. These measures are needed to minimize losses if data becomes corrupt. Claims will be being entered into the system every day, so it is important to back up data frequently**.**

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

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

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

Learning Outcomes:
(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.

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

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

Sources:
Financial Enterprise Risk Management, Sweeting, 2011, Ch. 7 Definitions of Risk

Value-at- Risk: The New Benchmark for Managing Financial Risk, Jorion, 3rd Edition
- Ch. 13 Liquidity Risk
- Ch. 14 Stress Testing

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

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

Commentary on Question:
This question asked candidates to assess risks in a non-traditional situation and to consider strategic decision-making from both a quantitative and qualitative standpoint.

Some candidates experienced difficulty in applying the risk concepts outside an insurance-company or other financial-services setting. They may have understood the material they had read but could not take the next step to identify the principles in an unfamiliar context. This was the biggest differentiator between candidates who did well on this question and those who did not.

3. **Continued**

Solution:
(a) Describe the following risks to Dr. Dan as they apply to Option I:

    (i) Liquidity Risk

    (ii) Counterparty Risk

    (iii) Operational Risk

    (iv) Professional Liability Risk (Legal obligations arising out of a professional's errors, negligent acts, or omissions during the course of the practice of his or her craft)

Commentary on Question:
The candidate had to make the connection between the types of risk and Dr. Dan's actual situation. Credit was not given for definitions or descriptions of the types of risk unless the corresponding example in the given scenario was specified. The answers shown in parts (a), (b), and (c) for Liquidity risk focus on Funding risk, but credit was also given for Asset risk if it was related to appropriate examples that were specific to the scenario.

Operational risk is the most relevant risk in these scenarios, so more credit was available for responses dealing with that risk than for the others.

The answers provided are more complete than required for full credit.

    (i) Liquidity Risk:
    Uncertain cash flow and volume of business:
    The timetable for development of the geographical area and likely increases in volume of business are very unpredictable. Can he manage the cash flow until the business is big enough to provide more dependable income?

    (ii) Counterparty Risk:
    Problem with clients paying their bills – the clients are Dr. Dan's counterparty.

3. Continued

(iii) Operational Risk:
- People risk
  - He does not manage his employees effectively
  - Small town location, lack of employee benefits make it harder to find good employees (size of his business does not support paying more)
  - High risk that accidents will happen to animals or that an employee does something wrong
- Crime risk, data risk, reputational risk
  - Could also result from substandard procedures and processes
- Business continuity risk
  - He does not have a back-up veterinarian
- Technology, regulatory
  - He does not have any resources providing him support in responding to new regulations
  - Running a one-man hospital gives him limited time -- keeping up on regulations may not be a priority

(iv) Professional Liability Risk
Lack of a more formal approach to hospital management is likely to result in serious errors made by employees. Although he has insurance, serious claims could result in greatly increased premiums or being deemed an uninsurable risk.

(b) Explain how the risks described in (a) change if Dr. Dan elects to pursue Option II.

Commentary on Question:
There had to be a logical connection between the type of risk and the scenario. Emphasis should be on what changes between the scenarios.

(i) Liquidity Risk: Dr. Dan's cash flow is his salary, which doesn't depend upon business volume; therefore, it's much more predictable.

(ii) Counterparty Risk: Dr. Dan's income does not depend on the financial arrangements between his employer and the clients. The risk is minimized if he is careful in choosing a financially-stable employer who can be expected to pay Dr. Dan's salary as expected.

(iii) Operational Risk: Dr. Dan is not responsible for hiring & firing other employees, or for training them, although since they assist him, he is directly affected by the quality of their work.

---

3. **Continued**

Crime risk & data risk are essentially nonexistent for him since he does not own the hospital.

Reputational risk affects primarily his employer, although his own professional reputation could suffer if his employer is not well-thought-of.

Technology risk affects primarily his employer

Regulatory risk affects his employer with respect to the hospital itself and its owner, but Dr. Dan is still responsible for complying with regulations affecting the practice of his profession.

(iv)   Professional Liability Risk: Dr. Dan's risk is minimized because he can concentrate on doing what he does best. He will not have to split his attention between managing a hospital and practicing medicine.

(c)   Explain how the risks described in (a) change if Dr. Dan elects to pursue Option III.

Commentary on Question:
There had to be a logical connection between the type of risk and the scenario. Emphasis should be on what changes between the scenarios.

(i)   Liquidity Risk: Cash flow should be more predictable due to MegaPet's established business model and the high-traffic location.

(ii)   Counterparty Risk: Risk from clients is minimized because Dr. Dan has to follow MegaPet's policy of charging up front. However, MegaPet is now a counterparty – MegaPet holds a considerable amount of Dr. Dan's money; if it goes under, he may have trouble recovering his money.

(iii)   Operational Risk: More subject to standardized procedures:
The corporate office monitors management reports generated by hospital admin system.
Standardized responses to regulatory risk and technology risk.

More corporate oversight to help minimize crime and people risk.

Better benefits attract better people, minimizing data risk.

Reputational risk is not so much dependent upon him as an individual; however, he is subject to the effects of unfavorable publicity concerning MegaPet.

---

3. **Continued**

    (iv)   Professional Liability Risk: Higher-quality management practices and employees make this lower-risk than for Option 1.

(d)

    (i)   Explain why, in the strategic risk management field, scenario analysis is adopted as a qualitative analytical tool, rather than as a quantitative tool.

    (ii)   Identify three qualitative factors that could influence Dr. Dan's choice among the three options.

Commentary on Question:
In part (i) for full credit two points needed to be made: insufficient data, and ignoring insights about the external environment due to being distracted by numbers. In part (ii) any reasonable qualitative factors that could influence Dr. Dan's choice were accepted.

    (i)   It is often difficult to estimate many of the strategic risks due to insufficient data. The statistical models backing the quantification of scenarios build on rather restrictive assumptions, such as no regime shifts, stable correlations and the absence of complex probabilistic or "fat-tailed" behaviors. There is a strong tendency for people to focus on numbers at the expense of more important qualitative aspects, such as the value of insights uncovered in the process of investigating the nature of the external environment. Scenarios can help to make blind spots visible and uncover areas where further knowledge and insight are needed.

    (ii)   How the population of the area will grow and thus be able to support a larger top line

        Operational risk in Option I because Dr. Dan's income depends to a great extent on employees who are not very well supervised

        There are so many moving parts to the business in Option I that it is not reasonable to expect that Dr. Dan can manage them well, in addition to practicing his profession

        Dr. Dan's hospital is only beginning to break even; there is no guarantee that that will continue. He already lacks capital. Can he survive?

(e)   Outline the guidance you will offer Dr. Dan as he chooses among the three options.

3.   **Continued**

Commentary on Question:
Candidates approached this question in various ways:

Some pointed out the pros and cons of each choice.

