

ERM-GC Model Solutions

Fall 2012

1. 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:

- (2b) Evaluate how risks are correlated, and give examples of risks that are positively correlated and risks that are negatively correlated.
- (2h) Construct approaches to managing various risks and evaluate how an entity makes decisions about techniques to model, measure and aggregate risks including but not limited to stochastic processes.
- (3e) Define and evaluate credit risk. Explain how to incorporate best practices in credit risk measurement, modeling and management.

Sources:

Financial Enterprise Risk Management, Sweeting, 2011, chapter 14

Value-at-Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion, 2007, chapter 18

Commentary on Question:

The focus of this question was credit risk and the variety of credit risk models presented in the syllabus. Successful candidates were expected to demonstrate their understanding of these models in the specific context of the question.

Solution:

- (a) Explain how Hamsik's perspective on credit risk would differ if it reported assets at market value rather than at book value.

Commentary on Question:

Most candidates performed poorly on this part of the question as they confused the financial reporting of assets by Hamsik with the book and market value of collateral supporting the Hamsik loan portfolio. Very few candidates commented that accounting convention did not impact the economic reality of risk.

1. Continued

To the extent that Hamsik reports at Book Value, its financial reporting is unaffected by temporary changes in the market value of its assets. Nevertheless, it is concerned with the ultimate ability to collect payments (both coupons and principal).

If Hamsik instead reported at Market Value, its financial reporting would be affected by both temporary changes in the market value (as a result of credit spread movements or downgrades) and by actual defaults.

Accounting convention does not impact the economic reality of credit risk.

- (b) Explain how credit risk and market risk can interact in the context of the Hamsik loans to Cayuga.

Commentary on Question:

Many candidates received full credit for this section. Almost all were able to get one of the two key points.

A downturn in the market may reduce investment portfolio income for Cayuga. Since Cayuga's income is highly dependent on his investment portfolio, a market downturn could lead to Cayuga's defaulting on his obligations to Hamsik.

The market value of the collateral backing the loans may fluctuate (regardless of the likelihood of default), which will increase/decrease the loss given default for Hamsik.

- (c) (i) Identify and describe the three broad types of quantitative credit risk models.

Commentary on Question:

Most candidates performed well on this part of the question.

Credit Scoring Models- use features of the entity (e.g. accounting ratios) to assign a score that represents the likelihood of insolvency. These are general linear models taking on values between 0 and 1.

Structural Models- model the value of the underlying entity (asset value, debt levels) to arrive at the probability of default.

Reduced Form Models- use the exogenously derived credit rating to arrive at the probability of default.

1. Continued

(ii) Categorize each of the following credit risk models into one of the three model types identified in part (i) above.

- (A) Probit/Logit Models
- (B) Merton Model
- (C) Credit Risk +
- (D) K-nearest neighbor (kNN)
- (E) Discriminant Analysis
- (F) KMV
- (G) Altman's Z Score
- (H) Support Vector Machines

Credit Scoring Models: A, D, E, G, H

Structural Models: B, F

Reduced Form Models: C

(d) Explain why each of the following specified approaches to modeling credit risk may or may not be appropriate for the GreatKibble.com loan.

- (i) Merton Model
- (ii) Discriminant Analysis
- (iii) Credit Migration Model

Commentary on Question:

Most candidates performed well on this section. Candidates lost points when they did not relate each approach specifically to Great Kibble.

Merton Model – Not good for Great Kibble. It's better for large borrowers with liquid and frequently traded equity, which Kibble is not. There are no tangible assets held by Kibble, which is required by the Merton Model. The volatility of newer companies is also not stationary, which is a requirement in the Merton Model.

Discriminant Analysis- Requires an entity to have a history of financial ratios. Great Kibble does not have a reliable history. It has a short history and the financials are being restated (i.e. current financials may not be reliable). However, this approach works well for smaller companies, so once the numbers have been restated this approach may be suitable.

Credit Migration Model- Requires an entity to be publicly rated. It is very unlikely that Kibble is publicly rated, so this approach is not appropriate.

2. Learning Objectives:

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 economic capital assessment and techniques to allocate the cost of risks within business units.

Learning Outcomes:

- (4c) Demonstrate means for transferring risk to a third party, and estimate the costs and benefits of doing so.
- (5a) Describe the concept of economic measures of value and demonstrate their uses in the risk management and corporate decision-making processes.
- (5d) Apply risk measures and demonstrate how to use them in economic capital assessment. Contrast and understand regulatory, accounting, statutory and economic capital.
- (5e) 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:

Value-at-Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion, 2007

- Chapter 5 Computing VaR

Article: Variance of the CTE Estimator, Risk Management, August 2008

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

Tiller, Life, Health and Annuity Reinsurance, 3rd Edition, 2005

- Chapter 5 Advanced Methods of Reinsurance

Financial Enterprise Risk Management, Sweeting, 2001

- Chapter 18 Economic Capital

Commentary on Question:

The question asked candidates to compute VaR and CTE risk metrics for the specified loss distribution and to use this information to make a decision regarding the cost / benefit of entering into a reinsurance arrangement. The question required the use of calculus, which proved to be a stumbling block for some candidates.

2. Continued

Solution:

- (a) Erie holds economic capital based on the tail risk of claims paid.

Compute the amount of required economic capital Erie should hold, prior to purchasing any reinsurance, for the following tail risk metrics:

- (i) VaR(95%)
(ii) CTE(95%)

Commentary on Question:

Most candidates could compute VaR and CTE. Some candidates did not subtract the expected claim amount from the VAR and CTE to arrive at the capital amount held by Erie. This oversight did not cost the candidate significant points in part (a) but failure to use the correct capital amount in subsequent parts led to incorrect results and conclusions.

Weaker candidates incorrectly computed a VAR amount which was greater than the computed CTE amount and failed to comment on this or otherwise indicate that this was not a reasonable outcome.

