

# ERM-GI Model Solutions

## Spring 2019

### 1. Learning Objectives:

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

### Learning Outcomes:

- (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:

ERM-122-14: Captives and the Management of Risk (chapter 1)

### Commentary on Question:

*This question sought to test candidates on various aspects of captive insurance and how it differs from commercial insurance.*

### Solution:

- (a) Explain why this captive would qualify as an Alternative Risk Transfer (ART) program.

### Commentary on Question:

*Most candidates received at least partial credit for this question. Those who defined ART but did not evaluate it in the context of this situation received partial credit.*

ART requires the innovative use of risk financing techniques and utilization of an alternative mechanism to finance risk.

This captive would qualify as an ART because the captive is offshore and is subject to the same regulatory requirements as CYP. Having a captive also means that CYP will be retaining some of the risk, so both criteria are satisfied.

## 1. Continued

- (b) CYP's CFO has proposed creating an offshore Pure Captive with the following characteristics:
- The captive cannot pursue its own external reinsurance business.
  - The offshore location has similar capital requirements but a lower tax rate.
  - Two accountants and an administrative assistant will be hired to run the captive from the offshore location.
- (i) Explain why a Pure Captive might be preferred over other types of captives for CYP.
- (ii) Critique the characteristics of the proposed Pure Captive.
- (iii) Describe two additional key actions that need to be completed with respect to establishing the Pure Captive.

### **Commentary on Question:**

*Candidates generally did well on this part. For subpart (i), candidates received only partial credit if they described a pure captive without saying why it was preferred in this situation. For subparts (ii) and (iii), reasons other than those shown below were eligible for credit if they were supported by a coherent explanation. More credit was given for demonstrating the ability to critique the pure captive of CYP and address additional key actions related to CYP; less credit was given if candidates elaborated on the concept of a pure captive in subpart (i) but did not connect their responses with CYP's circumstances as described in the question.*

- (i) A captive is an insurance company that is wholly owned and controlled by its insureds.

A pure captive is different from other captives because it only insures the business that CYP decides to send it. No outside business from another company will be sent to the captive (e.g., a joint ownership captive), and CYP is not paying fees to send its business to the captive (e.g., "rent-a-captive")

- (ii)
- CYP should set up an actual office and hire or contract people who are insurance professionals and who know the offshore location's rules.
  - CYP should leave open the option for pursuing outside business, as it may be complimentary to CYP's products, or even supplement its earnings.

## 1. Continued

- (iii)
  - Obtain an insurance license for operating in the offshore location.
  - Understand the rules and regulations for operating in the offshore location, especially reporting and tax regulation.
- (c) You are employed by the consulting firm that CYP has hired to perform its actuarial services. CYP's CEO has asked you to offer an opinion on whether CYP should retain this business or cede it to a captive.
  - (i) Evaluate the three key elements that distinguish a captive from a commercial insurer for CYP.
  - (ii) Recommend whether CYP should use a captive. Justify your answer.

### **Commentary on Question:**

*Most candidates received partial credit for this part, but very few demonstrated enough detail to receive full credit. For subpart (i), relevant points other than those shown below were eligible for credit, but most candidates did little more than list some or all of the three elements without providing any evaluation. For subpart (ii), any recommendation with appropriate justification was eligible for credit; most candidates received at least partial credit.*

- (i)
  1. The insurer is putting its own capital at risk
    - CYP is not transferring the risk away; it still retains the risk.
    - The captive would have recourse to CYP's capital if the captive was in default.
    - However, CYP would still have control over the captive because it has a vested interest in the company.
  2. The captive would be working outside the commercially regulated market for insurers
    - There is a risk that CYP's regulators may step in or take a keen interest in the workings of the captive.
    - Using a captive may involve a complicated legal structure, which has risks.
    - Off-shore location has a different regulatory authority which may view taxes and earnings differently than the current regulator.
  3. The captive is used by CYP to achieve its risk financing objectives
    - This gives CYP better control over the risks taken than an alternative such as reinsurance.
    - The captive may have better opportunities to achieve returns because it is not constrained by the Canadian regulatory regime.
    - The captive could insure outside risks to diversify CYP's business.

## **1. Continued**

- (ii) One recommendation is that CYP should not use a captive. Reasons include:
- CYP does not have its own actuarial staff and would have to rely on consultants to set up the captive.
  - CYP does not already have a captive so there is operational risk in setting one up.

## 2. Learning Objectives:

2. The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.
4. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.
5. The candidate will understand the concept of economic capital, risk measures in capital assessment and techniques to allocate the cost of risks within business units.

### Learning Outcomes:

- (2c) Analyze and evaluate risk aggregation techniques, including use of correlation, integrated risk distributions and copulas.
- (4a) Demonstrate and analyze applicability of risk optimization techniques and the impact of an ERM strategy on an organization's value. Analyze the risk and return trade-offs that result from changes in the organization's risk profile.
- (5a) Describe the concepts of measures of value and capital requirements (for example, EVA, embedded value, economic capital, regulatory measures, and accounting measures) and demonstrate their uses in the risk management and corporate decision-making processes.

### Sources:

Risk Appetite: Linkage with Strategic Planning Report

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

### Commentary on Question:

*The question was intended to assess candidates' ability to calculate RAROC, as well as the usage of a correlation matrix. In addition, the question tests candidates on their understanding of how to use RAROC to make business decisions such as optimizing business risk.*

### Solution:

- (a) You are given the following correlation matrix for the three product lines in 2018.

	Specialty	Homeowners	CAT
Specialty	1.0	0.2	0.2
Homeowners	0.2	1.0	0.2
CAT	0.2	0.2	1.0

## 2. Continued

- (i) Calculate the Risk Adjusted Return on Capital (RAROC) for each product line and the company in total. Show all work.
- (ii) Analyze the profitability of the product line with the lowest RAROC.

### Commentary on Question:

*Candidates generally did well on this part. Partial credit was awarded to candidates who solved product line RAROC but were unable to calculate total company RAROC, as well as for candidates who calculated the total company PV of required capital. Most candidates answered the question as described below, but full credit was also awarded for candidates who calculated the total company Required Economic Capital and then prorated to solve for PV of Required Economic Capital.*

- (i)  $\text{RAROC} = \text{PV of After-tax earnings} / \text{PV Required Economic Capital}$

$$\text{RAROC}_{\text{Specialty}} = 1.0 / 5 = 20\%$$

$$\text{RAROC}_{\text{Homeowners}} = 6.0 / 40 = 15\%$$

$$\text{RAROC}_{\text{CAT}} = 27.0 / 450 = 6\%$$

$$\begin{aligned} \text{Required Economic Capital after Diversification} &= [5^2 + 40^2 + 450^2 + (2 * \\ & 0.2 * 5 * 40) + (2 * 0.2 * 5 * 450) + (2 * 0.2 * 40 * 450)]^{1/2} \\ &= [212,305]^{1/2} \\ &= 460.77 \end{aligned}$$

$$\text{RAROC}_{\text{total}} = (1.0 + 6.0 + 27.0) / 460.77 = 7.38\%$$

- (ii) The CAT line has the highest profit margin among all three product lines, being the main contributor to the underwriting profit in terms of amount.