Some made statements like, "If work/life balance is the most important thing, then Option II would be best. If being your own boss is the most important thing, then Option I would be best . . . "

Some presented a series of questions and explained why the answers would be important in making the decision.

One way to test the validity of a candidate's response was to ask whether Dr. Dan would consider such advice worth paying for.

In general, outlining general steps that you (the consultant) would take to make a plan was not considered a very good answer: the response needed to be something specific that could actually guide Dr. Dan's decision-making.

Some important factors that Dr. Dan should consider:

Why is owning an animal hospital his dream? If he breaks apart the many aspects, he may find out what really matters most to him. For example, he may get more job satisfaction from maximizing the amount of time he is able to spend practicing his profession, than from "being his own boss".

If Dr. Dan is holding an extremely optimistic view of the future, he may be ignoring many pesky details because he is focused on a big future payoff that he does not want to share with anyone else.

If Dr. Dan is a pioneer in his field, he may have more freedom to try new things in Option I. In options II and III, what is management's tolerance for breaking new ground or differing from standard practice?

What is Dr. Dan's utility function? What are his family responsibilities? Does he have a life partner who could help absorb financial losses?

4. **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:

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

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

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

Commentary on Question:

The question tested candidates' understanding of the different return metrics used in a company. Candidates needed to show both how to calculate the returns and whether they understood how the various metrics are used.

Solution:

(a)　　Calculate the following measures of return for each unit:

　　　　(i)　　ROA

　　　　(ii)　　ROE

　　　　(iii)　　RAROC

　　　　(iv)　　RORAC

　　　　(v)　　RARORAC

　　　　Show your work.

Commentary on Question:

Candidates generally performed well on part (a). Some common mistakes were:
- *Not applying the Risk Adjustment to Net Income correctly. Some candidates incorrectly did the one or more of the following:*
  - *Summing Net Income and Risk Adjust to Net Income, as opposed to subtracting the Risk Adjustment to Net Income from the Net Income.*
  - *Using the Risk Adjustment to Net Income by itself as the RAR (risk-adjusted return) value in the numerator.*

---

4. Continued

> - *Either adding or subtracting Risk Adjust to Net Income to the Available Economic Capital or Required Economic Capital to determine the RAC (risk-adjusted capital) in the denominator.*
> - *Using Required Economic Capital in the RAROC calculation and Available Economic Capital in the RORAC and RARORAC calculations.*
>
> *If a candidate wrote down the formula, partial marks were given, even if the final numerical answer was wrong.*

	Unit A	Unit B
ROA = Net Income / assets	2.61%	2.80%
ROE = Net Income / Shareholder Equity (Assumption: Shareholder Equity = Available Economic Capital	11.60%	11.20%
RAROC = (Net Income - Risk Adjustment to Net Income) / Available Economic Capital	7.38%	6.40%
RORAC = Net Income / Required Economic Capital	11.86%	13.39%
RARORAC = (Net Income - Risk Adjustment to Net Income) / Required Economic Capital	7.55%	7.65%

(b) Explain the benefits of using risk-adjusted return measures as compared to traditional measures.

Commentary on Question:
Candidates performed well on this question part.

No points were given to candidates who merely stated that risk-adjusted return measures reflected risks while traditional measures did not, and who did not provide the benefits.

Risk adjusted returns can be compared across business units within a company as well as with the same measure employed in parallel businesses, such as banking, asset management and non-life insurance within diversified financial services companies.

Risk adjusted measure are considered more accurate, because the non-risk-adjusted return measures (ROE and ROA) do not take account of the risk that is being accepted to achieve the return generated.

4.   Continued

(c)   The CFO of Cypress concludes from your calculations that unit B is underperforming based on the RAROC measure.

   (i)   Explain why the CFO may be most focused on the RAROC measure.

   (ii)   Provide arguments to counter the CFO's conclusion that unit B is underperforming.

   Commentary on Question:
   Candidates generally did not perform as well on part (c). A few candidates, who did not derive the correct answer for RAROC in part (a), acknowledged that they may have made mistakes in their calculations for part (a) and answered part (c) with arguments as to how it could be shown that Unit B is not underperforming. These candidates did receive some credit.

   (i)   If Cypress is a stock company, the CFO could be interested in the measure that the stockholders are concerned with, which is RAROC. RAROC is based on the published capital that shareholders see.

   RAROC allows comparison across different product lines and takes into account the risks of the businesses. Shareholders will be most concerned about the risk-adjusted return of the equity position / available capital. Shareholders do not see required capital as this is typically for internal use.

   (ii)   Unit B does worse on a RAROC basis, but does better on a RORAC basis (and a little bit better on a RARORAC basis). So, once the capital is risk-adjusted, Unit B is performing better than A.

   RAROC is lower for Unit B because it has more excess capital. A sufficient buffer should be maintained between economic capital and risk-taking capacity, but Unit B appears to have more capital than it needs – it might be a newer business unit or a unit expected to be impacted by external forces (such as regulatory changes), which may warrant a larger buffer between economic capital and available capital. On a risk-adjusted basis Unit B would not be penalized for the excess capital.

5.   **Learning Objectives:**
   2.   The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.

Learning Outcomes:

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

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

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

Sources:
Financial Enterprise Risk Management, Sweeting, 2011, Ch. 14 Quantifying Particular Risks

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

ERM-101-12: Measurement and Modeling of Dependencies in Economic Capital, Ch. 4-5

Commentary on Question:
The goal of this question was to determine if candidates could apply financial models to a specific situation for two companies described in the stem. It asked candidates to apply a specified default model and a defined copula, and then analyze the reasonableness of the models used.

In parts (b) and (d) the candidate was asked to prove the answer given. (This allowed candidates who could not do the calculations in these parts to still proceed with the rest of the question.) We noted that some candidates provided a formula and numbers and then pretended to arrive at the correct answer. Those candidates did not receive any credit.

In sub-part (d)(iii) many candidates failed to justify their recommendations based on the information provided and instead provided generic reasons why copulas where appropriate.

5. Continued

Solution:
(a)

(i)   Explain how the payoffs to Acme's bondholders and stockholders can be viewed in terms of puts and calls.

(ii) Graph the payoffs to Acme's stockholders as a function of the potential asset values at the end of year three. Label your graph.