- (i) VaR (p) = x_p , so that $\Pr(X > x_p) = 1 - p$
 $F(x_p) = \Pr(X \leq x_p) = \int_0^{x_p} f(x) dx = \int_0^{x_p} e^{-x} dx = 1 - e^{-x_p} = p = 0.95$
 $x_p = -\ln(0.05) = 2.996$
So VaR (95%) = 2.996 billion

Expected Liability = $E[x] = \int_0^{\infty} xf(x) dx = \int_0^{\infty} xe^{-x} dx = 1$ (using the formula given in the stem of the question with $\phi = 0$)

Capital Held Based on VaR Measure = VaR(95%) - $E[X] = 2.996 - 1 = 1.996$ billion

- (ii) CTE (95%) = $E[X|X > x_p] =$
$$\frac{\int_{x_p}^{\infty} xf(x) dx}{\int_{x_p}^{\infty} f(x) dx} = \frac{\int_{x_p}^{\infty} xe^{-x} dx}{\int_{x_p}^{\infty} e^{-x} dx} = \frac{(1 + x_p) \times e^{-x_p}}{0.05} = \frac{(1 + 2.996) \times e^{-2.996}}{0.05} = 3.996$$
 billion
Capital Held Based on CTE Measure = CTE (95%) - $E[X] = 3.996 - 1 = 2.996$ billion

2. Continued

- (b) Compute the pre-tax return on economic capital, prior to the purchase of reinsurance, for both (i) and (ii) from part (a) assuming an investment earned rate of 0%.

Commentary on Question:

The most common mistake candidates made was to use VaR and CTE values as capital in the calculation without subtracting the expected claim amount.

	VaR(95%)	CTE(95%)
Premium	1.25	1.25
Investment Income	0	0
Claims	-1	-1
Pre-tax Return	0.25	0.25

Capital 1.996 2.996

*Table in billions

Return on capital = Pre-tax Return/Capital

VaR(95%)	CTE(95%)
12.53%	8.34%

- (c) Assume that Erie's only objective is to maximize return on capital.

Recommend whether Erie should purchase the reinsurance, assuming the following capital levels:

(i) VaR(95%)

(ii) CTE(95%)

Commentary on Question:

Most candidates could not compute the expected reinsurance claims correctly. Some candidates did not realize that VaR and CTE would change after the reinsurance was purchased.

Candidates are encouraged to signal to the grader that they understand when computed amounts seem unreasonable. For example, candidates who computed a VAR value which was greater than CTE or computed a reinsurance premium which exceeded the direct premium should signal to the grader that they understand or at least suspect that the computed value is incorrect before proceeding to use it further.

2. Continued

$$E[\text{Reinsurance Claims}] = \int_0^{\infty} \max[0, x - 2.5]f(x)dx = \int_{2.5}^{\infty} xe^{-x}dx - \int_{2.5}^{\infty} 2.5e^{-x}dx = 3.5e^{-2.5} - 2.5e^{-2.5} = 0.082 \text{ billion}$$

$$\begin{aligned} \text{Reinsurance Premium} &= 200\% \text{ of Expected Reinsurance Claims} \\ &= 200\% \times 0.082 = 0.164 \text{ billion} \end{aligned}$$

$$\begin{aligned} \text{Liability after reinsurance} &= E[X - \text{Reinsurance Claims}] = E[X] - \\ &E[\text{Reinsurance Claims}] = 1 - 0.082 = 0.918 \end{aligned}$$

- (i) VaR(95%) without reinsurance is 2.996 billion (from part a). Reinsurer will cover claims above 2.5 billion; therefore, for any claim above 2.5 billion, the liability to the insurance company is 2.5 billion. Therefore, at the 95th percentile, its exposure will no longer be 2.996 billion, it will be 2.5 billion.

$$\text{VaR Capital} = \text{VaR}(95\%) - E[X] = 2.5 - 0.918 = 1.582$$

	VaR(95%)
Premium	1.25
Reinsurance Premium	-0.164
Investment Income	0
Claims	-0.918
Pre-tax Return	0.168

$$\text{Capital} = 1.582$$

*Table in billions

$$\text{RoC} = \text{Pre-tax Return} / \text{Capital} = 10.62\%$$

VaR: RoC post reinsurance is reduced from 12.53% to 10.62%, so NO, Erie should NOT purchase the reinsurance if it holds capital based on VAR(95%) and Erie's only objective is to maximize return on capital.

- (ii) VaR (95%) with reinsurance is 2.5 billion (from part c (i)). Each of the worst 5% of claims is greater than 2.5 billion, and Erie is only responsible for 2.5 billion for each claim above VaR (95%) due to reinsurance. As a result, the average of the claims above VaR(95%) is 2.5 billion, which is CTE (95%).

$$\text{CTE}(95\%) = 2.5 \text{ billion}$$

$$\text{CTE Capital} = \text{CTE}(95\%) - E[X] = 2.5 - .918 = 1.582$$

2. Continued

	VaR(95%)
Premium	1.25
Reinsurance Premium	-0.164
Investment Income	0
Claims	-0.918
Pre-tax Return	<u>0.168</u>
Capital	1.582

*Table in billions

$$\text{RoC} = \text{Pre-tax Return} / \text{Capital} = 10.62\%$$

CTE: RoC post reinsurance is increased from 8.34% to 10.62%, so YES, Erie should purchase the reinsurance if it holds capital based on CTE(95%) and Erie's sole objective is to maximize return on capital.

- (d) Explain why Erie may want to purchase reinsurance even though it may reduce expected net income.

Commentary on Question:

Most candidates did this part of the question well. However, while there are a range of reasonable responses, the most pertinent response (given the analysis performed in parts (a) through (c)) is that Erie may be willing to reduce expected profits in exchange for limiting losses in the worst case scenarios. Weaker candidates failed to mention this but rather provided a generic list of benefits associated with reinsurance.