However, the profit margin measure does not reflect the risks the company has taken. Its RAROC of 6% is the lowest, i.e., the lowest risk-adjusted return. This is because CAT is known for having low-frequency high-severity losses.

- (b) Orange has developed the following risk appetite statement.

Orange has a long-term aggregate RAROC target of 10%. The company will earn at least 6% RAROC with a probability of 98% in each year.

- (i) Assess Orange's compliance with its risk appetite statement.
- (ii) Analyze Orange's business mix with respect to the company's RAROC.

## 2. Continued

### **Commentary on Question:**

*Candidates generally did well on this section. In order to receive full credit on subpart (i), candidates needed to explain that a single year of sales is insufficient to judge compliance with the 10% long-term target and/or that Orange needs to do additional modeling or assume a probability distribution to assess compliance with the requirement of 6% RAROC with a probability of 98%.*

- (i) Orange's 7.38% RAROC is below the long-term target of 10%, but we cannot tell if they will be in compliance over the long-term because we only know about one year's result. Orange's RAROC this year is above 6%, but we need more information on the probability distribution in order to tell whether it will meet the 6% target 98% of the time.
- (ii) The CAT line produces a much lower RAROC than the other two product lines, but more than half of Orange's business comes from the CAT line. This results in the relatively low overall RAROC of the company. In order to improve on its RAROC, the company should consider increasing its capacity for the other two lines or reducing CAT sales.
- (c) There will be no rate increases in 2019. The 2019 business mix plan needs to address the following requirements.
  - I. Collected premiums for each product line must be at least 90% and at most 150% of those in 2018.
  - II. For product lines with sales increase in 2019, collected premiums must be proportional to the collected premiums for those product lines in 2018.
  - III. The required economic capital for the business written in 2019 needs to be lower than the expected available economic capital of \$150 million.

Assume the following:

- The diversification between product lines results in a 30% reduction in required capital for business written in 2019.
- The ratio of the required capital to collected premiums in any year for each product line is constant.
- (i) Calculate the maximum total premium increase from 2018 to 2019 if Orange aims to maximize overall RAROC, subject to requirements I through III. Show your work.

## 2. Continued

- (ii) Orange has added a requirement that the aggregate RAROC target of 10% needs to be met by the business written in 2019.

Verify that a total premium increase of \$12 million from 2018 to 2019 satisfies this requirement. Show your work.

### **Commentary on Question:**

*Candidates generally performed poorly on this section. Many candidates omitted the section, and many others misinterpreted requirement II. Requirement II intended to make the premium growth rates of Specialty and Homeowners the same percentage.*

*Full credit was awarded on subpart (i) for candidates who solved for the \$14 million increase and proved that requirements I through III were met.*

*Full credit was awarded on subpart (ii) for candidates who calculated the new premium amounts, proved that requirements I through III were met, and calculated the correct RAROC. The most common answer is shown, but an alternate solution with Specialty at 15, Homeowners at 45, and CAT at 57 was accepted. Candidates who did not follow requirement II but answered the rest of the question correctly were awarded partial credit.*

- (i) Given CAT has the lowest RAROC among all three product lines, a relative shift from CAT to Homeowners and Specialty would increase RAROC. The premium increase for Specialty and Homeowners should be as much as possible subject to requirements I and II, and the decrease for CAT line should be as much as possible subject to requirement I.

Product	Original Premium	Premium Increase %	Calculation	New Premium
Specialty	10	+50%	$10*(1+0.5)$	15
Homeowners	30	+50%	$30*(1+0.5)$	45
CAT	60	-10%	$60*(1-0.1)$	54

Total premium =  $15 + 45 + 54 = 114$   
\$14 million premium increase



## 2. Continued

Required economic capital increases at the same rate as the premium increase.

Product	Original Required Economic Capital	Increase %	Calculation	New Required Economic Capital
Specialty	5	+50%	$5*(1+0.5)$	7.5
Homeowners	40	+50%	$20*(1+0.5)$	30
CAT	450	-10%	$150*(1-0.1)$	135

$$\begin{aligned} \text{Total company Required Economic Capital} &= (1 - 0.3) * (7.5 + 30 + 135) \\ &= 0.7 * 172.5 \\ &= 120.75 \end{aligned}$$

So requirement III is met.

- (ii) We will keep the \$6 million (or 10%) decrease in CAT premium, so the total increase in Specialty + Homeowners is  $12 - (-6) = \$18$  million.

In order to meet requirement II, the sales growth in Specialty and Homeowners must be at the same rate.

$$\begin{aligned} 10 + 30 + 18 &= 10 * (1+x\%) + 30 * (1+x\%) \\ x\% &= 45\% \end{aligned}$$

Product	Original Premium	Premium Increase %	Calculation	New Premium
Specialty	10	+45%	$10*(1+45\%)$	14.5
Homeowners	30	+45%	$30*(1+45\%)$	43.5
CAT	60	-10%	$60*(1-0.1)$	54

PV of after- tax earnings:

$$\begin{aligned} &1.0 * (1 + 0.45) + 6.0 * (1 + 0.45) + 27.0 * (1 - 0.1) \\ &= 1.45 + 8.70 + 24.3 \\ &= 34.45 \end{aligned}$$

Solve for Orange's PV of Required Economic Capital:

$$\begin{aligned} &(1 - 0.3) * [5 * (1 + 0.45) + 40 * (1 + 0.45) + 450 * (1 - 0.1)] \\ &= 0.7 * 470.25 \\ &= 329.18 \end{aligned}$$

$$\begin{aligned} \text{Total Company RAROC} &= 34.45 / 329.18 \\ &= 10.47\% \end{aligned}$$

which is higher than 10%.

### 3. Learning Objectives:

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

#### Learning Outcomes:

- (4a) Demonstrate and analyze applicability of risk optimization techniques and the impact of an ERM strategy on an organization's value. Analyze the risk and return trade-offs that result from changes in the organization's risk profile.
- (4h) Analyze funding and portfolio management strategies to control equity and interest rate risk, including key rate risks. Contrast the various risk measures and be able to apply these risk measures to various entities. Explain the concepts of immunization including modern refinements and practical limitations.
- (4i) Analyze the application of Asset Liability Management and Liability Driven Investment principles to Investment Policy and Asset Allocation.

#### Sources:

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

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

#### Commentary on Question:

*Candidates were tested on the ability to analyze interest rate risk, knowledge of risk optimization techniques, and the application of asset liability management principles to investment policy and asset allocation.*

#### Solution:

- (a)
  - (i) Compare and contrast the use of key rate durations and effective duration for quantifying interest rate risk.
  - (ii) Verify that the missing key rate duration is 1.44. Show your work.
  - (iii) Verify, using the effective duration, that the key rate durations have been calculated correctly. Show your work.