(iii) Graph the payoffs to Acme's bondholders as a function of the potential asset values at the end of year three. Label your graph.
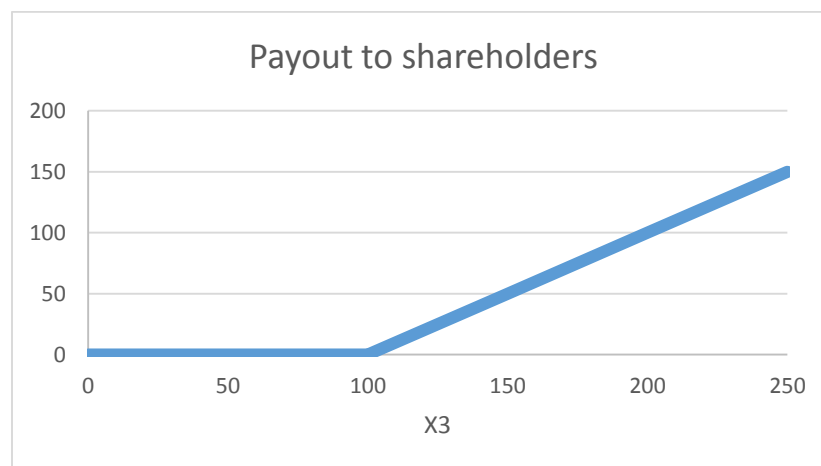
Commentary on Question:
Most candidates understood that the Shareholder was equivalent to the buyer of a call option. Many candidates did not recognize that the Bondholder was equivalent to the writer of a put option plus a risk free bond.

To receive full credit for the graphs candidates needed to label the x-axis, y-axis, and the debt level.
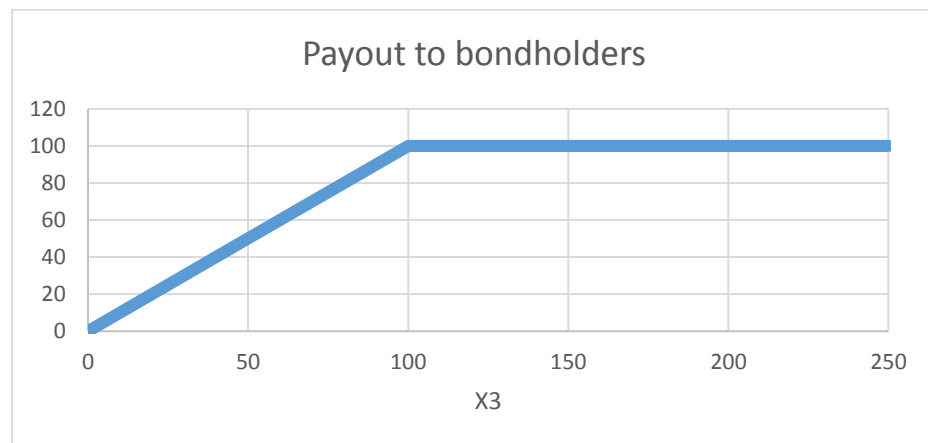
(i)   Bondholders receive B - max(B - X_3,0) This is equivalent to holding the bond, and writing a put option on the asset X_t, with term 3 years and strike B. Shareholders receive max (X_3 - B,0) This is equivalent to a 3-year call option on the asset X_t, with strike price B.

(ii)

Payout to shareholders

5. **Continued**

(iii)

Payout to bondholders

(b) Show that the probability of default at the end of year three using the Merton model is:

(i) 12.2% for Acme

(ii) 3.5% for Elliott.

Commentary on Question:
Candidates needed to demonstrate the steps in the calculation since the solution was given. Partial credit was awarded to calculating the mean and variance correctly, even if the candidate could not go further.

(i)

$$\frac{A_T}{A_0} \sim \log N\left((\mu\text{-}\sigma^2/2)\,T,\,\sigma\sqrt{T}\right) \sim \log N\,(\mu^*,\,\sigma^*)$$

$$\mu^*{}_A = (0.12 - 0.36^2/2) \times 3 = 0.1656 \qquad \text{and } \sigma^*{}_A = .36\sqrt{3} = 0.6235$$

$$\Pr[A_T < B] = \Pr\left[\frac{A_T}{A_0} < \frac{B}{A_0}\right] = \Phi\left(\frac{log(100/175) - 0.1656}{0.6235}\right) = \Phi(-1.164) = 0.1222$$

(ii)

$$\frac{A_T}{A_0} \sim \log N\left((\mu\text{-}\sigma^2/2)\,T,\,\sigma\sqrt{T}\right) \sim \log N\,(\mu^*,\,\sigma^*)$$

$$\mu^*{}_A = (0.04 - 0.29^2/2) \times 3 = -0.006 \qquad \text{and } \sigma^*{}_A = .29\sqrt{3} = 0.5023$$

$$\Pr[A_T < B] = \Pr\left[\frac{A_T}{A_0} < \frac{B}{A_0}\right] = \Phi\left(\frac{log\,(100/250) - (-0.006)}{0.5023}\right) = \Phi(-1.812) = 0.035$$

5. Continued

(c)   Calculate the probability that both companies will default at the end of year three. Show your work.

Commentary on Question:
Most candidates received full credit. Candidates who did not generally didn't assume independence as instructed.

0.1222 * 0.035 = 4.3%

(d)

   (i)   Show that the probability that both companies will default at the end of year three using the Clayton Copula is 3.4%.

   (ii)   Explain why the maximum possible value for the probability that both companies will default at the end of year three is 3.5%.

   (iii)   State with reasons whether the Clayton Copula with parameter $\alpha = 2$ is an appropriate model for the joint probability functions for the two distributions in this case.

Commentary on Question:
To receive full credit for sub-part (ii) candidates needed to identify that the maximum was limited by Elliott's probability of default and include a justification. Both mathematical and descriptive justifications were acceptable, assuming they were correct. Many candidates achieved full credit for this part.

Sub-part (iii) proved more challenging; a relatively small number of candidates noticed that the previous parts indicated a strong dependency between the two firms. Partial credit was given for relevant comments on tail dependency. Little credit was given for generic comments about the Clayton copula that did not relate to the question context.

   (i) $C_\theta(u_1, u_2) = (u_1^{-\theta} + u_2^{-\theta} - 1)^{-1/\theta}$, $(0.1222^{-2} + 0.035^{-2} - 1)^{-0.5} = 0.034$

   (ii)   The probability that both bonds default must be less than the probability that Elliott defaults. Adding another company cannot increase the chances above the probability of either individual company defaulting.

   (iii)   The Clayton Copula gives an answer very close to the maximum for joint default. This implies that if Elliott defaults, Acme will also default, which is an unreasonable assumption given that they operate in very different industries. Thus the Clayton Copula is not an appropriate model for this situation.

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

(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 modeling 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.

Sources:

Financial Enterprise Risk Management, Sweeting, 2011, Ch. 12 Extreme Value Theory

Value-at- Risk: The New Benchmark for Managing Financial Risk, Jorion, 3rd Edition Ch. 5 Computing VaR

Modeling Tail Behavior with Extreme Value Theory, Risk Management, Sept 2009

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

6. Continued

Commentary on Question:
The question is designed to test candidates' understanding of a company's risk modeling and various approaches to analysis of risk in the tail. Candidates are expected to be able to demonstrate and contrast how different risk metrics work, explain model and parameter risk, comprehend the appropriateness of various methods as applied to a company's businesses, and make reasonable recommendations.