- Reinsurance helps Erie to reduce expected claims especially in the worst case scenarios (or tail of the claims distribution). While this reduces the expected profit for Erie, it also reduces the volatility of profits for Erie.
- Erie may relieve capital strain.
- Erie can get expertise of reinsurer regarding liability.
- Erie may be looked upon positively from rating agency, regulator, etc.
- Reinsurance may allow Erie to take on more business.
- Reinsurance can help with tax planning.
- Reinsurance may enhance balance sheet.
- Reinsurance can help with strategic business planning.

3. Learning Objectives:

1. The candidate will understand the types of risks faced by an entity and be able to identify and analyze these risks.
2. The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.
4. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

Learning Outcomes:

- (1a) Explain risk concepts and be able to apply risk definitions to different entities.
- (1b) Explain risk taxonomy and its application to different frameworks.
- (1c) Identify and analyze risks faced by an entity, including but not limited to market risk, currency risk, credit risk, spread risk, liquidity risk, interest rate risk, equity risk, hazard/insurance risk, inflationary risk, environmental risk, pricing risk, product risk, operational risk.
- (2c) Analyze and evaluate risk aggregation techniques, including use of correlation, integrated risk distributions and copulas.
- (2e) Evaluate the theory and applications of extreme value theory in the measuring and modeling of risk.
- (2h) Construct approaches to managing various risks and evaluate how entity makes decisions about techniques to model, measure and aggregate risks including but not limited to stochastic processes.
- (4d) Demonstrate means for reducing risk without transferring it.
- (4k) Analyze methods of managing other risks (operational, strategic, legal and insurance) both pre-event and post-event.

Sources:

Financial Enterprise Risk Management, Sweeting, 2011

- Chapter 7 Definitions of Risk
- Chapter 8 Risk Identification
- Chapter 10.4 Copulas
- Chapter 12 Extreme Value Theory
- Chapter 15.5 Unquantifiable Risks
- Chapter 16 Responses to Risk

3. Continued

Value-at-Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion, 2007

- Chapter 19 Operational Risk Management (excluding 19.5)

Commentary on Question:

The focus of this question was operational risk. The question aimed to test the ability of the candidate to understand how operational risk could be managed in a specific context.

Solution:

- (a) Define operational risk.

Commentary on Question:

This was a simple retrieval question.

The risk of loss resulting from inadequate or failed processes (projects, data, products, models), people (crime, errors), and systems, or from external events.

- (b) The interviewer has asked for your opinion regarding the viability of Niagara offering this product for the U.S. banking market. Provide arguments for and against Niagara offering the product.

Commentary on Question:

The purpose of this part of the question was to test a candidate's perspective on operational risk, i.e., based on the candidate's reading of the syllabus, what would be the challenges and opportunities of offering such a product.

For:

- Operational risk is a material risk for banks with a history of leading to failure (Barings, AIB, etc.) or sizable losses (JPM). Thus an opportunity for Niagara.
- Could provide capital relief to banks' capital charge for op risk (third largest contributor to economic capital for banks).
- Could provide a natural hedge to Niagara compared to its exposures to credit and market risks.

3. Continued

Against:

- Moral hazard issues.
- Op risk is difficult to model as it involves the estimation of extreme events.
- Operational risk is highly correlated with Niagara's current exposure to market risk hence may compound capital requirements for Niagara
 - Op risk is also related to systemic risk; the traditional pooling effect of insurance may not apply.
- Definition of op risk is not standard in the industry
 - Legal issues likely to be significant given difficulty in defining indemnification provision

- (c) Outline for the interviewer what you believe to be the most important considerations in structuring and underwriting such a product.

Commentary on Question:

This knowledge utilization question builds upon the previous high level strategic analysis and aims at having the candidate explain how the different risks embedded in such a product might be managed.

Stronger candidates provided specific considerations (such as those listed below) and demonstrated their ability to apply the source readings in this specific context. Weaker candidates tended to answer in more general terms using a "list" approach and did not provide any structuring or client specific factors they considered important in underwriting this product.

- Product Structuring Considerations:
 - Have a meaningful Deductible as covering first dollar losses would engender moral hazard
 - Consider coverage exclusions
- Consider Specifics of Client
 - Lines of Business: Operational loss experience differs depending on the types of business policy owners are involved in (e.g. higher exposure for retail banking / retail brokerage and commercial banking than corporate finance and agency services).
 - Geographical dispersion of activities and related concentration of risk issues.
 - Consider corporate governance structure, organizational culture, independence of functions, compensation structure as these will provide insight into incentives provided to management with respect to op risk.

3. Continued

- Consider organization's risk measurement / management programs and systems, and management competency at managing risk. Assess how effective client is going to be at limiting future losses.
- Consider historical loss experience.
- Well Defined Indemnification Provision:
 - Exposure to legal risk when entering into such agreements -- ensure that the conditions under which indemnification payments are due are well defined

(d)

- (i) Explain the significance of ξ and whether using $\xi = 0$ would be appropriate in this context.

Commentary on Question:

This analysis question is testing the comprehension of Extreme Value Theory and what the EVT model parameters represent.

The ξ represents the shape parameter for the generalized Pareto distribution. It is used to model the tail of the distribution when using EVT. The choice of ξ will determine how heavy tailed the resulting distribution is. Selecting $\xi = 0$ corresponds to a relatively light tailed assumption (consistent with normal distribution assumption or exponential reduction in tail). It is not appropriate for operational type risks which tend to have small probabilities for potentially huge losses, particularly for risk related to human and external events.

- (ii) Using $\xi = 0.95$ and given a scale parameter of 20, determine the probability that Niagara will need to make an indemnification payment on this policy in excess of \$0.75 billion.