### 3. Continued

#### Commentary on Question:

Candidates performed fairly well on subpart (i), recognizing the uses of effective and key rate durations but did not perform well on subparts (ii) and (iii). The expectation for (ii) was that candidates would calculate key rate durations using the formula provided in the source and would then calculate effective duration in (iii) to verify. Full credit was given for both parts if effective duration was used in subpart (ii) to back out the 1.44 value and recognize that the solution would be the same for subpart (iii). Most candidates used some form of the effective duration calculation so that the first principles key rate duration calculation was rarely attempted. Common errors included using modified duration instead of effective duration and continuous interest rates instead of annual effective rates as was stated in the question body.

(i)

- Effective duration measures the risk of a parallel shift in the yield curve, whereas key rate durations measure the risk of a shift over a specific portion of the yield curve only
- Effective duration is often inadequate in measuring interest rate risk as the yield curve rarely moves in a parallel fashion. Key rate durations are more effective due to their ability to quantify all types of changes
- Key rate durations are more useful in analyzing complex options and creating replication portfolios compared to effective duration

(ii)

- Calculate the present value of cash flows prior to the shock:  
 $\text{sum}(CF_t/(1+i)^t) = 2834.62$
- The shocked interest rate to use in year 4 is  $0.1/2 = 0.05\%$
- Calculate the present value of cash flows after the shock:  
 $600/(1.005)+200/1.008^2+800/1.013^3+1000/1.0205^4+400/(1.03)^5 = 2830.53$
- Calculate the KRD:  $-(2,830.53 - 2,834.62)/2,834.62/.001 = 1.44$

(iii)

- From subpart (ii) the base PV is 2834.62
- The shocked PV, adding 0.1% to each rate, is 2826.07
- Effective duration:  $-(2,826.07 - 2,834.62)/2,834.62/.001 = 3.02$
- $\text{Sum}(\text{KRD}) = 3.02 \Rightarrow 0.21 + 0.14 + 1.44 + 1.23 = 3.02$

### 3. Continued

- (b) The Chief Investment Officer (CIO) has recommended using surplus volatility as the only risk measure instead because it covers both asset and liabilities.
- (i) Compare and contrast the "bottom-up" and holistic ALM/SAA approaches.
  - (ii) Explain how ABC Life's approach would need to change in order to use surplus volatility instead of asset-only volatility as the risk measure.
  - (iii) Critique the CIO's recommendation.

**Commentary on Question:**

*Candidates performed well on this part of the question. For full credit, candidates needed to recognize the independence of surplus, as this applied to both subparts (i) and (ii). Many candidates recognized that only using one risk measure in subpart (iii) was inadequate and provided several recommendations for others.*

- (i)

The bottom-up approach focuses on assets backing reserves independent of surplus whereas the holistic ALM/SAA considers the entire asset portfolio in aggregate to first optimize risk-adjusted returns within capital constraints and risk tolerance levels while simultaneously determining the most effective constraint for ALM.
- (ii)

When using a surplus volatility risk measure there is an interaction between the liability segments and the surplus segment. Therefore, ABC Life would need to take a more holistic approach and consider the entire portfolio in aggregate rather than the silo approach currently used.
- (iii)
  - The CIO is correct that asset-only volatility ignores half of the balance sheet (i.e. the liabilities). Incorporating a risk measure that accounts for both liabilities and assets such as surplus volatility can provide more information.
  - However, risk measures allow us to assess the effectiveness of different investment strategies by understanding the tradeoff between risk and return. Viewing the solution under a single risk metric as recommended does not provide a complete picture.

### 3. Continued

- (c)
- (i) Match labels A, B, and C to the approaches listed above. Justify your answer.
  - (ii) Recommend which approach to use. Justify your answer.

**Commentary on Question:**

*Candidates performed well on this part of the question. Most were able to deduce which graphs aligned with each description and provide an appropriate recommendation. While there was a clear 'best' recommendation, credit was awarded for other recommendations with reasonable justification.*

- (i)
- Letter A = approach 2 – Based on the first graph, portfolio volatility vs. net excess yield, we can see that A minimizes the portfolio volatility for any given net excess yield. This is consistent with the "Minimize asset-only volatility" portion of approach 2. If we look at the fourth graph, duration gap vs. net excess yield, we can see that A has a minimal duration gap for any net excess yield. This is consistent with the "while constraining the asset-liability duration gap" portion of approach 2.
  - Letter B = approach 3 – Based on the second graph, surplus volatility vs. net excess yield, we can see that C and B are minimizing surplus volatility for a given net excess yield. This implies that they correspond to the two approaches that minimize surplus volatility risk (i.e. approach 1 or 3). If we look at the fourth graph, duration gap vs. net excess yield, we can see that B has a minimal duration gap for any net excess yield. This is consistent with the "while constraining the asset-liability duration gap" portion of approach 3.
  - Letter C = approach 1 – As noted above, the second graph implies B and C are minimizing surplus volatility for a given net excess yield. If we look at the fourth graph, duration gap vs. net excess yield, we can see that C has a larger duration gap for any net excess yield. This is consistent with the "while relaxing the asset-liability duration gap" portion of approach 1.

### 3. Continued

(ii)

- Approach B is recommended.
- Approach A minimizes asset-only risk, which ignores half of the balance sheet and is therefore not recommended.
- Approach C can achieve a lower surplus volatility for a given level of net excess yield as seen in the surplus volatility graph. However, this is achieved by relaxing the asset-liability duration gap as seen in the asset/liability duration graph. The larger asset liability duration gap results in higher capital requirements for approach C as seen in the required capital graph and is therefore not recommended.

#### **4. Learning Objectives:**

1. The candidate will understand the types of risks faced by an entity and be able to identify and analyze these risks.
2. The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.
4. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.
5. The candidate will understand the concept of economic capital, risk measures in capital assessment and techniques to allocate the cost of risks within business units.

#### **Learning Outcomes:**

- (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.
- (4j) Demonstrate risk management strategies for other key risks (for example, operational, strategic, legal, and insurance risks).
- (4k) Apply best practices in risk measurement, modeling and management of various financial and non-financial risks faced by an entity.
- (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-126-15: ORSA - An International Requirement (Section 3.1 and Section 4.1)

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  
(pages 4-26)

ERM-120-14: IAA Note on Stress Testing and Scenario Analysis

Risk Appetite: Linkage with Strategic Planning Report

## 4. Continued

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

### **Commentary on Question:**

*This question focuses on strategic risk analysis: risk assessment and measurement, evaluation of its impact on capital, and ultimately decision-making utilizing risk-adjusted performance measures.*

### **Solution:**

- (a) Assess the appropriateness of the CRO's proposal.

### **Commentary on Question:**

*The purpose of this question is to test the candidate's understanding of ORSA and how this framework can be used to undertake strategic risk analysis. It is more than simply a compliance framework, as it is often envisioned.*

*Candidates received full credit if they successfully assessed each component separately and demonstrated their understanding of ORSA as a strategic risk analysis framework. Those candidates who simply described the many components of ORSA without relating it to strategic risk analysis did not demonstrate that they understood the concept of ORSA from the desired perspective.*

ORSA is an appropriate framework for strategic risk analysis because:

#### Risk management:

ORSA requires that risk analysis be performed continuously and embedded in normal operations. This approach can be leveraged to perform strategic risk analysis as well.