Overall, candidates struggled with this question. Many of them received partial credit for their answers, but very few were able to respond to the entire question appropriately. It showed on the papers that many candidates didn't fully understand how to approach the question.

Solution:
(a)   Calculate the following risk metrics for Gaia's life and annuity block at a 95% confidence level over a quarterly horizon:

      (i)   Parametric VaR

      (ii)   Empirical VaR

      Show your work.

Commentary on Question:
Either relative VaR or absolute VaR could be used to answer the question. However, candidates needed to stay with choosing one method (either relative or absolute) in both parts of the question

Candidates in general were able to provide calculations for this part of question. However, many were not careful in applying numbers to the parameters and in consistently using either the relative or absolute method. So, the number of candidates who received full credit was fewer than expected.

We recognize that there are alternative views on whether 95% VaR refers to the 96th ordered loss or the 95th ordered loss (i.e., 8.2 vs. 7.4) for the empirical calculation. Either was accepted as an answer. The model solution below uses 8.2.

      (i)   Parametric VaR:
            The quarterly loss is assumed to be normally distributed, with mean -5 and standard deviation 8. The (absolute) VaR of losses is
            $VaR = -5 + 1.645 \times 8 = 8.16$

            The relative VaR is (VaR - Mean) = 13.16

6. Continued

(ii)   The (absolute) VaR is estimated from the data as the 96th ordered loss value, i.e., VaR=8.2
The relative VaR is VaR - Mean = 13.2.

(b)   Calculate a 95% confidence interval for each of the following risk metrics with respect to a sample of 100 observations that have an underlying Normal distribution.

(i)   95% Parametric VaR

(ii)   95% Empirical VaR

Show your work.

Commentary on Question:
Comparison must be apples-to-apples, i.e., either using the absolute or relative VaR method. Some candidates took a mixed approach, which distorted their results and the recommendations that were required for the remaining parts of the question. Care was taken in grading to avoid double-penalizing candidates for taking the same incorrect approach throughout the question.

Candidates generally received at least partial credit for this part of the question. Common errors were: missing the 2-sided test component, omitting 1.96 or using 1.645 instead of 1.96 in their calculations.

We recognize that the question did not specify how the parameters of the Normal distribution were to be treated. However, candidates generally assumed that the standard error for the parametric VaR arose solely from uncertainty in the standard deviation estimate (and not from uncertainty in the mean estimate), which was what the committee intended.

(i)   The standard error for $\hat{\sigma}$ is $\dfrac{\hat{\sigma}}{\sqrt{200}} = 0.57$

This gives a 95% CI for σ of (8-1.96(0.57), 8+1.56(0.57)) = (6.9, 9.2), which gives a 95% CI for the VaR (ignoring uncertainty in the mean) of (6.35, 10.13). Subtract the mean for relative VaR, which gives (11.35, 15.13).

(ii)   For Sample: Need to calculate the density function f(q), which we approximate with the density of a normal distribution with the same mean and variance as the data, i.e.,

6. **Continued**

$$f(q) = \frac{1}{\sqrt{2\pi}(8)} e^{-\frac{1}{2}(1.645)^2} = 0.0129$$

Then the standard error of the VaR (absolute or relative) is

$$\sqrt{\frac{(0.05)(0.95)}{100 f(q)^2}} = 1.69$$

which gives a 95% CI for the VaR of

$$\big(8.2 - 1.96(1.69), \quad 8.2 + 1.96(1.69)\big) = (4.89, 11.51)$$

Subtract the mean for relative VaR:

$$\big(5 + 8.2 - 1.96(1.69), 5 + 8.2 + 1.96(1.69)\big) = (9.89, 16.51)$$

(c) Assess whether the parametric or empirical VaR is the better approach for Gaia's life and annuity block. Explain your conclusions using your analysis in (a) and (b).

Commentary on Question:
Recommendations for either method received credit based on substantiation from the candidate's earlier analysis and other relevant support, as detailed below. Candidates using different empirical values could draw different conclusions.

Based on the approach used in the model solution, given the results in (a), the two approaches seem equally appropriate. But based on (b), it could be argued that the parametric approach is better due to the narrower confidence interval. There is not sufficient information about the company and the distributions to make a definitive statement, and candidates could receive credit for discussing the issues involved in making a choice.

Credit was also given to candidates who answered in a logical fashion even though their answers from (a) might lead them to a different conclusion. In all cases, answers needed to relate back to the information provided about Gaia's situation.

Some candidates who were unable to complete part (b) were still able to receive credit for (c) by stating how assumed results for (b) would affect their decision on the better approach.

In general, candidates did relatively better on this part than on the computational parts of the question. Many were able to explain the fundamental differences between the parametric and the empirical approaches.

The explanations given below are more complete than expected from candidates for full credit, but are intended to be educational.

6. **Continued**

The two approaches give similar results for Gaia's traditional business:
Parametric VaR and empirical VaR are very close.

- For a 95% confidence level, which is not too high, the normal distribution
  may adequately represent the empirical distribution.
- If the normal distribution adequately represents the loss data, the parametric
  approach is justified and gives tighter bounds (though we have ignored
  uncertainty in the mean).
- Intuitively, the parametric σ-based VaR approach should be more precise:
  o Uses information about the whole distribution of the sample (in terms of
    all squared deviations around the mean), whereas a quantile, empirical
    approach uses only the ranking of observations and the two observations
    (or one) around the estimated value.
- However, VaR based on the normal distribution ignores the actual data in the
  tail.
- Without evidence that the normal distribution is appropriate, the non-
  parametric approach may be better, as it makes fewer assumptions. The CI is
  wider, but that may appropriately reflect greater uncertainty in the estimate.
  (Also, the CI for the parametric case would be wider if we allowed for
  uncertainty in the mean.)
- However, the use of the normal distribution in estimating f(q) can lead to
  errors in the estimators.

(d)   Calculate the following risk metrics for Kismah General over a one-year horizon
        and at a 98% confidence level:

(i)   Parametric VaR, assuming losses are normally distributed

(ii)   Empirical VaR

Show your work.

Commentary on Question:
*Similar to parts (a) and (b), because comparison must be apples-to-apples,
candidates needed to choose to use either the absolute or relative VaR method.
Grading credit was given to candidates who looked for a 98% confidence level on
the empirical data via interpolation or using an open interval concept (as
opposed to a closed interval).*

6. **Continued**

       (i)   Parametric: Mean = \$30m, Variance = \$30m, α=2.05, T=1
              VaR(98%)[relative to mean] = α(W(0)xσ)sqrt(T) = 2.05 x (\$30m) x
              sqrt(1) = \$61.5m.
              OR
              VaR(98%)[absolute] = \$61.5m - \$30m = \$31.5m.

