ERM-INV Model Solutions
Spring 2016

1. Learning Objectives:

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

Learning Outcomes:

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

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

Sources:

ERM-501-12 An RBC Overview

ERM-106-12 Economic Capital-Practical Considerations

Commentary on Question:

This question tests the ability of candidates to understand the components of the Risk Based Capital (RBC) formula and how to apply it to a given product. In addition, they were asked to compare and contrast RBC with economic capital and the most appropriate capital for a company's risk management strategy.

Solution:

(a) Explain how each of the four RBC risk components pertains to the Classic GIC portfolio and its supporting assets.

Commentary on Question:

Full credit required candidates to explain each risk and relate them back to the Classic GIC product.

Many candidates identified the risk of surrender as an insurance risk, and credit was awarded for this response. Also, many different responses were possible for business risk. Overall, candidates did well on this part of the question.

1. Continued

Asset Risk – Other: This is the risk of default associated with the investment grade bonds backing reserves and capital.

Insurance Risk: Because the GIC does not have a material insurance component, this risk is minimal or nonexistent.

Interest Rate Risk: This is the risk associated with the impact of changes in interest rates on statutory surplus. Because the GIC is surrenderable after two years, this risk could be significant on the Classic GIC.

Business Risk: This represents operational risk associated with the GIC portfolio.

(b) Explain how the RBC profile for Enhanced GIC differs from that of Classic GIC for each of the four RBC risk components.

Commentary on Question:
On this part of the question, candidates were asked to compare the RBC profile for the Enhanced GIC product with the Classic GIC. An emphasis was placed on the explanations for Asset Risk and Interest Rate Risk because these are the risks that differ substantially between the two products.

Most candidates recognized that asset risk would increase on the Enhanced GIC.

Asset Risk – Other: This risk will be higher on the Enhanced risk due to higher default risk as well as concentration risk on the higher-yielding bonds issued by Riley.

Insurance Risk: This risk is minimal on both products since neither has a material insurance component.

Interest Rate Risk: Interest rate risk is lower on the Enhanced GIC because the product is non-surrenderable, making duration or cash flow matching possible.

Business Risk: This should be similar between the two products given operational risks are similar.

(c) Explain why the introduction of Enhanced GIC may not generate a diversification benefit in total RBC for Arbutus.

Commentary on Question:
In this part, the objective was for candidates to make a connection to the RBC formula and realize that there is no covariance benefit between asset risk and interest rate risk.

1. Continued

A majority of candidates responded that there is no diversification benefit because the products are similar. This response did not get credit because many "similar" products have slightly different features that result in some level of diversification.

As a result, very few candidates achieved full credit on this part of the question.

The Enhanced GIC has higher asset risk and lower default risk than the Classic GIC. The RBC formula for Life insurers adds these two risks (C1o and C3a) together prior to squaring, and therefore they will offset one another with no diversification benefit occurring within the formula.

(d) Arbutus calculates Economic Capital for the GIC block of business based on a prescribed Conditional Tail Expectation (CTE) measure of the modeled present value of profits over a large number of scenarios.

Explain how each of the four RBC risk components can be captured in such a model.

Commentary on Question:
Many different responses were possible to receive credit. Full credit required an explanation of how each of the four risks could be captured in an Economic Capital model, not just a general discussion of those risks. Also, the responses needed to relate back to the GIC portfolio. For example, suggesting that insurance risk could be captured by shocking mortality rates isn't directly relevant to these products, which do not have a mortality component.

Asset Risk – Other: The Economic Capital model could explicitly model assets and expected reinvestments in each scenario, taking into account callability, etc. Their performance would be scenario-dependent, dynamically capturing defaults and associated correlation risk.

Insurance Risk: Given the lack of an insurance component on the GIC products, the model may assume no insurance risk.

Interest Rate Risk: The Economic Capital model should include the impact of scenario-dependent interest rate changes on both assets and liabilities. For the Enhanced GIC product, a dynamic surrender assumption would be used. Asset modeling would include scenario-specific reinvestments and sales.

Business Risk: A margin could be added onto the model to account for anticipated costs related to operational risk.

1. Continued

(e) Arbutus management is trying to decide whether to focus on RBC or Economic Capital for capital management purposes.

Recommend a course of action for Arbutus. Justify your response.