3. Continued

Commentary on Question:

This analysis question is testing the application of one model of EVT to a specific context. A common error on this part was the failure to adjust by the 1% probability of making a payment (see last step). Another common error was failure to account for the deductible (see second line below).

$$\begin{aligned} & \text{Prob}[\text{Indemnification payment} > 0.75\text{B}] \\ &= \text{Prob}[\text{Loss} - \text{Deductible} > 0.75\text{B}] \\ &= \text{Prob}[\text{Loss} > 1.25\text{B}] \\ &= \text{Prob}[(\text{Loss} - u) / \beta > (1.25 - 0.5) / 20] \\ &= \text{Prob}[y > .0375] \\ &= 1 - F(y = .0375) \\ &= (1 + .0375\xi)^{-1/\xi} \\ &= (1 + .0375 * .95)^{-1/.95} \\ &= 0.96382 \end{aligned}$$

This last number is the conditional probability of loss exceeding threshold given that we are above threshold. We are looking for the unconditional probability of having a loss in excess of .75B; hence, this needs to be adjusted by the probability of making payment, which equals 1%, resulting in a final answer of 0.009638.

- (iii) Determine the probability that Niagara will experience a loss in excess of \$0.75 billion for **at least one** of market risk, credit risk or Pirlo product risk, assuming these risks are independent.

Commentary on Question:

This analysis question is to determine the probability that Niagara will incur a total loss in excess of .75B level from at least one risk.

$$1 - (\text{Probability that each of Market / Credit / Pirlo losses are} < 0.75\text{B})$$

Probability of market loss below .75 billion = .95 from the given table.
Probability of credit loss below .75 billion = .957 from the give table.
Probability of Pirlo loss below .75 billion = $1 - .009638$ as calculated in part (d)(ii).

Since risks are assumed independent, the total probability is = $.95 * .957 * (1 - .009638) = 0.9003876$

Thus, the probability of at least one loss exceeding 0.75B = 10%.

3. Continued

- (iv) Determine the probability that Niagara will experience a loss in excess of \$0.75 billion for **at least one** of market risk, credit risk or Pirlo product risk using a Gumbel copula with alpha parameter equal to 5.

Commentary on Question:

This analysis question is the same as the previous subpart, but instead of assuming independence, we assume that there is a relationship between the risks that we model using the given Copula.

$$C(\pi_1, \pi_2, \pi_3) = \exp - [(-\ln(0.95))^5 + (-\ln(0.957))^5 + (-\ln(0.99036))^5]^{0.2}$$

$$\text{Probability} = 1 - C(\pi_1, \pi_2, \pi_3) = 1 - .94574 = 0.053839 = 5.38\%$$

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

Learning Outcomes:

- (1c) Identify and analyze risks faced by an entity, including but not limited to market risk, currency risk, credit risk, spread risk, liquidity risk, interest rate risk, equity risk, hazard/insurance risk, inflationary risk, environmental risk, pricing risk, product risk, operational risk.
- (4i) Analyze funding and portfolio management strategies to control equity and interest rate risk, including key rate risks. Explain the concepts of immunization including modern refinements and practical limitations. Contrast the various risk measures and be able to apply these risk measures to various entities.
- (4k) Analyze methods of managing other risks (operational, strategic, legal and insurance) both pre-event and post-event.

Sources:

Financial Enterprise Risk Management, Sweeting, 2011

- Chapter 16 Responses to Risk

ERM-110-12: Derivatives: Practice and Principles, Recommendations 9- 24 and Section III

Commentary on Question:

The overall performance on this question was below expectations. The question is focused on understanding and managing interest rate risk. Candidates had an awareness of these topics but struggled to apply them in the context of the question. In general, they were able to provide a “list” of responses but could not demonstrate a deeper understanding and failed to recognize which items from this “list” were applicable in the context of the question. Most candidates did well on the calculation in part (c).

Solution:

- (a) Compare and contrast the exposure to interest rate risk that the USFIS portfolio has relative to a typical pension plan.

Commentary on Question:

Most candidates described the differences in the durations of the USFIS portfolio and a typical pension plan. However, very few recognized that the USFIS portfolio did not have any liabilities to consider and most were unable to give a good description of the underfunding risk of a pension plan.

4. Continued

Partial credit was given for the duration comparison but to receive full credit the candidate needed to recognize that there are no liabilities in the USFIS portfolio and describe the risk of underfunding in a pension plan, a risk that does not exist with the USFIS portfolio.

Exposure in the USFIS portfolio is to changes in market value resulting from changes in interest rates. There are no liabilities to consider in this portfolio since fund redemptions are at market value and the fund is merely investing the bank's own money. There is no risk of underfunding nor an inability to meet obligations.

Exposure in a pension fund arises from having assets and liabilities with different sensitivities to interest rates (i.e., duration mismatch between assets and liabilities). The risk is that changes in interest rates result in underfunding or the inability to meet obligations because of the duration mismatch.

- (b) Describe Reddington's immunization, and explain whether it can or cannot be used to manage the interest rate exposure of the USFIS portfolio. Justify your response.

Commentary on Question:

Most candidates failed to fully describe Reddington's immunization technique. They defined this technique as a modified duration matching technique and did not consider the convexity requirement. In addition, candidates did not recognize that since there are no liabilities in the USFIS portfolio, Reddington's criteria cannot be used.

Reddington's Criteria:

- Present value match – the present value of bonds/swaps' fixed legs is equal to the present value of the liabilities.
- Modified duration match – modified duration of bonds/swaps' fixed legs is equal to the modified duration of the liabilities.
- If present values and modified durations are matched, then a small change in interest rates will result in both the assets and the liabilities changing by the same amount.
- Asset convexity > liability convexity – convexity of bonds/swaps' fixed legs is greater than the convexity of the liabilities.
- The advantage of the asset convexity being greater than the liability convexity is that small changes in interest rates would result in asset values increasing/decreasing more/less than the liability value.

Reddington's criteria cannot be used in this context because there are no liabilities supported by the assets in the USFIS portfolio.