       (ii)   Empirical: VaR(98%)[relative to mean] = E(W) - W* = \$30 - (-\$111)
              {2nd percentile value} = \$141m annually.
              OR
              VaR(98%)[absolute] = - W* = - (-\$111) = \$111m.

(e)

       (i)   Plot the losses predicted by assuming a Normal $\left(30, 30^2\right)$ distribution for
              the P&L of the Kismah General insurance block against the historical
              values at the following percentiles:

              1. 90th

              2. 95th

              3. 99th

       (ii)   Interpret the results.

Commentary on Question:
The candidates were expected to sketch a q-q plot with normal losses vs empirical losses, which do not fall on a 45 degree angled line. However, other graphs were also acceptable for demonstrating the loss comparison.

The question did not direct candidates to show their work, so a graph with the appropriate values could receive full credit in sub-part (i) even if candidates did not show the calculations. Partial credit was given to candidates who showed work correctly but didn't plot a graph.

6. Continued

(i)
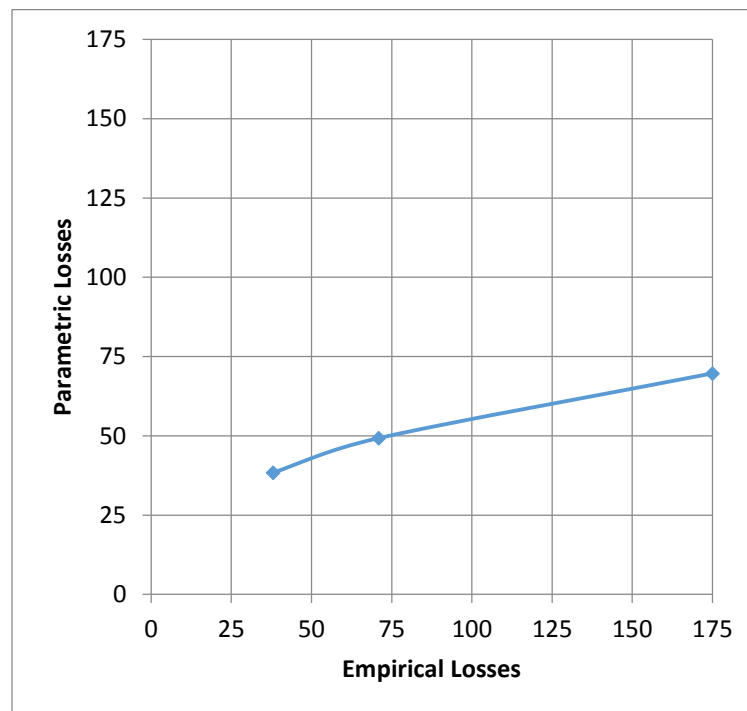
The answer should be a graph with these values:
Recall $z = (x-\mu) / \sigma$, therefore $x = \sigma z + \mu$
Loss (in million) [absolute]
90th sample:
$8 loss vs. N($30,30^2): $x = (-1.28 \times \$30) + \$30 = -(\$38.4 - \$30) = -\$8.4$.
95th sample:
$41 loss vs. N($30,30^2): $x = (-1.64 \times \$30) + \$30 = -(\$49.2 - \$30) = -\$19.2$.
99th sample:
$145 loss vs. N($30,30^2): $x = (-2.33 \times \$30) + \$30 = -(\$69.9 - \$30) = -\$39.9$.
OR
Loss (in million) [relative to mean]
90th sample:
$38 loss vs. N($30,30^2) - $30: $x = (-1.28 \times \$30) = -\$38.4$.
95th sample:
$71 loss vs. N($30,30^2) - $30: $x = (-1.64 \times \$30) = -\$49.2$.
99th sample:
$175 loss vs. N($30,30^2) - $30: $x = (-2.33 \times \$30) = -\$69.9$.

6. Continued

      (ii)   The Normal distribution does not fit well with the tails of the sample data. The further into the tail, the bigger deviation there is in estimating losses.

(f)   Calculate the 98th percent quantile estimator of VaR using your fitted Generalized Pareto model. Show your work.

Commentary on Question:
Most candidates did well on this part and received full credit. Among the candidates who earned only partial credit, many of them made mistakes in their computations because they assigned incorrect values to the parameters.

$c = 0.98$, $\xi = 0.5$, $\beta = 100$, $u = 41$
$\widehat{VaR} = u + (\beta / \xi) \{ [(N/Nu) (1-c)]^{\wedge}(-\xi) - 1\}$
$= \$41 + (\$100/(1/2)) \{ [(100/5)(1 - 0.98)]^{\wedge}(-1/2) - 1 \}$
$= \$41 + \$200 \{ [(20)(0.02)]^{\wedge}(-1/2) - 1 \}$
$= \$41 + \$200 \{ [0.4]^{\wedge}(-1/2) - 1 \}$
$= \$41 + \$200 \{ 1.5811 -1 \}$
$= \$41 + \$200 \{ 0.5811 \}$
$= \$41 + \$116.22$
$= \$157.22$ million

(g)   Recommend the most appropriate method for estimating VaR from those computed in (d) and (f) to use for the Kismah General insurance block. Justify your choice with reference to specific results from your analysis.

Commentary on Question:
The answer needs to apply to Kismah, and should reference the computations in (d), (e) and (f). To get full credit, candidates need to show good understanding in explaining their choice and in comparing Gaia and Kismah General. A good recommendation should not be simply based on which method would be easier to compute. It should use the results of analysis, giving reasons to reject methods that are less appropriate for Kismah's fat tail risk and to indicate why the recommended method is the best.

Most of the candidates were able to provide some levels of comparison between methods to support their recommendations, even if their computations in parts (d) and (f) were incorrect. Some candidates gave more thorough and logical answers than others and therefore received more credit.

6. **Continued**

With respect to current Parametric VaR:
Even though a higher confidence level is used, (d) and (e) demonstrate that the Normal distribution does not fit the tails of the historical data, getting worse as one goes further into the tail. The historical data clearly has fatter tails than the Normal distribution, so Gaia's current parametric approach should not be used for Kismah General.

With respect to VaR using historical data or EVT:
Comparing the results of (d) and (f), the estimated VaR using the fitted Pareto distribution indicates much higher risk exposures uncovered by the tail loss data than is revealed by the quantile measure.

EVT applies only to the tails and may be inaccurate for the center of the distribution. The extreme value semi-parametric approach should be used to assess Kismah General's losses, as this company has very concentrated risks which could be expected to exhibit greater relative losses than that experienced by the industry overall.

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.