ORSA takes a holistic, enterprise-wide point of view, which is also essential for evaluating strategic options.

#### Capital management:

Strategic options must be evaluated based on their impact on the overall capital of XYZ, both actual, projected and allocated.

This evaluation must be done prospectively and be aligned with strategy.



## 4. Continued

### Business strategy:

XYZ must integrate the results of the two previous steps into its strategic decision-making.

This process must be integrated and used by management and the Board to decide whether it should pursue an international expansion using risk-adjusted performance measures.

- (b) The CRO proposes that you use the PESTEL method to perform a preliminary strategic risk identification analysis.
- (i) Describe advantages and disadvantages of the PESTEL method for XYZ.
  - (ii) Identify, using the PESTEL method, the strategic risks that XYZ may face.
  - (iii) Propose an alternative risk identification method that may improve XYZ's assessment. Justify your response.

### **Commentary on Question:**

*The purpose of this question is to test the candidate's understanding and application of a particular qualitative method in assessing strategic risk.*

*For the PESTEL method, students had to state advantages and disadvantages, and then apply the method by classifying external threats and opportunities provided. The purpose was not to elaborate on more threats as some candidates did.*

*Additionally, students had to propose and describe an alternative risk identification method that could enhance the XYZ's risk evaluation. Some students wrote about an alternative risk management method, which was not the purpose of the question.*

*Globally, this question was answered well by most candidates.*

(i)

Some of the advantages of the PESTEL method are:

- The method is conceptually simple and easy to implement.
- It focuses on identifying general environmental risks, creating a foundation for assessing industry- and company-specific risks.

## 4. Continued

- It encourages XYZ to establish a regular environmental scanning of potential developments and external factors to capture a broad amalgam of risks.

Some of the disadvantages are:

- It is based solely on qualitative assessment. There is no quantification per se, therefore it is harder to translate risks into impact on XYZ in terms of ranking or prioritization of risks.
- It might be too narrow in its approach: risk categories might be too narrow/non-inclusive, some important risks might be ignored.
- It is less formalized than developing scenarios, thus unable to anticipate drastic or abrupt changes that may occur over time.

(ii)

Although presented in this manner, these factors intersect many categories, both causes and effects.

### Political:

- Changes in social programs affecting customers in terms of their long-term sustainability.

### Economic:

- Low interest rates by historical standards.
- Lingering impact of the 2008 financial crisis.
- Unknown economic impact of climate change. *Linked with Environmental.*

### Social:

- New challenges: longevity and changing family patterns.
- Demographic changes and migration patterns.

### Technology:

- Online-insurance intense competition.
- Insurance Tech and artificial intelligence entail an unknown future.
- Big data and predictive modelling opportunities.

### Environmental:

- Climate changes and its unknown impact on investments. *Linked with Economic.*

## 4. Continued

### Legal:

- New international capital regulation. *Linked with Economic.*
- Privacy regulations resulting from technological advances. *Linked with Technology.*

(iii)

*The following are a sample of acceptable responses. Other accepted responses include, but are not limited to, Risk Influence Matrix/Causal Loop, Case Study, and Group Risk Identification.*

SWOT analysis. The advantage of this method is that it also considers both strengths and weaknesses of XYZ, the ability of the organization to be resilient to threats, and the capacity/willingness to take advantage of opportunities.

A Risk Map can be created to analyze the frequency and severity of strategic risk. However, capital is not estimated explicitly. A Risk Timing Map can be implemented, which is a modified version of a static risk map, measuring the evolution of risk over time.

The Delphi method can be implemented where experts, in rounds, determine and then refine their findings on risks and opportunities. It focuses on a wider range of issues than PESTEL and can be used for more complex topics.

- (c) Describe four shortcomings of the assessment methodology used for this analysis.

### **Commentary on Question:**

*The purpose of this question was to test the knowledge of candidates concerning the scenario methodology and how scenarios can be used in the context of strategic risk analysis.*

*Some candidates simply commented on the results as shown in the table without referring to the underlying theory and best practices of scenarios as described in the source material. This was not the purpose of the question.*

## 4. Continued

Some of the shortcomings that can be inferred from the table and the proposed theory are:

- Some scenarios are limited in their assessment to potential short-term developments only while others focused solely on long-term ones. Some scenarios focused on threats only, while others focused on opportunities. Prospective, synthetic and option-like scenarios should be done consistently between all potential expansion options.
- The advantage of scenarios, compared to other more limited qualitative methods, is their capacity to define and describe complex situations. They can be expanded and refined as desired. In this case, it appears that the full use of their potential was not realized as they are purely descriptive, their terminology is vague, and content varies with each option.
- There is no account of potential interaction/interdependence between the different threats and opportunities, an aspect that scenarios should consider.
- There is no evaluation of their potential financial and operational impact of each described scenario if XYZ were to pursue one of these options.

(c)

- (i) Compare and contrast the following performance measures in terms of their use in strategic decision making. Justify your analysis by performing appropriate calculations.
  - ROE
  - RAROC
  - RARORAC
- (ii) Recommend to the Board which strategic expansion should be pursued based on your financial analysis. Justify your recommendation.

### **Commentary on Question:**

*The purpose of this question was to test the candidate's understanding of risk-adjusted performance measures that are used to inform strategic decisions.*

*Most candidates performed well on this question, calculating the measures correctly and providing sufficient comparison between them. In some cases, the RAROC and RARORAC could be the same depending on the Study Note referenced. Either was considered valid as long as the calculation was done properly.*

## 4. Continued

*However, some candidates performed the calculations by integrating all three options simultaneously. This was not appropriate as it was clearly stated in the stem of the question that XYZ was planning to pursue a single option.*

*Some candidates confounded ROE and RAROC. Importantly, ROE does not account for expected losses while RAROC does.*

(i)

ROE:

ROE = Net Income (Revenue – Costs) / XYZ Equity

European ROE = 5% = 10 / 200

Asian ROE = 25% = 50 / 200

African ROE = -5% = -10 / 200

- ROE – like ROA – is not a risk-adjusted metric. It is based solely on accounting values.

RAROC:

RAROC = Risk-adjusted return (Net Income – Expected loss) / Available Capital

European RAROC = (10 - 1) / 100 = 9%

Asian RAROC = (50 - 5) / 120 = 33%

African RAROC = (-10 - 5) / 75 = -20%

- RAROC is used by management usually within business units to gauge performance but can also be relevant to shareholders as well.

RARORAC:

RARORAC = Risk-adjusted return (Net Income – Expected losses) / Required Capital

European RARORAC = (10 - 1) / 54 = 17%

Asian RARORAC = (50 - 5) / 127 = 35%

African RARORAC = (-10 - 5) / 9 = -167%

- RARORAC is more complete than the previous two as it integrates both expected and unexpected losses.

