ERM Model Solutions
Fall 2024

1. Learning Objectives:

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

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

Learning Outcomes:

(3a) Demonstrate how each of the financial and non-financial risks faced by an organization can be amenable to quantitative analysis.

(3e) Demonstrate the importance of the tails of distributions, tail correlations, and low frequency / high severity events, and the use of extreme value theory to analyze these situations.

(3g) Evaluate and select appropriate models to handle diverse risks, including models that use a stochastic approach.

(4a) Determine risk exposures using common risk measures (e.g., VaR and TVaR) and compare the properties and limitations of such measures.

Sources:

Quantitative Enterprise Risk Management by Mary Hardy and David Saunders, Chapter 5 Extreme Value Theory

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

Commentary on Question:

The goal of this question was for candidates to understand why Extreme Value Theory is appropriate for modeling black swan events and why other risk measures are not. Candidates should have been able to recognize that there is often not enough internal data to model extreme events and how to approach the problem in light of that context. They should also understand the methods for modeling extreme losses and when to apply each.

1. Continued

Solution:

(a) ABC has only experienced a small number of claims related to gene-cell therapy and is considering the use of external data to supplement internal data.

(i) Explain the advantages of using external data in this situation.

You are evaluating the following three aggregation methods for combining external claim frequency data with internal data:

- Using external data directly
- Scaling external data using a scaling algorithm
- Applying a proportionality factor to external data

(ii) Explain the pros and cons of each aggregation method.

Commentary on Question:
Candidates performed very well overall on this first part of the question, with almost all candidates receiving at least half of the possible points, if not more. The first question was typically answered with relative ease by most candidates. Those who struggled here tended to use the same reasoning as pros/cons for both the scaling algorithm and the proportionality factor, without doing much or any differentiation between the two methods.

(i) Not having enough internal data could lead to incorrect results, as it would be difficult to model large losses or the shape of the tail distribution with only a handful of claims. Using too small of a dataset creates difficulty in reliability differentiating outliers. External data can supplement internal data to increase the incidence of high claims and lead to more accurate estimation of losses.

(ii) <u>Using external data directly</u>
Pros: This is the simplest and quickest method, as no adjustments to the data are necessary.
Cons: External firms may have different sizes or characteristics than ABC, so the external data may not appropriately align with the internal data, especially when considering that ABC is a smaller insurer.

<u>Scaling external data using a scaling algorithm</u>
Pros: This would produce the most accurate results since a more robust method is used to adjust the data to incorporate into ABC's internal data.
Cons: Developing a robust scaling algorithm may be challenging and resource intensive, and ABC may lack the expertise to appropriately develop, validate, and communicate the results.

1. Continued

Applying a proportionality factor to external data
Pros: This method is more straightforward and does not require as robust of mechanisms as using scaling algorithms, while still providing some appropriate adjustments to the external data that using it directly would ignore.
Cons: In some contexts this approach may be too simplistic and relies heavily on assumptions, which introduces the potential for bias or error.

(b) Your intern Alvin has combined external data with ABC's internal data. You ask him to consider using block maxima models to model extreme losses related to gene-cell therapy.

Alvin has made the following comments about distributions associated with block maxima models, where ξ is the shape parameter:

- "*The Fréchet distribution is the Generalized Extreme Value (GEV) distribution with* $\xi < 0$. *It is fat-tailed distribution for use in managing extreme risks in finance and insurance.*
- *The Gumbel distribution has* $\xi > 0$. *It is bounded and would not be recommended in this scenario.*
- *The Weibull distribution is the GEV with* $\xi = 0$. *This distribution has no upper bound and would be suitable in this case for large losses.*"

Evaluate the accuracy of each of Alvin's comments. Justify your response.

Commentary on Question:
Candidates performed generally well on this part, with most recognizing the inaccuracies in the shape parameters. Some candidates could have received more credit but they only addressed the shape parameters and did not address the accuracy of the commentary on tails or boundedness of the distributions.

Fréchet: this statement is partially correct. Alvin is accurate in his assessment of the Fréchet distribution being fat-tailed and is used in managing extreme risks in finance and insurance, however the shape parameter is positive, not negative, with larger values of ξ indicating fatter tails.

Gumbel: this statement is not accurate. The shape parameter of the Gumbel distribution is equal to zero, and the distribution is unbounded with tails ranging from thin to fat.

Weibull: this statement is not accurate. The Weibull distribution is the GEV with $\xi < 0$. The distribution is bounded from above and thus is not ideal for modeling large losses, unless they have a known upper bound, which is not the case in this scenario.