4. Continued

- (c) Compute the estimated change in the USFIS portfolio value for the alternate interest rate scenario in the table below:

Scenario	i_{short}	i_{medium}	i_{long}
Current / Baseline	5.0%	5.0%	5.0%
Alternate Scenario	4.5%	5.5%	6.0%

Commentary on Question:

Most candidates did well on this part. Some candidates performed the calculation but failed to explain how this could be used to estimate the magnitude and direction of the change in portfolio value as a result of the specified interest rate shift.

$$1.3 * (5.0\% - 4.5\%) + 2.7 * (5.0\% - 5.5\%) + 0.8 * (5.0\% - 6.0\%) = 0.65\% - 1.35\% - 0.80\% = -1.50\%$$

This shift will produce a 1.50% x P decrease in portfolio value.

- (d) Explain how the concept of key rate durations might be used to manage the volatility risk associated with an options portfolio.

Commentary on Question:

This was a challenging part of this question which required candidates to have a good conceptual understanding of KRD's as well as option volatility risk. Candidates did not do well on this part. Most candidates provided a list of uses for key rate durations which did not address the specific context of this question. To get credit for this part, candidates needed to describe that option volatility has a term structure and explain how KRDs could be used to understand this volatility.

The concept of key rate durations can be applied to volatility since volatility has a term structure just like interest rates. The price of options is contingent on the volatility of the underlying and variations in implied volatility/volatility assumptions will differ for short dated versus long dated options. Much like using key interest rates to understand one's exposure to changes in interest rates along the entirety of the yield curve, one could use key volatility rates to understand one's exposure to changes in volatility along the maturity spectrum for a portfolio of options.

- (e) In response to your information, the compliance department has drafted the following disclosure statement:

4. Continued

“Given that this portfolio aims to enter into offsetting positions with various counterparties, the risk of experiencing a loss on this portfolio has been virtually eliminated.”

Explain why you disagree with this statement by identifying and explaining two key risks that you believe this fund is exposed to.

Commentary on Question:

Most candidates were able to list and define one or two risks that the fund is exposed to but tended to focus on less important risks at the expense of the key risks. The stronger candidates identified the key risks and described how these risks applied in the context of this portfolio. Weaker candidates only described the risks in general.

Several candidates included basis risk as a key risk for the portfolio. The stem of the question states “...the portfolio aims to enter into offsetting positions...” Therefore, while basis risk may be a key risk for some portfolios, it is not a key risk for this portfolio.

This statement is incorrect because offsetting positions only serve to reduce the exposure to market risk (and not to the other risks this portfolio is exposed to). Even if the portfolio has perfectly offsetting positions (i.e. no basis risk), the portfolio is exposed to credit risk, operational risk, legal risk, and liquidity risk.

Candidates only needed to describe two of the following:

1. Legal risk – exposure relates to the risk that the derivatives contract (in whole or in part) with the counterparty owing you monies is unenforceable.
 - a. The USFIS portfolio is specifically targeting “less sophisticated parties” who may not legally be eligible to enter into such contracts.
2. Liquidity risk – exposure relates to the risk of having to make a payment or post collateral at unexpected or inopportune times.
 - a. While the portfolio may have entered into offsetting positions, there is no assurance that the settlement provisions or credit enhancement provisions for offsetting positions are equivalent.
 - b. While the fund may have a perfectly offsetting position it may still have exposure to liquidity risk if it needs to post collateral on a losing contract while its counterpart on the winning contract only needs to settle at maturity.
3. Operational risk – exposure relates to the risk that the company is operationally inefficient or unable to function, including business continuity risk, people risk, and technology risk.
 - a. Specific examples include company technology failing, company not hiring good employees, natural disasters (earthquake, fire, weather, etc.) making it impossible for employees to work.

4. Continued

4. Credit risk – exposure relates to the risk that a counterparty will not be able to fulfill its obligations.
 - a. While the fund enters into offsetting positions with major investment banks, the specialized derivative contracts are with less sophisticated counterparties which might impose some additional risk.

5. Learning Objectives:

1. The candidate will understand the types of risks faced by an entity and be able to identify and analyze these risks.
2. The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.

Learning Outcomes:

- (1a) Explain risk concepts and be able to apply risk definitions to different entities.
- (1c) Identify and analyze risks faced by an entity, including but not limited to market risk, currency risk, credit risk, spread risk, liquidity risk, interest rate risk, equity risk, hazard/insurance risk, inflationary risk, environmental risk, pricing risk, product risk, operational risk.
- (2d) Apply and analyze scenario and stress testing in the risk measurement process.

Sources:

Value-at-Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion, 2007

- Chapter 13 Liquidity Risk

Commentary on Question:

The focus of this question was on assessing the impact to liquidity risk exposure under a set of specific scenarios.

Solution:

- (a) Describe the different kinds of liquidity risk that a firm, in general, may be exposed to.

Commentary on Question:

Most candidates were able to list and explain the two types of liquidity risks.

Liquidity risk can be categorized as asset (market) or funding related.

- Asset liquidity risk is the risk that liquidation value of assets may differ significantly from their current mark-to-market values.
 - Funding liquidity risk is the risk of being unable to meet the payment obligations to creditors of investors
 - Risk increases with mismatches in the timing of payments
- (b) Identify and explain a stress scenario which could create a liquidity crunch specifically for LWD.

5. Continued

Commentary on Question:

This question requires the candidate to create a scenario based on the context of the question. While there are many possible responses, some are more relevant to the context and hence would result in higher grades. Generally candidates did well in this part; however weaker candidates provided scenarios which did not relate well to LWD or were not very plausible. Below is a sample answer.

- The LWD business model requires LWD to acquire a lot of inventory (pay out cash) and then get repaid from customers.
 - To the extent that LWD customers extend their repayment periods / opt to forgo the Pay-As-You-Go Program, this could create a liquidity crunch for LWD.
- (c) Describe the exposure to liquidity risk that each of the six financing alternatives creates for **Horseshoe**.

Commentary on Question:

This part of the question asked about the liquidity risk exposure for Horseshoe. Some candidates mistakenly addressed this question from the perspective of LWD. Instead of focusing on liquidity risk exposure, some candidates addressed the other types of risks that these six financing alternatives may create.