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

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

(5e)   Demonstrate the ability to develop a capital model for a representative financial firm.

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

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

ERM-118-14: Model Validation Principles Applied to Risk and Capital Models in the Insurance Industry

Summary of "Variance of the CTE Estimator", Risk Management, August 2008

SOA 2012 Annual Meeting - Session 53 -- Assumption Setting Best Practices (Steiner slides)

Commentary on Question:
This question tests candidates' understanding of model and parameter risk, by application to a specific company situation. Overall, candidate performance on this question was disappointing, particularly on the parts that required candidates to go beyond direct recall from the sources.

Solution:
(a)   Describe potential areas of concern with model governance (Principle II) at Bunche.

7. Continued

Commentary on Question:
Candidates did well on this question part.

Many candidates provided areas of concern with the model that were not specifically issues relating to model governance. Points were awarded only if the concern listed could be related to model governance. Three distinct concerns were required for full credit.

- Is the segregation of duties defined? Although the pricing actuaries created the model, the corporate risk actuaries converted it for internal capital. Both pricing and corporate risk teams are using the same model for different purposes, which indicates the segregation of duties is not well-defined.
- The groups responsible for model usage and model changes are not clearly defined.
- There is no reference to how senior management or internal audit is involved in the model implementation.
- Some of the model assumptions have not been changed since it was developed five years ago, which could indicate that model governance may not be aligned with the importance of the model as part of the decision making process.

(b) You are validating the model parameters for the following risks:

    (i)   Pandemic Risk

    (ii)   Operational Risk

    (iii)   Expense Risk

Identify an appropriate estimation method for parameterizing each of the risks listed above. Explain your response.

Commentary on Question:
Candidates appeared to struggle with this question part.

The question was intended to get at specific parameter estimation methods, but many candidates addressed the question more generally, describing how they might estimate, without identifying a specific method. Credit could still be earned for this approach.

Many candidates provided a method for validating and described the method, but didn't explain why that method was appropriate for the specific risk. Partial credit was given in these cases.

7. **Continued**

Some candidates specified risk estimation methods, not parameter estimate methods. Depending on the level of detail, partial credit was given.

(i)   A *Pandemic Risk* model uses frequency and severity parameters to determine the impact of a pandemic. Information may be limited, but if some information is available, the parameters could be estimated using MLE.

(ii)   An *Operational Risk* model also uses frequency and severity parameters. Information may be limited, but if some information is available, the parameters could be estimated using MLE.

(iii)   If there is not enough historical information then the *Expense Risk* model could include an expense assumption that would be estimated using model free methods. If expenses are based on claim amounts, then the claim amount parameter could be estimated using Regression analysis.

(c)   The mortality assumption currently used in the model was provided by a consultant five years ago and has not been updated since. There have been changes to the product designs and mix of business in the last five years.

(i)   Identify key considerations that should be taken into account in updating Bunche's mortality assumption.

(ii)   Explain how to apply each of Principles I, II, and III to the mortality updating process.

Commentary on Question:
Candidates did well on both sub-parts of this question.

On sub-part (ii) many candidates explained Principles I, II, and III but not how to specifically apply them to the mortality updating process. Points were only awarded if the explanation could be applied to the mortality updating process in an EC model.

The model solution given is more complete than would be required for full credit under exam conditions.

7. **Continued**

(i) *Experienced Mortality* – mortality assumption should not be solely based on industry data, but should also reflect experienced mortality. Reinsurer and consultant data should also be considered. As the experience data becomes more credible, it is given a larger weight in the assumption.

Industry trends – has the industry seen a trend in mortality of insured lives?

Target market – have the market demographics of people buying the product changed over the past five years? For example, has the male / female ratio changed? Has the distribution of risk classes (standard / preferred) changed over the past 5 years? Different cohorts could experience different mortality.

Distribution- Have the distribution methods for selling the product changed? If the distribution has changed (e.g., selling via the internet vs. agent-sold business), Alpha could be exposed to more anti-selection, which would negatively impact mortality.

Product Changes – Both product design changes and new product opportunities can give the policyholder more choices. If there are more choices, then there is more opportunity for the policyholder to anti-select, which could negatively impact mortality.

(ii) *I. Model design and build need to be consistent with the model's intended purpose*
- Ensure the mortality assumption is valid for an EC Model (the original model was for pricing, but its current intended use is EC).
- Is the mortality assumption a critical component of the EC model? This will help determine the level of sophistication that should be used in modeling this assumption.
- Ensure the correlations between mortality and other risks are reflected (e.g., mortality and lapse may be inversely related due to anti-selective behavior).

II. Ensure appropriateness of established model governance
- Are there controls around updating the mortality assumption (e.g., model version control)? Are results from prior model versions reproducible?
- Are the duties of those updating / validating / reviewing the mortality assumption clearly defined?
- Is relevant model documentation updated accordingly?

7. **Continued**

III. *Validate the model components* (Input - Calculation - Output)
- Ensure the new mortality assumption is implemented properly (e.g., dynamic validation testing of trends, single cell testing, etc.).
- Have all the key considerations been included in validating the mortality assumption (e.g., impact on other assumptions)?

(d) Outline the process you would follow to determine if your manager's focus on validating only the mortality and lapse assumptions in the EC model is appropriate.

Commentary on Question:
Candidates overall did not do well on this part.
Common responses that received partial credit were:
(i) describing the steps for validating a model in general
(ii) describing the steps for validating an EC model without a discussion of the choice of validating mortality and lapse over other assumptions

No points were awarded for responses that described the process for validating the mortality and lapse assumptions without mentioning other assumptions in the model.

- An important model validation principal is "Make model validation efforts proportional to evidenced areas of materiality and complexity". Is there evidence that the other assumptions are not as material as mortality and lapse? Are there defined company guidelines as to the materiality of risks?
- Evaluate sensitivities to each of the input assumptions used in the model: Mortality, Surrender/Lapse, Interest Rates, and Discount Rates. Were valid parameter estimation methods used?
- Evaluate sensitivities to the correlation assumptions. If the correlation changes, how significantly will this impact the Economic Capital?
- Are there components missing in the model? Are all the risks addressed?
- Does the complexity of the modeling for each risk correlate with the materiality of that risk?

8.

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

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:
(2h) Construct approaches to modeling 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.

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

(4j) Demonstrate risk management strategies for other key risks (for example, operational, strategic, legal, and insurance risks).

Sources:
ERM-605-12: Modern Investment Management, Litterman, Ch.10: Strategic Asset Allocation in the Presence of Uncertain Liabilities

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

8. Continued

Commentary on Question:
This question tests the candidate's understanding of surplus risk in a pension plan. It requires both directed calculations of risk metrics and demonstration that the candidate understands what the metrics mean.