Commentary on Question:
In order to receive full credit, candidates had to draw a distinction between RBC and Economic Capital, relate them to the company's GIC portfolio, and use that information to support a recommendation. The recommendation should explain that neither Capital measure should be ignored.

In general, candidates did a good job with the comparison and making a recommendation to use Economic Capital, but many did not relate this decision back to the company.

Candidates who recommended using RBC were awarded credit, as long as their response was justified from a capital management perspective as opposed to a regulatory perspective.

RBC is a formulaic calculation with each component calculated independently. While the formula takes into account diversification among the components, the formula is static and doesn't take into account company-specific considerations.

Economic Capital can be built more dynamically, taking into account company-specific considerations, including costs of correlated risks and benefits of diversified risks. For the GIC portfolio, the economic capital model can consider the impact of interest rates on assets and liabilities simultaneously, which may not be captured by RBC.

While a multiple of RBC will need to be maintained to satisfy regulators, economic capital is the superior choice for capital/risk management purposes and should be used by Arbutus.

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.

Learning Outcomes:

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

(4k) Apply best practices in risk measurement, modeling and management of various financial and non-financial risks faced by an entity.

Sources:

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

Commentary on Question:

The question was designed to provide a unique setting, mortgage insurance, in order to test the ability of the candidates to do the following::

- *Understanding model risk concepts, including concepts on model risk governance and controls*
- *Applying these concepts to the specific situation*

Each part of this question was addressing specific dimensions of model risk and its governance.

Solution:

(a) Assess whether the PMI EC model is fit for its intended purpose.

Commentary on Question:

A fully acceptable answer could either say that the model was fit or wasn't fit (and required specific additional adjustments). The point was for candidates to identify the key aspects for model fit for EC use. Many candidates did well on this part.

Model type: for EC, you need a risk model, which can capture tail behavior, not only central/average tendencies.

Weaknesses of the model described:

- Using company experience for claims model may not capture tail risk – may need to extrapolate for EC purposes.
- May have too little experience for extreme unemployment or LTV ratio combinations.
- Time horizon may be too short – only average mortgage period, may need to extend

2. Continued

Strengths:

- Modified CFT model can be run through multiple scenarios, allows for dynamic policyholder behavior.
- Enough economic factors modeled to test

Modified CFT looks like good fit for EC, with some further adjustments.

(b) Describe aspects of model governance that MIC should have in place.

Commentary on Question:
The elements of model governance come straight from the reading, but answers here are more comprehensive than needed for full credit. The key phrases are underlined below.

Model governance policy should define segregation of duties with designation of responsible people for model use, maintenance, IT, etc.

Also indicate who has access to which parts of the model – example: who controls the economic scenarios used; who sets the claims model; who can change the code

Define senior management's involvement as related to model implementation

Model governance should be aligned with complexity and importance

Need a process for version control, update cycle, change control, etc.

Model governance should be assessed by internal audit function, separate from modeling team

(c) Identify which specific aspects of the PMI EC model warrant most of the validation effort. Justify your response.

Commentary on Question:
We were looking for candidates to identify which aspects were most important and/or complex; wanting to see a statement that an aspect qualified under those criteria. Candidates did get credit for aspects other than the two detailed below, but those were considered less important. Results were mixed among candidates here. Some candidates wrote only one aspect in response.

2. Continued

Model validation efforts should be related to materiality and complexity of particular aspects.

Two most material & complex parts of model: ESG and Claims model

Economic scenario generator:
- Relatively complex model.
- The adverse extreme scenarios have material impact on the claim projection and final result.
- Main concerns for the validation efforts: interest rate, US home prices, unemployment rates.
- Dynamic functions to capture consumer behavior, such as refinancing, policy termination and mortgage default in response to the interest rate environment and home prices.

Claim projection:
- Based on company own experience, may need external data to supplement
- May need to consider alternative models – projected claims may be more correlated than expected
- Material to results, determines cash flows heavily

(d) Explain how you would apply each of the following model input validation tests to the key drivers of the PMI EC model:

(i) Static Validation

(ii) Back-testing established distributions

(iii) Benchmarking

Commentary on Question:
It was not enough to define the meaning of these terms, though some credit was given for definitions. We were looking for a specific aspect of the PMI EC model the test would be applied to. Some candidates did not recognize the meaning of these tests (defined in the reading) and seemingly guessed based on the words in the phrase – this did not earn credit. In some cases, candidates may not have recalled the specific reading, but had modeling experience…as industry actuarial practice is in line with these model validation tests, their experience should have aligned with the reading, though the words used would be different.