1. Continued

(c) Alvin has selected a distribution and provided estimates for the scale parameters μ and θ, and the shape parameter ξ for two different scenarios. One scenario uses a 12-month block size, and the other scenario uses a 24-month block size. The standard error of each parameter is in parentheses.

- Block size of 12 months: $\mu = 124.5\ (20), \theta = 10.3\ (2.4), \xi = 0.850\ (0.012)$
- Block size of 24 months: $\mu = 150.3\ (18.8), \theta = 9.3\ (1.4), \xi = 0.943\ (0.543)$

(i) Identify which of the above three distributions is most appropriate for each scenario given the parameter estimates. Justify your response.

(ii) Explain the tradeoff between using either the 12-month or 24-month block sizes.

Commentary on Question:
This part of the question is where some candidates started to struggle with the concepts. Many candidates recognized that the distributions were Fréchet, given the positive shape parameter, unless they were also incorrect in those parameters in part (b). In subpart (i), some candidates identified the 24 month block size as a Gumbel distribution given the higher standard error (0.543), but given it was still two standard errors above zero, Fréchet was still the more appropriate choice. Many candidates struggled with subpart (ii) and incorrectly assumed that 12 and 24 months were referring to lengths of time as opposed to sample block sizes. Very few candidates received all of the possible credit on that subpart.

(i) As the shape parameter for each of the distributions is greater than zero, both scenarios follow the Fréchet distribution.

(ii) Using the block maxima method runs the risk of the exclusion of some maxima depending on how the blocks fall. With larger blocks, we can be more confident that the maxima sampled from each block fall in the tail of the distribution, however this also provides fewer overall maxima to fit a model with. Smaller blocks provide a larger sample of maxima but they may not be near the tail of the distribution. As evidenced by the 24-month block size above, larger data sets can also lead to higher standard errors for the epsilon parameters, which is problematic since the epsilon indicates the form of the GEV distribution to use.

1. Continued

(d) Alvin has gathered a sample of 200 losses using the combined data set shown in the tab "Q1.d" of the Excel spreadsheet. He plans to use the following formulation of the generalized Pareto distribution (GPD) to calculate tail risk metrics.

$$Q_\alpha = d + \frac{\beta}{\xi}\left(\left(\frac{S_x(d)}{1-\alpha}\right)^{\xi} - 1\right)$$

(i) Recommend an appropriate threshold to use to indicate extreme tail events for gene-cell therapy claims given the sample data set. Justify your response.

(ii) Calculate the 95th, 99th, and 99.9th percentiles of the loss distribution using the GPD with the parameters as shown in the tab "Q1.d" of the Excel spreadsheet . Show your work.

Commentary on Question:
This part of the question saw a wide distribution of outcomes across candidates, with many receiving the majority of the credit but some others struggling to provide a sufficient response. While not shown in the model solution, calculating and graphing using the MEL method was accepted as a solution, and many candidates took that route and received credit, though some of them suggested a significantly lower threshold than was reasonable, which led to them receiving less credit. In part (ii), most candidates were able to set up the percentile formulas correctly, but some failed to correctly calculate the d and $S_x(d)$ parameters, or failed to realize that they should not change for each percentile calculation. In some instances, this led to unreasonable outcomes which could have been recognized by candidates as an error in their work.

(i) Refer to Excel template for solution.

(ii) Refer to Excel template for solution.

(e)

(i) Explain why VaR and TVaR are not appropriate risk measures for this situation.

(ii) Recommend which method – block maxima or GPD – is more appropriate for modeling large losses due to gene-therapy claims. Justify your response.

1. Continued

Commentary on Question:
On subpart (i), candidates seemed to grasp what the question was asking but sometimes came short in providing a sufficient response, specifically failing to mention why TVaR is not an appropriate risk measure – though almost all candidates understood why VaR is not appropriate. In subpart (ii), candidates performed very poorly overall – many did not seem to fully understand the difference in the two methods or how they could be applied to the context of the problem. More importantly, this seemed to be a situation where candidates were not responding to the verbs put for the in the problem appropriately, as the question asked for a recommendation and a justification, and very few candidates provided much of a response to justify their recommendation.

(i) VaR is a threshold measure representing only the probability that a single value will be exceeded a certain percentage of the time, which does not provide any information as to the severity of losses beyond that threshold. Although TVaR is an improvement upon VaR as it gives some information pertaining to the tail beyond a threshold, it is still not ideal for modeling extreme losses in black swan events. TVaR assumes a level of independence between losses in the tail, which is not always appropriate, particularly in extreme events where losses might exhibit conditional tail dependence.