## 4. Continued

- (ii) The Asian expansion should be pursued if the decision is made using RARORAC as it exhibits the largest value. Even when required capital is not accounted for, the expansion still represents the largest contributor to return. ROE, on a forward basis, will increase which will benefit shareholders. The only concern is the fact that available capital is below required capital. This should be addressed before pursuing this expansion option.

## 5. Learning Objectives:

2. The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.
3. The candidate will understand how the risks faced by an entity can be quantified and the use of metrics to measure risk.

### Learning Outcomes:

- (2a) Demonstrate how each of the financial and non-financial risks faced by an entity can be amenable to quantitative analysis including an explanation of the advantages and disadvantages of various techniques such as Value at Risk (VaR), stochastic analysis, and scenario analysis.
- (2c) Analyze and evaluate risk aggregation techniques, including use of correlation, integrated risk distributions and copulas.
- (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.
- (3b) Analyze and evaluate the properties of risk measures (e.g., Delta, volatility, duration, VaR, TVaR, etc.) and their limitations.

### Sources:

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

ERM-103-12: Basel Committee - Developments in Modelling Risk Aggregation, pages 72 – 89

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

Value-at- Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion Ch. 12 Monte Carlo Methods

### Commentary on Question:

*Commentary is included below under each part.*

## 5. Continued

### Solution:

- (a) VaR is calculated independently for NorthPole and SouthPole. It is your task to aggregate VaR at the enterprise level.
- (i) Determine the 96% daily absolute VaR of aggregate claims for each city. Show your work.
  - (ii) Determine the theoretical range of the aggregate 96% daily absolute VaR based on the VarCovar method. Show your work.
  - (iii) Assume claim amounts in NorthPole and SouthPole have a correlation of  $\rho = 0.8$ .  
  
Determine the 96% daily VaR of aggregate claims for both cities combined using the VarCovar method.
  - (iv) Discuss the appropriateness of the VarCovar method for calculating enterprise capital.

### Commentary on Question:

*Many candidates struggled with the calculation of VaR in (i), though were generally able to aggregate the calculated VaRs correctly in (iii). Additionally, while most candidates realized that assuming perfect dependence ( $\rho = 1.0$ ) would result in the highest aggregate VaR, many assumed that the lowest aggregate VaR would result from independence ( $\rho = 0.0$ ) rather than using  $\rho = -1.0$ .*

- (i) 96% is greater than the 95% of the time claims are based on normal weather.

Thus, we are in the extreme weather category, which is 5%. If we divide the range into 5 parts (the “highest” 5 percentiles), the “breakpoint” of the first part is the point at which 4% of claims will exceed that amount, which is 1/5 of the way through the higher range of both cities:

- \$3,400 for NorthPole
- \$4,600 for SouthPole



## 5. Continued

(ii) Overall VaR using VarCovar method  
 $= (\text{VaR}_{\text{NP}}^2 + \text{VaR}_{\text{SP}}^2 + 2\rho * \text{VaR}_{\text{NP}} * \text{VaR}_{\text{SP}})^{0.5}$

Using  $\rho$  at the extreme values of -1 and 1, we get the following:

$$(3400^2 + 4600^2 + 2 * (-1) * (3400) * (4600))^{0.5} = \underline{1200}$$

$$(3400^2 + 4600^2 + 2 * (1) * (3400) * (4600))^{0.5} = \underline{8000}$$

(iii)  $(3400^2 + 4600^2 + 2 * (.8) * (3400) * (4600))^{0.5} = \underline{7599}$

- (iv) VarCovar only uses a single correlation coefficient calculated over the whole distribution. With VaR, we are more interested in the behavior of the tails of the loss distributions, so the aggregate correlation coefficient may understate tail risk.

However, the VarCovar method is easy to compute and could be easier to explain and understand than some alternative methods, e.g. copula.

- (b) (5 points) Your manager asks you to perform a simulation exercise to estimate warranty claims for NorthPole and SouthPole. He suggests using Monte Carlo simulation with correlated uniform random variables for this task.
- (i) Explain how you would apply Cholesky factorization to address your manager's request.
- (ii) Calculate the Cholesky factors using the correlation coefficient from part (a). Show your work.

You have partially populated the following table using the Cholesky factors from part (b)(ii). Z1 and Z2 represent random draws from a N(0,1) distribution. Your manager said to initially induce correlation on these variables, producing Z3 and Z4, before translating them to U(0,1) variables.

*Claim Amount Simulation from 1,000 replications  
Ordered from lowest aggregate claims to highest aggregate claims*

## 5. Continued

Simulation Number	Z1	Z2	Z3	Z4	U1 = F(Z3) is U(0,1)	U2 = F(Z4) is U(0,1)	Aggregate NorthPole Claims from U1	Aggregate SouthPole Claims from U2	Total Aggregate Claims
959	1.08	1.99	1.08	2.06	0.86	0.98	905	5,800	6,705
960	1.52	1.39							
961	0.13	3.53	0.13	2.22	0.55	0.99	579	6,400	6,979

- (iii) Determine the absolute VaR using your manager's suggested method by completing the above table. Show your work.

While the simulated random variables have a correlation of  $\rho = 0.8$ , the simulated claim amounts are correlated with  $\rho = 0.7$ . Your manager suggests the correlation discrepancy may be due to the choice of dependency measure and recommends using Spearman's rho.

- (iv) Explain your manager's feedback.

### Commentary on Question:

*In subpart (i), most candidates failed to explain the key steps of implementing Cholesky factorization or may not have approached the question by providing a step-by-step outline as desired. Not every step shown below was required for full credit, but full points were awarded if it was clear the candidate understood how the method could be applied to the stated problem.*

*Calculations in subparts (ii) and (iii) were generally done well. Answers resulting from minor rounding discrepancies in subpart (iii) were awarded full points.*

- (i) Take the correlation matrix and decompose it (using Cholesky factorization) into an upper and a lower triangular matrix.

Since there are two variables, the lower triangular matrix  
 $L = \begin{bmatrix} 1 & 0 \\ \rho & (1-\rho^2)^{0.5} \end{bmatrix}$

If  $N$  is a vector of two independent normal random variables with unit variance, then the matrix product  $LN$  gives two variables of unit variance that have the same correlation as the original correlation matrix.

For each replication, generate two independent normal random variables of unit variance.

## 5. Continued

Multiply the matrix product LN.

Determine  $D = F(x)$ , the value of the distribution function at  $x$ , for each of the correlated random variables.  $D$  is a uniform random variable from 0 to 1; and the two  $D$ s will have a correlation of 0.8

Determine  $C = F^{-1}D$ , the value of the NorthPole and SouthPole claims that gives the same point in the distribution as the correlated random variable (i.e. the inverse distribution method of simulation)

Determine total claims for the replication by summing the simulated claims for NorthPole and SouthPole.

After all replications have been completed, rank from lowest aggregate claim cost to highest and find the 96th percentile. This is the simulated VaR.