- All of the options will increase the asset related liquidity exposure because Horseshoe will hold a sizable position in LWD (\$10M stake in a company with \$76M in market value) and this position will tend to have high liquidity risk.
- Option I will also create funding liquidity risk as LWD may elect to draw on the LOC at some future date creating a cash demand on Horseshoe.
- Option II will be relatively more liquid compared to the other options as it has an acceleration of principal provision in the event that LWD fails to maintain certain financial ratios.
- Option III is less liquid as Horseshoe would hold LWD stock and the stock is traded (presumably thinly traded) on the OTC market.
- Option IV is less liquid as private placements usually involve less transparent offerings with non-standard provisions, which are less readily transferrable. Further, since these are zero coupon bonds, they will result in an increasing exposure over time.
- Option V is relatively more liquid than IV as the securities are publically traded (hence more standard / transparent than private placements). Also, the periodic coupon rate will either keep the exposure constant or accelerate payment to Horseshoe in the event that the quality of the LWD notes decline.

5. Continued

- Option VI is less liquid as structured notes usually involve less transparent offerings with non-standard provisions.
- (d) Assess each of the alternatives with respect to its impact on the liquidity risk exposure it creates for **LWD**, and rank them from least to greatest liquidity risk exposure. Justify your assessment.

Commentary on Question:

Most candidates were able to correctly rank these options (with some exception on option VI)

Best to Worst: III – VI – I – IV – V – II

- Option I does not create liquidity risk exposure for LWD; it helps to solve it by providing a source of additional funding to LWD if / when required.
- Option II's acceleration provision creates funding liquidity risk as it will require unanticipated payment of principal in times of distress.
- Option III does not create liquidity risk as there is no obligation to repay equity investment or even to pay the dividend.
- Option IV does not create liquidity risk as it only requires LWD to make the expected repayment as scheduled.
- Option V creates liquidity risk exposure as it may increase LWD's interest burden in times of distress.
- Option VI does not create liquidity risk; rather it helps solve it by eliminating cash flow mismatch between LWD cash inflows and debt payment outflows.

6. Learning Objectives:

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

Learning Outcomes:

- (2b) Evaluate how risks are correlated, and give examples of risks that are positively correlated and risks that are negatively correlated.
- (2c) Analyze and evaluate risk aggregation techniques, including use of correlation, integrated risk distributions and copulas.
- (3a) Apply and construct risk metrics to quantify major types of risk exposure such as market risk, credit risk, liquidity risk, regulatory risk, etc., and tolerances in the context of an integrated risk management process.

Sources:

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

Value-at- Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion Ch. 9

Commentary on Question:

This question tests candidates' ability to calculate Value-at-Risk for a portfolio of assets. Candidates' knowledge of time-varying risk models, such as the exponentially weighted moving average (EWMA) process, is also assessed. The last part of the question requires the candidates to analyze the impact of a proposed trade on the risk of the portfolio.

Solution:

- (a) Calculate the 99% VaR for the portfolio as of today.

Commentary on Question:

Full points were also awarded for candidates who expressed the portfolio variance formula in matrix form (assuming done correctly), instead of writing out the equations, as shown in the response that follows.

First, we need the portfolio variance:

$$\begin{aligned}\sigma_p^2 &= W_{\text{wolf}}^2 \sigma_{\text{wolf}}^2 + W_{\text{lion}}^2 \sigma_{\text{lion}}^2 + 2W_{\text{wolf}}W_{\text{lion}}\sigma_{\text{wolf,lion}} \\ &= 0.5^2 * 0.0225 + 0.5^2 * 0.01 + 2 * 0.5 * 0.5 * 0.005 \\ &= 0.010625\end{aligned}$$

6. Continued

The 99% VaR for the portfolio is:

$$\begin{aligned}\text{VaR}_p &= \alpha \sigma_p W \\ &= 2.33 * \text{sqrt}(0.010625) * (500 + 500) \\ &= 240.17\end{aligned}$$

- (b) Calculate the expected conditional covariance of the portfolio to use in tomorrow's calculation.

Under the EWMA process, we have the conditional covariance tomorrow as:

$$\begin{aligned}\sigma_{\text{wolf, lion}; t+1} &= \lambda \sigma_{\text{wolf, lion}; t} + (1-\lambda) r_{\text{wolf}; t} r_{\text{lion}; t} \\ &= 0.95 * 0.005 + 0.05 * 5\% * 5\% \\ &= 0.004875\end{aligned}$$

- (c) Tyrion wants to increase one of his commodity positions by 1%. His goal is to increase his expected future profits while minimizing the change in VaR. Determine whether Tyrion should increase the investment in wolf fur or lion mane. Justify your response.

Commentary on Question:

Partial points were given to candidates who used a marginal VaR approach. This is because the marginal VaR measures the change in the portfolio VaR resulting from an additional dollar of exposure to a given component, and could inadequately capture the change in portfolio VaR when a component changes by a larger amount (in which case VaR changes nonlinearly). To receive full points under the marginal VaR approach, the calculated marginal VaR of a dollar change in either commodity needs to be scaled to the level of change specified by the question (1% or \$5).

To assess the exact change in VaR, the incremental VaR approach is used:

First, test the incremental VaR of increasing the wolf fur position:

Increase wolf fur position by 1% → 505 in wolf fur and 500 in lion mane

$$\begin{aligned}\sigma'_p{}^2 &= w'_{\text{wolf}}{}^2 \sigma_{\text{wolf}}{}^2 + w_{\text{lion}}{}^2 \sigma_{\text{lion}}{}^2 + 2w'_{\text{wolf}} w_{\text{lion}} \sigma_{\text{wolf, lion}}{}^2 \\ &= (505/1005)^2 * 0.0225 + (500/1005)^2 * 0.01 + 2 * (505/1005) * (500/1005) * 0.005 \\ &= 0.01066\end{aligned}$$

6. Continued

$$\begin{aligned}\text{VaR}'_p &= \alpha \sigma'_p W' \\ &= 2.33 * \text{sqrt}(0.01066) * (500+505) \\ &= 241.73\end{aligned}$$

$$\begin{aligned}\text{Incremental VaR} &= \text{VaR}'_p - \text{VaR}_p \text{ (from part a)} \\ &= 241.73 - 240.17 \\ &= 1.56\end{aligned}$$

Repeating the above steps for increasing the lion mane position by 1%, we get an incremental VaR of 0.85, which is less than the incremental VaR from increasing the wolf fur position.