Solution:

(a) Explain to the Pension Committee how each of the terms R_B, ε, and β contribute to modelling the Plan liabilities effectively.

Commentary on Question:
Candidates did well on this part. Some candidates used CAPM definition of β; such candidates received partial credit.

R_B: represents the return on a bond index/portfolio of bonds
If the Plan liabilities were known with certainty, the liability would resemble a portfolio of bonds that could be priced using the current term structure of interest rates. A publicly traded bond index can be used as a proxy.

ε: Noise term
The uncertainty of future payments requires a noise term in the valuation.

β: Ratio of the liability duration to the bond index duration
The bond index excess return is levered by the factor β to match the duration of the bond index, B, to that of the liability stream, L.

(b) Demonstrate that RACS is analogous to the Sharpe ratio.

Commentary on Question:
Candidates did well on this part. Some candidates only explained the analogy, instead of deriving it, they received partial credit.

Expand $S = A - L$, where A = assets and L = liabilities, then:
$RACS_t = E_t [(A_{t+1} - L_{t+1}) - (A_t - L_t)(1 + R_f)] / \sigma_t [A_{t+1} - L_{t+1}]$,
$= E_t [(A_t (1 + R_{A,t+1}) - L_t(1 + R_{L,t+1}) - (A_t - L_t)(1 + R_f))] / \sigma_t [A_t (1 + R_{A,t+1}) - L_t (1 + R_{L,t+1})]$
In the absence of Liabilities, i.e., $L_t = 0$:
$RACS_t = E_t [(A_t (1 + R_{A,t+1}) - (A_t)(1 + R_f))] / \sigma_t [A_t (1 + R_{A,t+1})]$
$= E_t [(A_t (R_{A,t+1} - R_f))] / \sigma_t [A_t (1 + R_{A,t+1})]$ ($E_t [A_t] = A_t$)
$= (E_t [R_{A,t+1}] - R_f) / \sigma_t [R_{A,t+1}]$, which is the Sharpe Ratio of an asset portfolio

8. **Continued**

(c) Calculate the following values for the Plan's Passive Benchmark asset portfolio:

    (i)   Expected asset portfolio excess return

    (ii)   Volatility of the asset portfolio return

    (iii)   Sharpe Ratio

Show your work.

Commentary on Question:
Candidates did very well on this part. Candidates who had the correct formulae but made calculation mistake(s) received partial credit.

    (i) $E[R_P - R_F] = 0.45\ (2.22\%) + 0.20\ (1.6\%) + 0.35\ (0.26\%) = 1.41\%$

    (ii) $\sigma_P^2 = w' \Sigma w = [0.45\ 0.20\ 0.35] \times$ Variance-Covariance Matrix $\times [0.45$
            $0.20\ 0.35]' =$
            $\sigma_P^2 = [0.45\ 0.20\ 0.35] \times [0.0143\ 0.0149\ 0.0007]'$
            $= 0.00966275$
            $\sigma_P = \mathrm{sqrt}(0.00966275) = 0.0983 = 9.83\%$

    (iii)   Sharpe ratio = (Asset Excess Return) / σ_P = 1.41% / 9.83% = 0.143

(d) Calculate the following values for the Plan liability portfolio:

    (i)   Expected liability portfolio excess return

    (ii)   Volatility of the liability portfolio

Show your work.

Commentary on Question:
A number of candidates omitted this part. Candidates who provided the CAPM definition for β in part (a) received partial credit for sub-part (i).

    (i) $E[R_L - R_f] = E[\beta(R_B - R_f) + \varepsilon]$
            $\beta =$ Duration Liability / Duration LG&C index = 10 / 10.2 = 0.98
            $E[R_L - R_f] = 0.98(0.50\%) + 0 = 0.49\%$

8. Continued

(ii)   Variance (R_L) = Variance $(\beta(R_B) + \varepsilon)$
         = β^2 Variance(R_B) + Variance(ε)
         = $(0.98)^2 (\sigma_B^2) + (2\%)^2$ (where 'B' is LG&C bond index)
         = $(0.98)^2 (7.1\%)^2 + 0.0004$
         = $0.004841 + 0.0004$
         = 0.005241
         Thus, volatility is sqrt $(0.005241) = 7.24\%$

(e) Given Plan assets of $644 million and Plan liabilities of $736 million, calculate the following values:

     (i)   Expected dollar excess return on surplus

     (ii)   Volatility of S_1

     (iii) $RACS_0$

Show your work.

Commentary on Question:
Most candidates did not do well on this part. The most common mistakes were not calculating the dollar excess return in sub-part (i) and using the wrong volatility formula for the surplus. This part depends on results from prior parts; candidates who had the prior part wrong but the correct formulae and calculations in this part received full credit.

     (i) $E[R_S - R_f]$ = E[$Excess return on assets - $Excess return on Liabilities]
         = $644 (1.41%) - $736 (0.49%)
         = $9.080 - $3.606 = $5.474 million

     (ii)   Variance (S_1) = Variance $(A_0 (1 + R_A) - L_0 (1 + R_L))$ = Variance (Assets - Liabilities)
         = $(\$644^2 \sigma_A^2) + (-\$736^2 \sigma_L^2) + 2\rho (\$644)(-\$736)\sigma_A\sigma_L$
         = $(\$644)^2 (0.0983)^2 + (-736)^2 (0.0724)^2 + 2(0.62)(644)(-736)(0.0983)(0.0724)$
         = $4,007.55 + 2,839.44 - 4,182.90$
         = $2,664
         Volatility = sqrt(2,664) = $51.61

     (iii) $RACS_0$ = Excess Surplus return / Volatility
         = $5.474 / $51.61 = 0.106 = 10.6%

8. **Continued**

(f)   Interpret your RACS metric result relative to the Sharpe ratio of the Plan assets for the Pension Committee.

Commentary on Question:
Most candidates provided only partial answers.

RACS generalizes the Sharpe ratio to incorporate the risk / reward profile of the liabilities.

The Sharpe ratio of 0.143 means that there is a reward of 0.143 per unit of risk on the Plan's assets.

The RACS metric of 0.106 incorporates the Plan's liabilities, and thus reflects the Plan surplus, and means the Plan Surplus has a reward of only 0.106 per unit of risk.

The Sharpe ratio overstates the risk/reward relationship.

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

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

  (4j)   Demonstrate risk management strategies for other key risks (for example, operational, strategic, legal, and insurance risks).

Sources:
ERM-608-14 Elements of an Investment Policy Statement for Institutional Investors

Commentary on Question:
The question tests candidates' understanding of governance considerations related to pension plan investment policy statements. They were asked to apply the governance elements from the source to the SLIC policy statement provided in the case study and to analyze the specific recommendations given in the question stem.

Most candidates had difficulty with the question, perhaps because it was not quantitative, as is more usual for the case study questions.