(ii)  $L = [[1,0], [\rho, (1-\rho^2)^{0.5}]]$

Where  $\rho = 0.8$ ,

$$L = [[1, 0], [0.8, 0.6]]$$

(iii) Correlated Normal random variables: 1.52 and  $0.8 * 1.52 + 0.6 * 1.39 = 2.05$

$$P(Z \leq 1.52) = 0.94$$

$$P(Z \leq 2.05) = 0.98$$

$$\text{Point on the NorthPole claim distribution} = .94/.95 * 1000 = 989$$

$$\text{Point on the SouthPole claim distribution} = (.98 - .95)/.05 * 3000 + 4000 = 5800$$

$$\text{Total claims} = 989 + 5800 = 6789$$

The 96 percentile is the  $0.96 * 1000 = 960$ th observation. The 960th observation is 6789.

## 5. Continued

- (iv) The Pearson's correlation coefficient of 0.8 was calculated based on empirical loss data. The simulation exercise does not impose this correlation on the losses themselves, but rather on the loss percentile for a given distribution. Instead of Pearson's correlation coefficient, we can calculate a rank correlation metric such as Spearman's rho or Kendall's tau, and use this value in the simulation based on Cholesky factorization.

Spearman's rho has the property that it is invariant under monotonic scaling of the losses because it depends only on the relative rank of the observations within a data set rather than the actual values of the observations. Therefore, rank correlation does not depend on marginal distributions of both variables.

- (c) After rerunning the analysis in part (b) using Spearman's rho, your manager explains that this method is equivalent to simulation using a Gaussian copula. You are evaluating the following options:

- Monte Carlo Simulation using a Gaussian Copula
- Monte Carlo Simulation using an Archimedean Copula
- Copula methods should not be used

- (i) Describe the pros and cons of the two copulas listed.
- (ii) Identify three key considerations for determining the most appropriate option.

### **Commentary on Question:**

*Most candidates were able to describe the key relevant attributes for the two copulas in (i). In general, discussions regarding additional considerations were focused on copula choice (often by reiterating items from (i)) and seemed to ignore the fact that "not using copulas" was also an option.*

- (i) Gaussian copulas are easy to simulate, but do not have distributions that can be described in closed form and do not exhibit tail dependence.

Archimedean copulas required advance techniques for simulation, have distribution that can be described in a closed form, and capable of modeling tail dependence.

## 5. Continued

- (ii) Examples of additional considerations:

Does empirical data suggest that correlation between NorthPole and SouthPole losses is not constant over time? We may need a copula if empirical data suggest correlation changes under extreme weather circumstances.

Is there enough data available to accurately calibrate a copula model?

Is the potential aggregate loss significant enough to warrant addition complexity in the modelling approach?

- (d) Describe one key advantage and one key disadvantage for each of the following methods as they pertain to Pleasant Air's analysis:

I. VarCovar

II. Simulation using Cholesky factorization / Gaussian Copula

III. Simulation using Archimedean copula

**Commentary on Question:**

*Many candidates did not focus their responses on the pros and cons of each method given the situation described in the stem, i.e. adding additional cities to the company's portfolio. Therefore, answers tended to be an overly generalized comparison of each method.*

I. VarCovar –

Simple, which is important as the number of cities expands, but not necessarily accurate, as it does not consider variations in correlation along the distribution (i.e. ignores tail correlation), which may be important for cities that are close to each other.

II. Simulation Using Cholesky Factorization/Gaussian Copula –

Easy to simulate, which is important as the number of cities expands (otherwise you could have models that quickly become unmanageable); but cannot exhibit tail dependence, which may be important for cities that are close to each other.

## **5. Continued**

### III. Simulation Using Archimedean Copula –

Can be calibrated to model tail correlation, which may be important for cities that are close to each other new locations are added; however, it requires advanced techniques to simulate, which could be difficult to understand and evaluate.

## 6. Learning Objectives:

5. The candidate will understand the concept of economic capital, risk measures in capital assessment and techniques to allocate the cost of risks within business units.

### Learning Outcomes:

- (5a) Describe the concepts of measures of value and capital requirements (for example, EVA, embedded value, economic capital, regulatory measures, and accounting measures) and demonstrate their uses in the risk management and corporate decision-making processes.

### Sources:

ERM-123-14: S&P Enterprise Risk Management Criteria

ERM-501-12: Risk Based Capital-General Overview

### Commentary on Question:

*This question tests the candidate's ability to knowledge of regulatory capital and rating agency requirements, particularly extensions of requirements into corporate strategy.*

*This question also tests the candidate's ability to make decisions and recommendations, including providing support or explanation for how a determination was made.*

*Candidates generally did not demonstrate the depth of knowledge required for this question.*

### Solution:

- (a) The CEO has asked you to evaluate the three blocks. PQR has \$5 million of seed money available for the acquisition and capital support.

- (i) Describe the risks associated with each RBC component identified above.

- (ii) PQR evaluates each block separately. For example, when evaluating block A, blocks B and C are ignored.

Populate the missing RBC Ratio values in the table. Show all work.

- (iii) Evaluate the pros and cons of each block for PQR.

### Commentary on Question:

*Subpart (i) required candidates to describe the risks associated with the RBC components given. Many candidates simply listed the risks and did not describe them. Descriptions of each risk were required for full credit.*

## 6. Continued

*Subpart (ii) required candidates to calculate RBC ratios and show work supporting the calculations for each of the potential acquisition blocks. Very few candidates received full credit. Nearly all candidates failed to recognize that when a block is acquired that PQR would pay the purchase price, leaving the seed money less the purchase price as PQR's TAC. This was required for full credit. Many candidates made assumptions for TAC, which resulted in partial credit. However, some candidates recalculated the ACL and used this for TAC, resulting in RBC ratios very close or equal to 100%. Candidates that did so did not demonstrate appropriate depth of knowledge and subsequently received only partial or no credit.*

*Subpart (iii) required candidates to evaluate the pros and cons of each block for PQR. Candidates generally were able to evaluate pros and cons of each block, however very few candidates related the blocks to PQR. Full credit required either one pro or con statement for each block and that the statement related to PQR. Candidates were not required to have the correct responses from subparts (i) and/or (ii) to receive full credit on (iii).*

(i) C0: Asset Risk – Affiliates: This is the risk of default of assets for affiliated investments. The parent company is required to hold an equivalent amount of risk-based capital to protect against financial downturns of affiliates.

C1: Asset Risk – Other: This is the risk of default of principal and interest or fluctuation in fair value of assets.

C2: Insurance Risk: The life insurance risk factors calculate the surplus needed to provide for excess claims, both from random fluctuations and from inaccurate pricing for future level of claims.

C3: Interest Rate Risk: The interest rate risk encompasses the risk of losses due to changes in interest rate levels. The factors in this calculation represent the surplus necessary to provide for a lack of synchronization of asset and liability cash flows.

C4: Business Risk: Business risk for life insurers is based on premium income, annuity considerations, and separate account liabilities. Also, included in business risk exposures is litigation.