(ii) With the block maxima method, some large values may be left out of the maxima if they are adjacent to another large value within the same block. Additionally with block maxima, some non-extreme data points may be incorporated into the estimation. In this case, given that ABC does not have much exposure to these types of claims, they should use the GPD method as it would allow them to retain more data that would be potentially lost with the block maxima method. This method may also be useful if ABC is considering using reinsurance to mitigate losses from gene cell therapy, as the GPD method is more useful when modeling losses exceeding a defined threshold, such as a reinsurance level.

2. Learning Objectives:

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

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

Learning Outcomes:

(2c) Identify and analyze specific risks faced by an organization, including but not limited to: financial, environmental, operational, legal, reputational and strategic risks.

(5d) Demonstrate how derivatives, synthetic securities, and financial contracting may be used to reduce risk within a static or dynamic hedging program.

(5e) Determine an appropriate choice of mitigation strategy for a given situation, which balances benefits with inherent costs (including exposure to moral hazard, credit, basis and other risks).

(5i) Choose appropriate techniques to measure, model and manage various financial and non-financial risks faced by an organization.

Sources:

ERM 150-22 Exchange Rate Risk Measurement and Management

Quantitative Enterprise Risk Management by Mary Hardy and David Saunders, Chapter 2: Risk Taxonomy

ERM-149-22 Managing 21st-Century Political Risk

Quantitative Enterprise Risk Management by Mary Hardy and David Saunders, Chapter 15: Risk Mitigation Using Options and Derivatives

Commentary on Question:

The goal of this question is to test the candidates' understanding of foreign exchange rate risk as it applies to a particular company. Candidates are also asked to demonstrate understanding of risk management practices and mitigation instruments addressing foreign exchange risk. Lastly, candidates are required to apply their knowledge of political risk to the same company and context.

Candidates that were able to apply their risk knowledge around exchange rate risk and political risk into GRD's specific situation performed well. Candidates that gave generic responses could only receive partial credit.

2. Continued

Solution:

(a)

(i) Describe the three types of exchange rate risk as they apply to GRD.

(ii) Assess whether each type of risk described in (i) is low, medium, or high for GRD. Justify your answer.

Commentary on Question:
While most candidates demonstrated knowledge and understanding of the three types of exchange rate risk, some struggled to articulate their application to GRD.

a(i):
Transaction Risk: GRD pays for parts manufactured in Country X in their local currency. If the exchange rate between the US dollar (USD) and Country X's currency weakens (depreciates) before GRD pays the factory, they will need to spend more USD to cover the same amount in the local currency. This would lead to higher costs for parts and potentially lower profit margins.

Translation risk: GRD reports its financial statements in USD. If the exchange rate between the USD and Country X's currency weakens (depreciates) after GRD has purchased parts but before they sell the finished toys, the value of their inventory (which is denominated in Country X's currency) will appear lower when translated into USD on their financial statements.

Economic Risk: This is the risk of exchange rate fluctuation to GRD's company value. This risk would be reflected on the changes of GRD's future operating cash flows from exchange rate movement. For example, A sustained weakening of the USD compared to Country X's currency could make GRD's finished toys relatively more expensive in the US market. This could lead to decreased demand and lower sales for GRD.

a(ii):
Transaction Risk: Considering the long-term relationship and frequent transactions with the factory in Country X, the transaction risk is ranked as High for GRD.

Translation risk: Low Risk. Considering GRD's sales have been surging in recent years, the inventory delinquency time is not material.

Economic Risk: This risk is High considering Country X 's economy has been volatile, and the foreign exchange rate is likely to be impacted.

2. Continued

(b) Jon Doe, the CFO of GRD, states the following:

> "*While we lack a formal exchange rate risk management program, we've been actively monitoring the fluctuations of the ELI against the US Dollar (USD). Historically, we've mitigated potential risk by using currency forwards when anticipating a stronger ELI. This approach has been successful in the past and we expect it to continue working in the future. Considering the ELI has been consistently weakening since the pandemic, the exchange rate risk is a positive risk for us. We've got this under our control and don't need to spend any more time on this risk.*"

Critique Jon Doe's statements on exchange rate risk management.

Commentary on Question:
The question sought to have candidates critique each part of the statement specifically, rather than giving generic feedback or comments. Successful candidates connected their critiques directly back to GRD's situation and context.