2. Continued

(i) Static Validation: checking how administrative systems info feeds into the model – check policy count, net amount at risk, home value at valuation date – checking point in time info

(ii) Back-testing established distributions: Compare ESG distribution to actual historical observations, such as home prices, unemployment rates, interest rates. Consider extreme scenarios, such as real estate market meltdown of 2008; Assess recent claims experience against assumed claims function

(iii) Benchmarking: Key drivers for claims same as those used by competitors or common industry use? Have to look at statistics generally tracked in industry: mortgage default and pre-payment assumptions on liability side, asset performance relative to economic environment on asset side

(e) Explain how you would apply each of the following model calculation validation tests to the key drivers of the PMI EC model:

(i) Sensitivity testing parameters

(ii) Dynamic validation

Commentary on Question:
As with part (d), we wanted to see application to the PMI EC model specifically, not just a definition of these calculation validation tests. As with part (d), some candidates seemed to be guessing what "dynamic validation" meant [in contrast to static validation from part (d)] as their definition was nowhere near the correct definition.

(i) Sensitivity testing parameters – involves taking one parameter/module and shocking up/down and seeing how the result changed and assessing the reasonability of the change – direction and magnitude. Aspects to sensitivity-test for PMI EC:

1. Key risk drivers: interest rates, home prices, mortgage defaults

2. Parameters of functions of key risk drivers: parameters/data in claims function assumption, parameters in policyholder behavior model

2. Continued

(ii) Dynamic validation – produce projected cash flows across spectrum of scenarios, where multiple items change simultaneously

3. Projected claims v. home prices

4. Mortgage default v. interest rate

5. Premiums v. interest rate or home prices

3. Learning Objectives:

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:

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

(3b) Analyze and evaluate the properties of risk measures (e.g., Delta, volatility, duration, VaR, TVaR, etc.) and their limitations.

(3c) Analyze quantitative financial data and insurance data (including asset prices, credit spreads and defaults, interest rates, incidence, causes and losses) using modern statistical methods. Construct measures from the data and contrast the methods with respect to scope, coverage and application.

Sources:

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

Value-at- Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion Ch. 5 Computing VaR, Sections 5.1-5.3, including appendices

Commentary on Question:

This question tests two different daily return models: IID Normal model and GARCH model as well as the VaR calculation for these two models. Most candidates did well in the calculation of mean, standard deviation, unconditional standard deviation and the 1-day 99% VaR part. When it came to explanation of certain observations such as part (ii) of (c) and part (d), most candidates just gave general descriptions of the characteristics of GARCH model, rather than using the specific parameters in this question to give a clear explanation.

Solution:

(a)

(i) Calculate the mean and standard deviation of Y_1 under the GARCH model. Show your work.

(ii) Show that the unconditional standard deviation of daily returns under the GARCH model is 0.016 to the nearest 0.001.

(iii) Show that the daily returns Y_t and Y_{t+1} are uncorrelated under the GARCH model.

3. Continued

(iv) State with reasons whether the daily returns Y_t and Y_{t+1} are independent under the GARCH model.

Commentary on Question:
In general, candidates did fine in (i) and (ii). A common mistake was calculating the variance instead of standard deviation. In part (iii), most candidates started proving the daily returns are uncorrelated by trying to show the covariance is 0. However, some candidates did not show clearly why the covariance is 0. Partial credit was given for trying to prove the covariance is 0. In part (iv), a little more than half of the candidates correctly identified that the daily returns are not independent and explained from the formula, h_{t+1} depends on Yt. Some even went further to explain why they can be uncorrelated, but still dependent. This further explanation was not needed to receive full credit.