## 6. Continued

- (ii) Step 1: Calculate  $TAC = 5,000,000 - \text{Price}$  for each block  
Step 2:  $RBC = TAC / ACL$

	Block A	Block B	Block C
ACL	820,000	1,360,000	710,000
Price	3,500,000	1,500,000	3,200,000
TAC	1,500,000	3,500,000	1,800,000
RBC	183%	257%	254%

- (iii) Block A – Block A is not appropriate to purchase. Its RBC is at the company action level (150-200%) while the other blocks are much higher (both above 250%).

Block B – Block B has a high concentration of both asset risk and investment / market risk. This aligns nicely with the hedge fund expertise of the parent company / investment advisor.

Block C – Block C has most of its capital tied up in insurance risk. PQR has hired several actuaries with strong mortality background, so this block aligns nicely with that expertise.

(b)

- (i) You anticipate that PQR's Emerging Risk Management and Strategic Risk Management subfactors will be scored as Negative by S&P.

Assess each of the remaining three ERM score subfactors for PQR. Justify your answer.

- (ii) Determine PQR's expected overall ERM score. Justify your answer.
- (iii) Recommend two improvements to PQR's ERM program to increase the overall ERM score to the next level. Justify your recommendation.

### **Commentary on Question:**

*Subpart (i) required candidates to assess each of the three remaining subfactors for PQR. Most candidates did very well on this subpart. Full credit required correct identification of each of the three remaining subfactors, correctly scoring the subfactor, and providing supporting statements for the subfactors.*

*Subpart (ii) required candidates to determine PQR's overall ERM score. Most candidates struggled with this subpart. Many candidates continued to use the positive, neutral, negative rating scheme as was used for the subfactors. Candidates were not required to have correctly scored the ERM subfactors in subpart (i) to receive full credit.*

## 6. Continued

*Subpart (iii) required candidates to recommend improvements to PQR's ERM program that would increase the overall ERM score to the next level. Full credit required two improvements PQR should make, with each requiring a justification. Candidates generally did well, with many receiving full credit.*

- (i) Risk Management Culture – Neutral
- The PQR Life Board of Directors participation in the ERM process is infrequent.
  - PQR Life manages risks within the business units.

Risk Controls – Neutral

- PQR Life has identified and monitors its main sources of material risks.
- PQR Life has a formal limit enforcement policy.

Risk Models – Positive

- PQR Life model limitations are documented and understood within the organization.
- PQR Life has implemented a strict model governance process.

- (ii) PQR would be scored as “Adequate.”

Overall, PQR does not satisfy the requirement for “Adequate with Strong Risk Control” because:

- Risk control subfactor is not scored positive
- Strategic risk management is not scored at least neutral
- At least one subfactor was scored negative

Furthermore, the risk controls and risk management culture subfactors are scored at least neutral. A “Weak” score would be assessed if one or both of these were scored negative.

- (iii) To increase PQR's overall ERM score to the next level:

1. Risk control subfactor needs to be scored positive. To be scored positive, the insurer has identified all material risks from all sources and frequently monitors its risk exposures with multiple metrics.

## **6. Continued**

2. Strategic risk management cannot be scored negative. To be scored as neutral, the insurer's capital allocation is risk-based but mainly reflects the views of external constituents.

“Adequate with Strong Risk Control” requires:

- Risk control subfactor is scored positive
- Strategic risk management is scored at least neutral
- No subfactor is scored negative

## **7. 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:**

- (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.
- (4c) Demonstrate means for reducing risk without transferring it.
- (4j) Demonstrate risk management strategies for other key risks (for example, operational, strategic, legal, and insurance risks).

### **Sources:**

Why Insurers Fail

AIA Climate Change

PC Insurance Company Insolvencies

### **Commentary on Question:**

*The goal of this question is for candidates to demonstrate understanding of the impact on the insurance marketplace resulting from various external events, including global climate change. Additionally, candidates were asked to assess the risk of an insolvency given different types of potential acquisitions.*

## 7. Continued

### Solution:

- (a) Predict the impact on the number of firms and profitability of those firms that the following events would be expected to have. Justify your answer.
- (i) Regulators adopt new capital requirements, increasing the amount of capital that companies must hold.
  - (ii) New technologies that allow companies to lower customer acquisition expenses by selling directly to consumers emerge and become widespread.
  - (iii) Larger companies in the market begin to use proprietary claims data to more accurately predict future claims amounts.
  - (iv) An increase in the availability of alternative capital sources lowers the cost of capital for insurers.
  - (v) Global climate change increases the uncertainty of losses in future years.

### Commentary on Question:

*This question asks the candidate to apply the market equilibrium model in different situations. It is expected that candidates will know that profitability and the number of firms are inversely related. Despite this relationship, to earn full credit, the candidate must provide the impact on both profitability and the number of firms for all question parts. In addition, complete solutions provided a justification showing the impact on the cost of entry.*

(i)

**Cost of entry:** Increasing capital requirements means a higher cost of entry.

**Number of Firms:** Lower productivity firms will exit the market, which means fewer firms

**Profitability:** Higher profitability

(ii)

**Cost of entry:** Lower cost of entry means more new entrants.

**Number of Firms:** More firms

**Profitability:** Lower profitability

(iii)

**Cost of entry:** Proprietary data is a cost of entry

**Number of Firms:** Higher entry costs mean more market exits for companies that don't have the proprietary data

**Profitability:** Higher profitability for remaining firms

## 7. Continued

(iv)

**Cost of entry:** Lower cost of capital will lead to lower barriers to entry.

**Number of Firms:** More firms will enter the market

**Profitability:** Lower profitability

(v)

**Cost of entry:** Higher uncertainty will increase the cost of entry

**Number of Firms:** Increased cost of entry means fewer firms entering the market

**Profitability:** Higher profitability for the remaining firms

(b) Robert James will be attending a CEO round table on global climate change with other CEOs. He asks you to identify public policy proposals Pryde can support that will both be sustainable and lower insurance costs.

(i) Describe three energy efficiency policies that will also reduce auto insurance costs.

(ii) Describe three policies that will improve property sustainability and lower property insurance costs.

### **Commentary on Question:**

*The reading specifically called out “Pay-at-the-pump” or pay per mile as an example of one climate change proposal that would undermine the insurance process and negatively impact vehicle and highway safety. Credit for this answer was only given if very clear and specific justification was given.*

(i) **Public Transportation** - Initiatives that encourage less congestion including public transport, carpooling, and pedestrian and bicycle access which reduce energy usage and promote cleaner air. For auto insurance, they reduce congestion in urban areas and stress on drivers that leads to increased accident rates. They also provide increased options and mobility for higher risk teenagers and very elderly drivers.

**Telecommuting** - Increased telecommuting takes drivers off the road during the highest morning and afternoon rush hours in the most congested urban areas where accident rates and insurance costs are the highest. Telecommuting also reduces energy consumption and emissions.