Jon Doe is correct in stating that using a forward contract is a useful way to mitigate exchange rate risk, as it allows the company to transfer the entire exchange rate exposure to a third party.

However, the mitigation strategy Jon Doe described is only a tactical approach that addresses short-term transaction exposures. This strategy does not cover other types of foreign exchange risks, such as economic risk and translation risk.

Jon is relying on past risk management experiences to predict that the same process will work in the future. Without a formal exchange rate risk management framework, the company lacks clarity on the extent of its risk exposure and which risk management strategy is the most effective and efficient.

Although the current transaction risk exposure is favorable for the company, the currency of Country X has experienced high volatility due to its weakened economy. Consequently, GRD's US earnings could be volatile. Considering the company is contemplating an IPO, this volatility could negatively impact the company's valuation, as investors may perceive the risk-adjusted return for GRD to be low.

The statement that there is no need to spend more time on this risk fails to consider the exchange rate risk comprehensively and evaluate the hedging strategy holistically. When determining the hedging strategy, GRD should also consider the impact of risk exposure on other risks. Specifically, forward contracts from OTC markets could have higher counterparty credit risk and liquidity risk compared to instruments from an exchange.

2. Continued

Although forward contracts can be effective, they might not be the most efficient mitigation strategy for the company, as they forgo potential gains when exchange rates move favorably. The company should establish a formal program to measure risk exposure and explore various hedging strategies.

A comprehensive risk assessment should consider how exchange rate movements impact other risk categories, shaping GRD's overall risk profile. For instance, mitigating exchange rate risk through currency forwards could increase credit risk exposure.

(c) GRD does not have expertise in investing and hedging. You have been helping the company design its hedging strategies and explore hedging instruments in both OTC and exchange-traded markets. GRD is considering the following alternatives for its hedging strategy.

- Currency (call) options
- Currency futures

(i) Assess the suitability of each alternative for mitigating exchange rate transaction risk including any risk implications. Justify your response.

GRD has decided to further consider currency (call) options as an alternative to forwards (as noted by Jon Doe) and would now like to examine cash flows and potential benefits. There is an upcoming payment of 1 million ELI in three months.

As of today, the prevailing spot exchange rate stands at $1.26 per ELI.

You have two choices for hedging:

- An over-the-counter three-month currency forward contract with a predetermined forward rate of $1.30 per ELI. There are no transaction costs.
- An exchange-traded three-month currency call option on ELI with a strike price of $1.28 per ELI. The premium for the call option is $0.012 per ELI.

You are given:

- The interest rate in the U.S. is 2.5% per annum.
- The interest rate in Country X is 1.75% per annum.
- It is forecasted that the exchange rate will increase to at least $1.30 per ELI in three months.

2. Continued

This information is shown in tab "Q2.c.ii" of the Excel spreadsheet.

(ii) Calculate the dollar costs in three months for each of the two hedge choices assuming the forecast is correct. Show your work.

(iii) Recommend which hedging choice best meets the needs of the company. Justify your answer.

You are asked to perform a sensitivity analysis on the exchange rate which would impact the choice of hedging instrument.

(iv) Calculate the breakeven exchange rate in three months such that the dollar costs in three months of the currency forward and currency option are equal. Refer to tab "Q2.c.iv" of the Excel spreadsheet. Show your work.

Commentary on Question:
Most candidates demonstrated a basic understanding of hedging instruments and their respective pros and cons. Generally, candidates either performed the calculations correctly or produced nonsensical answers that could have been avoided by checking their answers for reasonableness.

c(i)
A currency option has an initial cost but provides the flexibility to capitalize on favorable currency movements, allowing GRD to benefit from the upside. As an exchange-traded currency hedging instrument, it carries lower credit risk compared to OTC instruments.

Currency futures are also exchange-traded contracts with specified volume and settlement dates. Unlike options, there is no upfront cost; however, GRD will forgo any potential upside profits. Using currency futures as a hedging instrument could increase GRD's liquidity risk due to potential margin calls. In addition, similar to currency options, currency futures have lower credit risk compared to OTC instruments.

2. Continued

c(ii)

Inputs/Assumptions	
Annual interest rate in US	2.50%
Quarterly interest rate in US	0.625%
Predetermined forward rate ($/ELI)	$1.30
Call option strike price ($/ELI)	$1.28
Spot Rate ($/ELI)	$1.26
Premium for call option ($/ELI)	$0.012
Upcoming payment (ELI)	1,000,000
The dollar cost in three months using a forward contract	
$1,300,000	
The future dollar cost using a call option contract	
Total option premium	12,000
3 months simple interest	$75
Cost to exercise the options at strike price	1,280,000
Total expected cost of buying 1000000 ELI	**1,292,075**

c(iii)

Candidates could have used an incorrect calculation from c(ii) combined with additional qualitative justification to recommend futures and still receive full credit for c(iii).