(i) Under a GARCH process $Y_1 = \sqrt{h1} * \varepsilon_1$, with $\varepsilon t \sim N(0,1)$
Mean of $Y_1 = E[Y_1] = E[\sqrt{h1}\ \varepsilon_1] = \sqrt{h1} * E[\varepsilon_1]$ as ε_1 is independent of other terms.
Since ε_1 is N(0,1), thus $E[\varepsilon_1] = 0$, thus $E[Y_1] = \sqrt{h1} * 0 = 0$.
We have $h_1 = \alpha_0 + \alpha_1 Y_0^2 + \beta h_0 = (7.7 \times 10^{-6}) + (0.2 * (0.05)^2) + (0.77 * 0.0162) = (0.0000077 + 0.0005 + 0.00019712)$
where $\alpha_0 = 7.7*10^{-6}$, $\alpha_1 = 0.2$, $\beta = 0.77$, $h_0 = 0.0162$, $Y_0 = 0.05$
so $h_1 = 0.00070482$
the Standard deviation of Y_1 = sqrt(Variance[Y_1]) = $\sqrt{0.00070482} = 0.02655$

(ii) The unconditional standard deviation of daily returns under the GARCH model is

$$\sqrt{\frac{\alpha_0}{1-(\alpha_1+\beta)}} = 0.01602,$$ rounded to 0.016.

(iii) $Cov(Y_t, Y_{t+1}) = E[Y_t Y_{t+1}] - E(Y_t) * E(Y_{t+1})$
$E[Y_t Y_{t+1}] = E[Yt\sqrt{h(t+1)}\ \varepsilon_{t+1}\ ] = 0$ as ε_{t+1} is independent of the other terms, and has zero mean.
As shown in (i), $E[Y_1] = E[\sqrt{h1}\ \varepsilon 1] = \sqrt{h1} * E[\varepsilon 1] = 0$
Hence, covariance =0, which means the daily returns Y_t and Y_{t+1} are uncorrelated.

(iv) The daily returns Y_t and Y_{t+1} are not independent under the GARCH model.
$Y_{t+1} | Y_t \sim N(0, h_{t+1})$ where $h_{t+1} = \alpha_0 + \alpha_1 Y_t^2 + \beta h_t$
Thus, the variance of Y_{t+1} depends on the value of Y_t.

3. Continued

(b)

(i) Calculate the 1-day 99% VaR at time zero using Model 1. Show your work.

(ii) Show that the 10-day 99% VaR for Model 1 is approximately $\sqrt{10}\times(1\text{-day 99\% VaR})$.

Commentary on Question:
Most candidates were able to correctly calculate the 1-day 99% VaR at time 0. Common mistakes included using the incorrect weighting, or using inconsistent timing (1-day volatility but annual timing t=1/252).
For Part (ii)of this question, most candidates just plugged in 10 days in the VaR formula and said because t is the only parameter in the VaR formula that changed from part (i), 10-day 99% VaR for Model 1 is $\sqrt{10}\times(1\text{-day 99\% VaR})$ *instead of trying to derive why the formula works for the normal i.i.d. model. Small partial credit was given for this type of answer without detailed explanation.*

(i) $VaR = W_0 \alpha \sigma$
Where the value of the portfolio at time zero is:
$W_0 = 10{,}000 * S_0 = \$100{,}000$
99% $\alpha = 2.326$
1-day volatility = 0.016

Thus 99% VaR of the portfolio over a 1-day horizon = $W_0 \alpha \sigma$
= \$100,000 * 2.326 * 0.016 = \$3,721.6

Alternatively, the loss over 1 day is $L = 10000(S_0\text{-}S_1) = 10000(S_0\text{-}S_0(1+Y_1)) = -10000S_0Y_1$
The 99% quantile corresponds to the 1% quantile of the return
$Q_{99\%}(L) = -10000S_0Q_{1\%}(Y_0) = -10000S0(Z_{1\%}\sigma) = -10000*10*\text{-}2.326*0.016 = 3721.6$
where Z_α is the inverse standard normal distribution function, $Z_{1\%} = -2.326$

3. Continued

(ii) The 10-day return is :

$S_{10}/S_0 - 1 = (S_1/S_0)*(S_2/S_1)*....*(S_9/S_8)*(S_{10}/S_9) - 1 =$
$(1+Y_1)(1+Y_2)(1+Y_3)\ldots(1+Y_{10}) - 1$

For a 2-day return, we have $(1+Y_1)(1+Y_2) -1 = [(1*1) + (1*Y_1) +(Y_2*1) +(Y_1 *Y_2)] -1 = [1+ Y_1 + Y_2 +Y_1Y_2] -1$

For a 3-day return, this becomes $[1+ Y_1 + Y_2 +Y_1Y_2] [1 + Y_3] -1 = [1+ Y_1 + Y_2 + Y_1Y_2 + Y_3 + Y_1Y_3 + Y_2Y_3 + Y_1Y_2Y_3] -1$

Thus, the 10-day return is $1 + \sum_{j=1}^{10} Yj$ + terms of order $(Y_jY_k) - 1$, ignoring even higher order cross-terms.