As such, assuming both commodities have the same expected rate of return, Tyrion should increase his position in lion mane to meet his goal.

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 analyze risks faced by an entity, including but not limited to market risk, currency risk, credit risk, spread risk, liquidity risk, interest rate risk, equity risk, hazard/insurance risk, inflationary risk, environmental risk, pricing risk, product risk, operational risk.
- (4b) Demonstrate and analyze applicability of risk optimization techniques and the impact on an organization's value of an ERM strategy.
- (4k) Analyze methods of managing other risks (operational, strategic, legal and insurance) both pre-event and post-event.

Sources:

Financial Enterprise Risk Management, Sweeting, 2011

- Chapter 8 Risk Identification
- Chapter 16 Responses to Risk

ERM-107-12: Strategic Risk Management, Andersen & Schroder

- Chapter 1 The Strategic Nature of Corporate Risk Management
- Chapter 7 Strategic Risk Analysis

ERM-402-12: Countering the Biggest Risk of All (also coded FE-C106-07)

Commentary on Question:

Most candidates did not do a complete analysis, choosing only a couple items for each of S/W/O/T, and often not focusing on the most important aspects.

Many candidates ignored the distinction between internal (strengths and weaknesses) and external (opportunities and threats).

Few candidates considered the pension plan when considering risks within the company.

It did not appear that candidates had done sufficient analysis of the case study in advance of the exam; there was little evidence that candidates could recognize risky situations that were inherent in the case study.

Solution:

- (a) Perform a SWOT analysis for SLIC in which you identify the primary strengths, weaknesses, opportunities, and threats. Make sure your analysis is specific to SLIC.

7. Continued

Strengths

- Brand – good reputation, market dominance in term
- Risk policies in place – investment, liquidity
- Strong relationship with Conservative Re
- EC models exist and EC is calculated regularly
- Risk management process includes both stochastic and stress testing

Weakness

- Board dysfunction, too small, few external members, planning to eliminate risk committee
- Distribution limited to one system (brokers) and hence to one segment of customers
- Weak risk culture – new CRO getting hired, but he/she will become an officer and will result in disbanding of the Risk Management Committee
- UL admin system unable to fully administer policies, and VA admin system needs upgrades for new products
- VA hedging ignores Greeks other than delta and rho
- Op risk management weak – no model, poor broker training can lead to inappropriate sales

Opportunities

- Possible new products or modifications to current product can lead to increased sales
 - VA product to add new funds and riders
- New customers via demographics or geography
- Expansion of distribution
- Improved brand management
- Low interest rates – access to cheap capital

Threats

- Low interest rates – implied or explicit product guarantees; product management pressures
- Industry competition via third-party admin
- New competitor from outside – Nat Bank
- Lack of affordable new reinsurance

- (b) Select the two most important opportunities identified for SLIC from the analysis performed in part (a). Justify your selection.

Commentary on Question:

The response below gives two possible “important opportunities”. Candidates received credit for selecting other opportunities if they appropriately justified why they were important.

7. Continued

Expand distribution beyond brokers

- Expands types of customers that the company can access
- Potentially reaches higher margin customers
- May reduce reliance on ‘fast follower’ model to improve margins
- Strengthens brand with additional exposure

Improve brand management

- Customers pay more for strong brand
- There are several opportunities for SLIC to make changes that will improve its “brand:”
 - Need for marketing department improvements to control brand erosion
 - Improved risk management can reduce potential for poor publicity, which could hurt brand
 - Increase product differentiation to make brand more unique

- (c) Consider your analysis of weaknesses in part (a) and the Slywotzky and Drzik categories of strategic risks. Select the three most important categories of strategic risk that you feel the new SLIC CRO should focus on first. Justify your response.

Commentary on Question:

The response below presents three important categories for SLIC. Candidates received credit for other selections as long as the importance of each was appropriately justified.

New Project Failure

- Admin systems’ weaknesses can lead to poor service and brand deterioration
- High expense to manage product features manually
- Lengthy time to market for new VA product could mean that competitors will have improved faster, making new product obsolete

Industry

- Reduce admin expense via system investment or third-party admin
- Investigate alternate distribution systems to access broader types of customers, increasing diversification and potentially selling higher margin products
- Improve hedging to reduce income volatility vs. peers
- Increase ALM frequency to quarterly and use effective duration to improve return for risk vs. peers

7. Continued

Brand

- Improve Board to strengthen market view of company
- Make CRO a senior position and independent of lines of business to improve governance and hence reputation with market and regulators; don't disband Risk Management Committee
- Improve products to increase brand uniqueness
- Improve broker training to control company message

8. Learning Objectives:

2. The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.
3. The candidate will understand how the risks faced by an entity can be quantified and the use of metrics to measure risk.
5. The candidate will understand the concept of economic capital, risk measures in economic capital assessment and techniques to allocate the cost of risks within business units.

Learning Outcomes:

- (2h) Construct approaches to managing various risks and evaluate how an entity makes decisions about techniques to model, measure and aggregate risks including but not limited to stochastic processes.
- (3d) Describe and evaluate risk management techniques in terms of best practice that can be used to deal with financial and non-financial risks.
- (5c) Explain the challenges and limits of economic capital calculations and explain how economic capital may differ from external requirements of rating agencies and regulators.