A call option is the best hedging instrument for the company. As demonstrated in the calculations in question c-(ii), the cost of a forward contract is higher when the future spot rate for ELI exceeds the strike price of $1.28. Unlike futures or swaps, a currency option provides the right, but not the obligation, to transact, allowing the company to benefit from favorable exchange rate movements. Additionally, although there is an upfront "sunk" cost for the call option, this cost is known and fixed at the outset.

c(iv)

Some candidates correctly noted that there are no meaningful exchange rates that can make the cost of a currency option equal to the cost of a currency forward. Candidates who received full credit correctly set up the calculation, attempted to derive a number using Goal Seek or algebraic methods and/or correctly concluded that there are no exchange rates that will equate the cost of both instruments.

2. Continued

Currency Option	
Exchange rate in 3 months	**N/A**
	1.287925
The future dollar cost using a call option contract	
Total option premium	12,000
3-months simple interest	$75
Cost to excerise the options at strike price or simply buy the curren	$1,280,000
Total expected cost of buying 1000000 ELI	**1,292,075**
Currency Forward	
The future dollar cost using a forward contract	1,300,000
Cost Difference between Currency Forward and Currency Option	$7,925.000

(d) As you continue your review, you note that there have been more instances where political issues have caused disruptions than you were originally led to believe. You recommended to GRD management that it add political risk to its risk taxonomy. Katie, a director of Risk Management at GRD, disagrees with your recommendation. In her email, she states:

"*We believe the company's exposure to political risk in Country X is minimal and doesn't necessitate active management. Here's our reasoning:*

- *Limited Ownership: We don't directly own the factory, minimizing direct risk from disruptions.*
- *Non-Sensitive Goods: The imported components are not subject to heightened regulatory scrutiny due to their nature.*
- *Past Performance: The factory has maintained deliveries despite previous political events in Country X.*"

Critique Katie's statement on political risk.

Commentary on Question:
Candidates generally performed well in critiquing the three points Katie outlined. Those who received full credit also identified areas where they agreed with Katie's statements and provided justifications for their agreement.

2. Continued

Katie is correct that, compared to companies that directly own subsidiaries in Country X, GRD's exposure to political risks in Country X is lower. Additionally, since GRD is not importing sensitive goods, the probability of regulatory changes impacting these imports is also lower. However, Katie's statement that the company's exposure to policy risk in Country X is minimal fails to consider the potential impact of disruptions due to political events. In other words, even if the likelihood of political events in Country X affecting GRD's supplier is low, the impact on GRD could still be significant if the cost of switching to an alternative supplier is high. Specifically, Katie's reasoning has the following issues:

1. **Limited Ownership**: Although GRD does not directly own the factory, Katie's assessment fails to consider other types of political risks, such as internal conflict, social activism, and geopolitics, especially given that the factory has experienced shutdowns in the past few years.
2. **Past Performance**: While the foreign factory managed to deliver during prior shutdowns, GRD should still learn from these "near miss" events, develop contingency plans, and test the effectiveness of these plans.
3. **Non-Sensitive Goods**: Identifying this as a risk and including it in the company's risk taxonomy helps reduce blind spots, such as the potential for these goods to become sensitive in the future. When assessing whether the company is exposed to this risk, the decision should not only be based on the current materiality of the risk but also on its potential to become material.

3. Learning Objectives:

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

6. 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:

(3g) Evaluate and select appropriate models to handle diverse risks, including models that use a stochastic approach.

(3g) Evaluate and select appropriate models to handle diverse risks, including models that use a stochastic approach.

(6b) Apply risk measures and demonstrate how to use them in value and capital assessment

(6c) Propose techniques of attributing the "cost" of risk/capital/hedge strategies to business units in order to gauge performance (e.g. returns on marginal capital)

Sources:

Quantitative Enterprise Risk Management by Mary Hardy and David Saunders, Chapter 18: Risk-Adjusted Measures of Profit and Capital Allocation

Commentary on Question:

The goal of this question is to test the candidate's understanding of various ways to allocate capital by lines of business and the pros and cons of different approaches. In addition, the candidate is asked to consider the use of RAROC in setting compensation targets.