Solution:
(a)   Select any three of the five key governance elements listed above, and for **each of the three**:

        (i)   Identify requirements in the Plan's current Statement of Funding Policies and Procedures and SIP&P that apply to the given governance element.

        (ii)   Identify one of Bill's recommendations that should be addressed by the specific governance element, and assess whether that recommendation would violate the Plan's current policies on governance.

        Commentary on Question:
        Candidates did reasonably well on sub-part (i) and not as well on sub-part (ii) Sub-part (i) asked candidates to identify the requirements in the current SIP&P; some candidates instead answered what such policy should require in general, those candidates received limited credit. In sub-part (ii), many candidates were able to recognize the governance concerns that were built into Bill's recommendations in the stem of the question, but did not do as well on assessing the recommendations against the current policies.

        Sample answers are provided for all five governance elements; candidates needed to respond for any three of the five. The answers given are examples; other appropriate responses could receive credit.

9. **Continued**

(i) **I. Specification of responsibilities:**

- Management (CFO & VP, HR) will establish, review, and amend the SIP&P
- Pension consultant / actuary will assist in preparation of the SIP&P
- Custodian will present at least annually reviews on Fund Manager performance

II. Process for reviewing and updating SIP&P:

Policy states "The Management will establish, review, and amend, as required, the SIP&P."   However, there is no stated explicit process for updating the SIP&P. Management is the CFO (vacant) and VP, HR (Mary).

III. Responsibility for engaging and discharging external advisors:

Policy states "Management will select one or more Fund managers, the Pension Consultant and the Actuary." The excerpts presented in the case study do not address the responsibility for discharging external advisors (but it may be implied that "selecting" includes discharging and then selecting a different manager).   Management is the CFO (vacant) and VP, HR (Mary).

IV. Roles and responsibilities of boards and staff:

Policy states "The Board of Directors of SLIC has delegated responsibilities for the day-to-day management of the Plan to the VP, HR and the CFO. The CFO's focus is on financial reporting and cash contribution requirement; the VP, HR is largely responsible for all other activities.

"Allocation of Responsibilities" also states that management is responsible for the statement of funding policies and procedures, selecting the pension consultant and actuary, and reviewing funding reports. Management is the CFO (vacant) and VP, HR (Mary).

V. Responsibility for determination of asset allocation:

There is no statement as to who determines asset allocation policy, the inputs used, and the criteria for setting assumptions.

9. Continued

(ii) **I. Specification of responsibilities:**

Bill has been monitoring the Plan's investment results and is now suggesting investment policy changes as well as suggesting that he ultimately execute some of the policy by managing some of the Plan's funds directly. Bill is not part of the Pension Committee or Management (as defined in the policy).

There is a potential problem with Management responsibilities at this time because half of the management team, the CFO, is not in place, leaving Mary to carry full responsibility. Bill has been stepping into this role, which could be seen as inappropriate interference or as an appropriate attempt to assist Mary. Changing the SIP&P only on Bill's recommendation would be a violation.

II. Process for reviewing and updating SIP&P:

Bill wants Mary to rush through an amended SIP&P, citing urgency with respect to current market opportunities.

Changing the SIP&P solely on Bill's recommendation, without taking the time to review each suggestion with appropriate due diligence would be a violation. It also isn't clear whether Mary, as the only specified Management person currently, could unilaterally update the Investment Policy Statement.

III. Responsibility for engaging and discharging external advisors:

Bill is proposing that Mary discharge one of the current external bond fund managers and engage his team's services.

The question arises of whether Mary can act unilaterally to make changes, as the only specified member of Management currently. If so, she would be acting within her (i.e., Management's) responsibilities to discharge the current external bond manager and replace with Bill's team. There is no stated prohibition against using internal SLIC managers.

IV. Roles and responsibilities of boards and staff:

Bill is asking Mary to get a revised SIP&P to the Board for approval as soon as possible, citing urgency related to market conditions.

9.   **Continued**

Management has been delegated the authority to amend the SIP&P, and Mary is currently the only specified Management person. The question arises as to whether it is appropriate for her to act unilaterally. Assuming she can, she also has authority to "be responsible for the assumption or delegation of any unmentioned responsibilities, so it would seem she has policy support to act on her own as "Management".

V. Responsibility for determination of asset allocation:

Bill is recommending a shift in the Plan's asset allocation by adding a 10% allocation to hedge funds, funded by a reduced allocation to US Equity.

Changing the universe of permitted asset classes to include the hedge fund would require a change in investment policy, which can be done by ""Management"". Without a CFO, Mary is the only specified Management person. It appears that technically Mary can change the policy on her own, or perhaps this needs to wait until a CFO is appointed.

If Mary acts on her own, an allocation of Plan assets to hedge funds should only be considered after an allocation to a new asset class is approved in conjunction with the pension consultant and actuary, and an asset allocation exercise determines the appropriate percentage to be allocated.

(b)

(i)   Identify and explain a sixth key governance element that is not on the list above.

(ii)   Propose a new statement to be added to the SIP&P that would rectify this shortcoming in the Plan's governance.

Commentary on Question:
This part asked candidates to recall the additional governance element from the source that was not provided in the question. Most candidates were not able to recall that information, and many candidates skipped this part. The answer shown for sub-part (ii) is an example, and other appropriate answers received full credit.

(i)   "Assign responsibility for risk management, monitoring, and reporting" is the governance element that is missing from the list in the question. This governance element suggests that a statement should be included in the SIP&P detailing who has responsibility for setting risk policy, monitoring the risk profile of the investment portfolio, and reporting on portfolio risk.

9. **Continued**

        (ii)   This SIP&P sets forth responsibilities for risk measurement, monitoring, and management to be fulfilled by the Risk and Compliance Officer, based on input from the Chief Investment Officer. Additional risk management oversight may be provided by the Treasurer's office, as the Chief Investment Officer deems necessary, to supplement the primary responsibilities identified.

(c)   Recommend a new organizational structure defining roles and responsibilities for investing the Plan's assets. Justify your recommendation.

Commentary on Question:
This part of the question asked candidates to look more holistically at the weaknesses of the existing structure and recommend how it could be improved. A number of candidates omitted this part. Some candidates recommended a new organizational structure for the Company instead of the Plan; such candidates received minimal credit.

Several possible approaches would be appropriate, and candidates received credit for reasonable recommendations. The answer shown is an example of one that would receive full credit.

A pension committee should be formed with more members, including VP of HR, CFO, and Chief Investment Officer. There should be a back-up interim committee member to represent any position that is currently vacant (as with the SLIC CFO) or to address temporary absences. The Board should have oversight responsibility for the investment of the Plan's assets and should delegate investment authority to this pension committee. As the focus is on investing the Plan assets, the Chief Investment Officer should be the chair.