Sources:

Risk Evaluation in Enterprise Risk Management – ASB Exposure Draft – April 2012
http://www.actuarialstandardsboard.org/pdf/exposure/ASOP_ERM_Risk_Evaluation_exp_draft_april_2012.pdf

Commentary on Question:

Many candidates did poorly on this question. Most did not write complete enough answers considering the point count for the question. Candidates did better on part (b) than on parts (a) and (c).

Solution:

- (a) Explain how each of these three elements will apply in your evaluation of Lyon's risk profile. Provide specific references to Lyon in your response, where appropriate.

Commentary on Question:

Part (a) in general was answered poorly by most candidates. In order to do well on part (a), candidates needed to provide an explanation for each of the three elements given in the question, and needed to provide examples from the case study.

8. Continued

I. The organization's risk profile, and the nature, scale and complexity of the risks faced by the organization

The "nature of the risks" involves identifying the source and potential impacts of each risk. Case Study Example: For the life insurance entity, there are different sources of risks coming from different products (Mortality from term life, interest rate risk from UL).

The "scale of the risks" involves quantifying the risks and determining which risks are material, the degree of materiality, and determining how well Lyon can withstand the scale of its risks. Case study example: The interest risk for SLIC's UL may be much larger than for other lines of business.

The "complexity of the risks" involves determining how interrelated the risks are, and how complicated the modeling will be. Case study example: We may want to consider the correlation between equity risk on VAs and credit risk on reinsurers.

II. The organization's profit-related goals, including goals for the level and volatility of profits

The evaluation would consider items such as the following:

Is pricing done on a risk-adjusted basis? What risk-adjusted measure is used?
Which of the possible return measures (ROI, NPV, etc.) are used?

The evaluation should look at whether there is a preference for low volatility in profit goals, because this generally minimizes liquidity and investment risks.

The evaluation can compare profit goals against benchmarks, for instance, how does the term life product's profit compare against the industry. Are the profit goals short term or long term in nature?

The evaluation should also consider whether the profit goals are unrealistic, which might lead management to take inappropriate risks.

III. Limitations to the fungibility of capital across the organization

The evaluation should consider if there are regulatory restrictions on transferring capital across the company. Case study example: Lyon has many subsidiaries in different regulatory settings -- is it possible to transfer capital from one to another?

If limitations exist on fungibility, the evaluation should consider potential liquidity risks.

8. Continued

- (b) The ASOP draft lists several criteria that actuaries who work with economic capital models should consider.

Commentary on Question:

Most candidates scored the majority of their points on part (b). Some candidates did very well in this section, though others did not respond thoroughly to the question.

- (i) One of these is “the quality, accuracy, appropriateness, and completeness of data underlying the models”.

Describe the steps you would take to ensure compliance with this criterion in the context of your assignment at Lyon.

Steps:

- Check if the values make sense with sample data
- Check if the data is complete or incomplete
- Check for errors in the data (e.g. Bad dates, unrealistic values)
- Check data against an underlying source (E.g. Industry, historical data)

- (ii) Another of these is “the appropriateness of the methodologies used for model validation, calibration and sensitivity”.

Describe the steps you would take to ensure compliance with this criterion in the context of your assignment at Lyon.

- Static model validation (Reconcile results to current actual)
- Dynamic model validation (e.g., Examine trending results)
- Consider if methods are up to industry practice or recommended approaches
- Check if sensitivity analyses cover plausible over adverse cases, catastrophic cases and the current economic situation
- Check if the output is consistent with desired risk and financial metrics

- (iii) Identify three additional criteria from the ASOP that actuaries who work with economic capital models should consider.

8. Continued

Commentary on Question:

Candidates did well on this part and there were alternative acceptable approaches to responding. Candidates could answer in terms of the specific criteria for working with EC models, which was the intent of the question, but they also received credit for giving considerations such as: the time frame of the EC models, the appropriateness of the assumptions, etc.

A sample of an acceptable response follows:

- The appropriateness of the methodologies used for modeling dependencies and interactions among risks
- The appropriateness of the cash flow and discounting methodologies used in the models.
- The inherent statistical and theoretical limitations of the models

- (c) The ASOP draft identifies a number of considerations when selecting model assumptions

Commentary on Question:

Part (c) was not done particularly well. Many candidates did not attempt sub-part (i). Those who did answer generally did not provide the list in the ASOP but were given credit for other adequate answers. Sub-part (ii) was closely related to sub-part (i), so candidates who did not know the ASOP list were at a disadvantage because they could not provide the level of detail expected in sub-part (ii).

- (i) List three of the ASOP considerations related to assumption selection.
- Whether the assumptions are supportable, appropriately documented, and allow for deviations from the expected
 - Whether the assumptions are regularly revisited to determine their appropriateness
 - Whether the assumptions that explicitly reflect anticipated management actions in response to future events are supportable and appropriately documented
- (ii) Explain how each of the considerations you chose in (i) would inform your judgment in setting each of the three key assumptions for SLIC's economic capital model.

8. Continued

Mortality:

- Supportable through experience studies and industry data
- Allow deviations from the expected with provisions for adverse deviation (PADs) and mortality improvement/worsening
- Appropriately documented with memos and reports
- Regularly revisited with trending analysis, experience studies, or environmental scanning
- Anticipated management actions are reflected with trending

Lapse

- Supportable through experience studies and industry data
- Allow deviations from the expected with PADs, dynamic lapse
- Appropriately documented with memos and reports
- Regularly revisited with trending analysis, or experience studies, or environmental scanning
- Anticipated management actions are reflected with trending, scenario analysis

Interest Rates

- Supportable - In line with regulatory standards, use current assumptions, reflect basis risk, use interest rate generator/scenarios etc.
- Appropriately documented with controls, regulatory filings, reports
- Allow deviations with adverse scenarios, PADs, Stochastic modeling
- Regularly revisited quarterly or monthly to measure impact
- Anticipated management actions are reflected with scenario/sensitivity testing