Solution:

(a)

(i) Compute the capital allocated to each business unit using Pryde's current approach and the projected 2024 data provided in the tab "Q3 - 30k CapitalSim Scenarios" of the Excel spreadsheet. Refer to tab "Q3.a.i" of the Excel spreadsheet. Show your work.

You decide to evaluate alternative capital allocation methods.

(ii) Calculate the allocated capital following the Proportional and the Co-VaR allocation methods based on the VaR(99.6) and using the projected 2024 data provided in the tab "Q3 - 30k CapitalSim Scenarios" of the Excel spreadsheet. Refer to tab "Q3.a.ii" in the Excel spreadsheet. Show your work.

3. Continued

(iii) Recommend a change to Pryde's current methodology. Justify your answer.

Commentary on Question:
See excel for solution to a (i) and (ii) and additional commentary around responses and partial credit. Some comments:

Key information is found in Case Study section 4.5. This section includes an explanation of Pryde's approach to required capital and capital allocation as follows:
"Pryde defines required capital as the capital necessary to protect Pryde's policyholders in order to meet all of their claims on a VaR basis with a confidence level of 99.6 percentile over a one-year time horizon. Pryde uses 30,000 simulation results to estimate the amount of required capital.
Pryde allocates capital to lines and products using a Co-CTE approach on modeled GAAP equity at the 99.0 percentile using the outputs from the economic capital model over a one-year horizon. Risk adjusted return on capital (RAROC) is calculated for each line and product using expected net income after tax divided by the required economic capital allocated for each segment."

Most candidates did well on parts (i) and (ii). If candidates used different excel functions other than Percentile to arrive at the correct results (e.g., use Vlookup or Index function to look up the correct scenario(s) to calculate VaR99.6 and CTE99), they will earn full credits as well. In addition, candidates were not penalized if they left the VaR99.6 and CTE99 values as negative ones.

If candidates make a mistake in any calculation, but they carry the mistake through with the correct methodology, they would only lose points for the item where the mistake was made.

For (iii), candidates must recommend a change with justification to receive full credits.

(iii) Recommend a change to Pryde's current methodology. Justify your answer.

3. Continued

Answer:
I think Pryde should rethink their current capital approach. For one thing, they are mixing approaches which likely does not lead to satisfying all four fair allocation criteria. I recommend that they change their capital to equal a 99% CTE measure and then use a Co-CTE approach. The 99CTE would result in a total capital measure that is very similar to the 99.6% VaR measure used today. But adding consistency between the approaches used to determine required capital and then those used to allocate capital means that we can satisfy all four fair allocation criteria.

(b) Pryde uses RAROC to reward appropriate risk-taking behaviors in its compensation structure for business unit leaders.

Pryde's net income by line of business was as follows (000's):

	2022	**2023**
Commercial Multiple Peril	77,184	20,696
Workers Compensation	6,179	6,716
Total Net Income	83,363	27,412

(i) Compute the retrospective RAROC for Pryde's two lines of business for 2022 and 2023. Use Pryde's current approach for calculating economic capital (EC) and assume the EC is constant throughout each year. Refer to tab "Q3.b.i of the Excel spreadsheet. Show your work.

The Commercial Multiple Peril business unit leader asserts that the RAROC-based compensation structure is unfair, but the Workers Compensation business unit leader disagrees.

(ii) Explain each business unit leader's reasoning.

(iii) Recommend a change to address fairness for both business unit leaders. Justify your recommendation.

Commentary on Question:
See excel for solution to b(i). Some comments:

In order to calculate the retrospective RAROC, the candidate needs to essentially repeat the calculation in part A for 2022 and 2023. They are given additional work space in the template, but they need to understand what should go in there and complete accordingly. (They won't be penalized for doing this incorrectly if they were already penalized in part A.) Once they have the allocated capital for the denominator, the numerator is the net income provided in the question stem.

3. Continued

Note that retrospective RAROC in the text is calculated with average EC in the denominator. Candidates don't have to calculate an average here since the EC assumed to be constant throughout each year.

(ii) Explain each business unit leader's reasoning.

Commentary on Question:

Each business leaders' thinking should be tied together to make a logical conclusion of fairness to receive full credit.

RAROC can be a useful indicator for performance-based compensation. However, for salary-based incentives to be effective, the measures used must be perceived by the employees to be fair, and should reward performance that is within the control of the individuals, not for factors from outside their domain. For Pryde, the realized net income of the commercial multiple peril business unit in particular is highly dependent on natural catastrophes. Using retrospective RAROC in 2022 and 2023 would have provided an outsize reward in 2022 and would have penalized the commercial multiple peril team in 2023, neither of which were due to conditions the team members had control over.