**Lower Speed Limits** - Lower national speed limits saved energy and reduced greenhouse gas emissions, but also lowered deaths and injuries on the highways during the 1970's and 1980's

## 7. Continued

- (ii) **Strong building codes** - Insurance companies are advocates for catastrophe mitigation. Regardless of whether global climate change results in an increase in severe weather events, mitigating the losses that might occur will reduce losses from the events that do occur.

**Supporting new building technologies** - Better roofs, windows, and structural connections will make homes, businesses, and communities more resilient to natural disasters

**Land use planning discouraging building in disaster prone areas.** - Sound insurance principles show that it is generally less expensive to proactively limit development in flood plains, beachfronts, earthquake faults, and areas subject to mudslides and wildfires than to deal with the effects following a natural catastrophe. Limited development in these areas should be built into a stricter code.

- (c)
- (i) Rank the five firms by the risk of insolvency or failure assuming that each remains a standalone firm. Justify your answer, noting which factors increase the risk of insolvency and which factors decrease the risk of insolvency for each firm.
- (ii) Explain how the risk of insolvency would change for each of these firms if it were acquired by Pryde rather than remaining a standalone firm.

### **Commentary on Question:**

*There was not one specific answer for subpart (i). Therefore, the justification provided by the candidates was important. Correct answers highlighted that the small insurers working in a limited geographic area with fast growth and short tenure have the highest risk. Answers that placed a high weighting on the affirmative RMAD were considered incorrect. The following is one potential answer.*

*For subpart (ii), the objective was to note that some of the risk factors would change post-acquisition since the companies would now be part of a larger firm. Full credit was awarded when the response was properly justified relative to the response to subpart (i).*

## 7. Continued

(i)

1. E – Higher risk: unfamiliar line of business, few states, fast growth, short tenure management. No impact: adverse loss development and RMAD
2. C – Higher risk: 1 line, fast growth, short tenure management. Lower risk (diversified across states, albeit all hurricane-prone states). No impact: Absence of an affirmative RMAD does not preclude insolvency.
3. B – Higher risk: 1 line, 1 state, short management tenure. Lower risk: Diversified into 2 lines of business. No impact: Absence of an affirmative RMAD does not preclude insolvency.
4. A – Higher Risk: Firm is in 1 line of business, and in a limited number of states. Lower Risk: Management Tenure is high. No impact: Existence of affirmative risk of material adverse deviation (RMAD)
5. D – Higher risk: 1 line. Lower risk: 30 state diversification, high tenure management. No impact: loss development and no affirmative RMAD.

(ii)

1. A – Being a single line company is less of a concern as it is now part of a diversified firm.
2. B – Management tenure is less of a concern given Pryde's experience in Personal Auto
3. C – Management tenure is less of a concern given Pryde's experience in Personal Property. Fast growth could still cause a concern.
4. D – Being a single line company is less of a concern as it is now part of a diversified firm.
5. E – Small company is now part of a larger firm, however being in a business in which Pryde is unfamiliar could still be a concern.

(d) Describe two additional pieces of information that you would want to review to better evaluate the risk of insolvency or failure of these companies.

1. **Underwriting profitability:** lower profitability firms are more likely to exit.
2. **Capital Adequacy:** adequately capitalized firms are more likely to weather adverse deviations or events.



## 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.

### Learning Outcomes:

- (2e) Evaluate the theory and applications of extreme value theory in the measuring and modeling of 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.

### Sources:

ERM-712-16: Catastrophe Modeling: Guidance for Non-Catastrophe Modellers (GI)

ERM-713-16: Stochastic Modelling of Catastrophe Risks in DFA models (GI)

### Commentary on Question:

*The first two parts consisted of comprehension and analysis of the two catastrophe modeling methods. Some candidates were able to provide strong answers to these first two parts.*

*The last part of the question is linked to knowledge utilization where credit was given to reasonable answers that were different than the model solution. Most candidates performed well on this part.*

### Solution:

- (a)
  - (i) Describe the two approaches to Cat modeling suggested by Diers.
  - (ii) Provide reasons why Pryde would want to use both approaches in its analysis.
  - (iii) Explain how the impact of climate change can be incorporated in each of the two approaches.

### Commentary on Question:

*Some answers lacked enough substance to get full credit, but partial credit was awarded to these incomplete answers.*

- (i) Approach 1: Use of complete event loss tables generated as outputs of Cat model  
Approach 2: Mathematical statistical approach uses only return periods and associated PMLs for the insurance company itself, rather than complete ELTs, as output from Cat Model."

## 8. Continued

- (ii) Reasons for including both approaches include the following:

Modelling based on mathematical statistical methods encompass all of the historical events, which are used to fit the underlying distributions. This aids plausibility testing on high PMLs, as these have to fit the historical losses. This results in a good basis for management acceptance of the model, as the results are highly intuitive

Mathematical statistical models can and should be used to test the plausibility of ELTs.

Statistical models present another advantage in that the model is based on modelling the random variables degree of loss and average claim severity, enabling quantification of the exposure of corporate strategy such as expansion in individual divisions, withdrawal from various agreements or universal introduction of deductibles, on the risk capital requirement of the entire company. This is not directly possible using ELTs as a basis, as ELTs only reflect the exposure of individual catastrophe events on the current portfolio, meaning that the corporate strategies and general strategies affecting gross business (before reinsurance) cannot be directly represented.

ELT methods could incorporate climate change its own design

Mathematical statistical modelling may be not appropriate for reinsurance calculations or optimization

- (iii) Approach 1 (ELT) could incorporate the climate change in its event sets by representing the physical forces causing the losses and the event loss tables are complete.

Approach 2 (Statistical) Uses empirical data therefore cannot incorporate the future changes directly. It is subject to continuous review and immediately adjusts for changing conditions.

- (b) The most recent update of the two models was completed prior to March 2018. Since that date, three major wildfire loss events have occurred.

Describe how you would update each model to reflect the three recent wildfire events.

**Commentary on Question:**

*Full credit required an adequate description of each model update.*

## 8. Continued

Model/Approach 1 (ELT): The actual incurred claim amount will be used to test the plausibility of the event loss set. This is an indirect adjustment to the ELT model.

Model/Approach 2 (Statistical): The actual incurred claim amount will be incorporated into the in-house empirical data and also used to test the PML plausibility if the event is sufficiently significant with high return period that is as high as the external data. This is a direct adjustment to the Statistical model.

- (c) Describe five methods for Pryde to manage the risk of wildfire.

**Commentary on Question:**

*Full credit was given to reasonable answers that were different from the model solution shown below.*

Method 1: Risk exclusion: stop providing cover for wildfire

Method 2: Risk reduction: provide wildfire cover with sublimit or co-insurance or deductible

Method 3: Risk transfer: reinsurance or any other financial contract to transfer wildfire risk

Method 4: Risk prevention and monitoring: Encouraging the use of alert and monitoring system to warn customers to get prepared for an incoming fire

Method 5: Monitor the overall aggregated exposure in one area so that the overall exposure is within specified limits