Answer:
Risk adjusted returns are fairly volatile for the Commercial Multiple Peril business unit, due to exposure to catastrophic events. The risks that threaten risk adjusted returns are largely out of the business' control since they are natural disasters. Since the CMP business can't control the risk and results are volatile, the CMP business leader would see volatile performance-based compensation under the current structure. They could argue however, it's not really due to their performance, and conclude it is unfair.

Risk adjusted returns are relatively stable for the Worker's Comp line. The risks that threaten risk adjusted returns are largely in the business' control. Since WC is doing a fairly good job of controlling the risk, resulting in stable results, the WC business leader can count on steady performance based compensation under the current structure, which they'd likely consider fair.

(iii) Recommend a change to address fairness for both business unit leaders. Justify your recommendation.

Commentary on Question:
For (iii), Only one "fix" needs to be recommended for full credit with good justification. However, it should tie directly to the observations provided in part (b) - ii, even if the response to (b) - ii is incorrect.

3. Continued

Answer:
Given the huge volatility of net income shown for CMP for 2022 and 2023, we may consider removing or smoothing cat losses before calculating RAROC to balance YOY volatility, as the volatility is most likely due to natural disasters which is out of business leaders' control.

4. Learning Objectives:

1. The candidate will understand the ERM framework and process and be able to apply them to organizations.

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

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

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

Learning Outcomes:

(1d) Assess the overall risk exposure arising from an organization's current and emerging risks.

(1e) Propose ERM solutions or strategies that effectively manage risk under different real (case study) and hypothetical situations facing financial and non-financial organizations.

(2c) Identify and analyze specific risks faced by an organization, including but not limited to: financial, environmental, operational, legal, reputational and strategic risks.

(4c) Analyze risks that are not easily quantifiable, such as liquidity, operational, and environmental risks.

(5h) Demonstrate possible risk management strategies for non-financial risks.

Sources:

ERM-151-22: Developing Key Risk Indicators to Strengthen Enterprise Risk
ERM-152-23: Managing environmental, social and governance risks in life & health insurance business

Commentary on Question:

This question was testing candidates' understanding of the value KRIs bring to an organization by enabling early identification of emerging risks, including ESG risks, and assist in providing actionable insights that drive risk management. Full credit answers required candidates to have a sufficiently thorough understanding of these concepts that they could argue persuasively for implementing new risk identification & management measures that would benefit an organization (SLIC) based on the specific risks that organization was exposed to. This included both emerging ESG risks & recent risk events that a better risk management culture would have helped prevent.

4. Continued

Solution:

(a)

(i) Identify one element of good KRIs that is present in the quarterly dashboard's metrics. Justify your response.

(ii) Identify one element of good KRIs that is missing from the quarterly dashboard's metrics. Justify your response.

(iii) Recommend three specific ways that SLIC could benefit from including more effective KRIs. Justify your recommendation.

Commentary on Question:
The metrics presented were not KRIs, but were actually KPIs. While KPIs like these have some elements that aid in risk management they are lacking critical components like the ability to reduce risk before the company experiences the identified risk event. For SLIC this may include the many risks that do not have a currently defined trigger or limit. E.g. Interest rate risk, legal, strategic, environmental, political or cybersecurity risks. Effective KRIs may have identified the asset administrative system's age before it became outdated and smoothed the transition to the new system (e.g. could have started gradual, organic downsizing instead of implied immediate layoffs). Could also help with smoother transitions when we need to react to existing thresholds like the asset/liability duration mismatch.

The metrics on the quarterly dashboard are more like KPIs, not KRIs, but like KRIs they are based on **established benchmarks** (like loss ratios) that are easily understood by the senior management. This helps to improve communication and understanding of any emerging risk exposures.

The metrics are **lagging indicators, not leading indicators**. Those metrics above reflect past events that have already affected the firm. KRIs, however, should be able to reflect increasing risk exposure and serve as early warning signals. Having a better understanding of SLIC's emerging risk exposure through better KRIs will allow it to make better strategic decisions that protect and grow the value of the firm. For example, SLIC could identify VA Hedging opportunities for the opportunistic hedging they're interested in.

Having better KRIs related to its operational risks could alert SLIC to the increased risk of any operational failures like those associated with the asset administrative system aging out. This would reduce the possibility of business disruption or customer dissatisfaction. This would therefore lead to improved operational processes and maintain SLIC's reputation.

4. Continued

Having better KRIs related to its insurance risk exposure will ensure that SLIC is able to modify and adjust its risk mitigation measures to deal with any increasing risk exposures. By having this "proactive" feedback loop, this may reduce the perceived risk of SLIC's business, thereby improving its credit rating and also reducing the cost of capital. These are all top of mind considerations for SLIC and Lyon, e.g. the work done around Kelly's rating and Lyon's strategic objective to be able to raise capital.

(b) The new CRO is particularly concerned about the impact of Environmental, Social, and Governance ("ESG") risks on the organization's key risks. Refer to tab "Q4.b" in the Excel spreadsheet.

(i) Identify three ESG risks that could be significant to the financial results of SLIC's life and annuity blocks.

(ii) Evaluate the anticipated risk impact and likelihood of each identified risk with regard to SLIC's life and annuity blocks by placing it on the likelihood/severity table in the Excel spreadsheet.

(iii) Justify each identified risk's placement on the likelihood/severity table.

Commentary on Question:
Full credit answers would demonstrate an understanding of the effects of various ESG risks on annuity & life insurance blocks. To be a significant ESG risk the identified risk must be expected to change in frequency or severity over time based on environmental, social or governance drivers. For example, a change in capital requirements is a risk, but unless the candidate was able to justify that this event is expected to increase in frequency or severity over time it would not be an ESG risk. Similarly, if a candidate later placed the risk in a low-impact/low-frequency box then it would not have fulfilled the requirement in (i) to identify significant risks. Commonly identified significant ESG risks included Pandemics, Extreme Weather Events, and Healthcare improvements. Candidates were not required to identify a risk in each ESG category, merely to identify three in total.

For Part (iii) candidates receiving full credit had to justify all elements of the risk's placement – not just to re-state their placement. That is – they had to provide rationale for why the likelihood would be where they placed it, why the severity would be where they placed it, and why the frequency would be where they placed it with an explanation that considered the specific situation at SLIC with a large exposure to mortality risk and a much smaller offset from longevity risk.

4. Continued

Question parts were graded based on what each part was asking. For example, if a candidate identified three risks that were NOT ESG risks, they would not receive full credit for (i) but may receive full credit for (ii) & (iii) depending on their justification & risk placement on the grid.

Model solution provided in attached spreadsheet.

(c) Recommend a KRI to monitor for each ESG risk from part (b). Justify your recommendation using the characteristics of good KRIs.

Commentary on Question:
This question had two parts and was graded on candidates ability to identify a KRI that conformed to multiple characteristics of good KRIs and to identify those characteristics. Many examples were provided in the source text and candidates were expected to apply their learning to this new context. There was no set list of acceptable answers but generally the recommended KRIs needed to identify a risk before it affected SLIC (vs looking at SLIC's historical results or experience) and be easily obtainable, allow for comparisons across time etc.

Environmental: key profitability metrics like Earnings Per Share for listed companies grouped by their environmental ESG rating

- Profitability metrics are based on established benchmarks, so are easily understood
- Profitability metrics allow comparisons over time
- Addresses a root cause event – poor environmental performance (root cause) leading to poor investment performance (risk event)
- Consistent with SLIC because SLIC is part of Lyon which is a listed company
- Information is readily available and doesn't consume a lot of resources to obtain
- While these metrics may only be obtained on a quarterly or semiannual basis, the identified risk has a more long-term horizon so the current reporting frequency is appropriate.

Social: proportion of rejected applications by each underwriting method, classified by reason for rejection

- The data is internal data so it is the most relevant for SLIC. It is easy to obtain and the frequency of monitoring can be performed regularly.
- The data addresses to the root cause event. Because of bias reflected in the underwriting method, then social risk about discrimination will arise.
- Comparisons of the data can be monitored over time and across different UW methods, such as between existing and the proposed accelerated underwriting method.

4. Continued

Governance: total number of governance violations published by the insurance regulator, arranged by type of governance violation (e.g. poor risk management).

- Increases in this KRI over time can indicate that regulatory scrutiny is increasing – the KRI is easily understandable
- Severe governance violations are published by the regulator regularly and can be obtained easily. The information also comes from a trustworthy source
- While the KRI may not include all governance violations from insurers, it reflects the most severe ones which should be the priority for SLIC to address. So this is acceptable.
- The violations published also contained a lot of qualitative information which may be useful in assessing the emerging risk exposure too.