Ignoring second order cross-terms, the 10-day return is approximately $\sum_{j=1}^{10} Yj$, thus the 10-day return is approximately equal to the sum of the 1-day returns.

The variance of the sum of i.i.d. variables is the sum of the individual daily variances or 10 * (1-day variance).

Hence, the standard deviation of the 10-day return is approximately equal to $\sqrt{10} *$ (1-day volatility)

99% VaR of the portfolio over a 10-day horizon = W0 α σ
= W0 α * 10-day volatility = W0 α * 1-day volatility

Full derivation of the 10-day variance was not needed for full credit. Full credit was given as long as there was good reasoning why the 10 day variance equals the sum of day-1, day-2, …, day-10 variance. Since the variance is i.i.d., the 10 day variance equals to 10 day-1 variance.*

For example, the following alternative solution was also accepted for full credit.

Alternative solution: Normal is close to lognormal for small sigma, and returns are additive under lognormal, thus the 10-day variance equals the sum of day-1, day-2, …, day-10 variance.

(c)

(i) Calculate the 1-day 99% VaR at time zero using Model 2. Show your work.

(ii) Explain whether the 10-day 99% VaR will be greater than, less than or equal to $\sqrt{10} \times (1\text{-day 99\% VaR})$ for Model 2 based on the initial conditions provided in the stem above.

3. Continued

Commentary on Question:
Part c(i) is similar to part b(i), which applies the same formula to calculate the 1-day 99% VaR at time 0. In addition to the common mistakes in b(i), some candidates failed to use the correct 1-day volatility for model 2.
For part (ii) of this question, more than half of the candidates failed to understand that the square root of the time equation does not apply for the GARCH model and simply concluded that the 10-day 99% VaR is equal to $\sqrt{10} *$ *(1-day 99% VaR) by applying the approximation formula for n-day VaR. Some candidates gave some general explanation by describing the general characteristics of the GARCH model. Very few candidates were able to give specific explanations using the details related to the initial conditions in this question. Only specific explanations connecting to the initial conditions provided in the stem received full credis.*

(i) $VaR = W_0 \alpha \sigma$
Where the value of the portfolio at time zero is:
$W_0 = 10{,}000 * S_0 = \$100{,}000$
99% $\alpha = 2.326$
From a(i), the Day 1 volatility of return (or standard deviation of Y_1) forecasted under GARCH is $\sqrt{h1} = 0.02655$
Thus 1-day 99% VaR at time zero using Model 2= $W_0 \alpha \sigma$
= \$100,000 * 2.326 * 0.02655 = \$6,175.53

Alternatively, From part a(i), model 2: $Y_1 \sim N(0, 0.02655)$
1-day 99% VaR at time zero = $Q_{99\%}(L) = -10000S_0Q_{1\%}(Y_0)$
$= -10000S_0(Z_{1\%}\sqrt{h1}) = -10000*10*-2.326*0.02655 = 6175.53$

(ii) The 10-day 99% VaR is less than $\sqrt{10} *$ (1-day 99% VaR).
In the question a(ii), we calculated that the long term volatility is 0.016.
From a(i), we calculated the day 1 standard deviation is 0.02655.
Thus, under Model 2, we start the process at the Day-1 volatility of 0.02655, and the volatility over time is expected to trend down to the long term volatility of 0.016.
Thus the 10-day variance is expected to be less than 10 times of the 1-day variance values and the 10-day 99% VaR is less than $\sqrt{10} *$ (1-day 99% VaR).

3. Continued

(d) Explain why the GARCH model generates a higher 1-day 99% VaR than Model 1, even though the models have the same mean and long term variance.

Commentary on Question:
Most candidates just listed some general characteristics of the GARCH model without specifically comparing the value of the initial condition, Day-1 variance and long term variance. Only specific explanations relating to the specific values in this question received full credis.

Although the long term variance for the GARCH model is the same as the variance in model 1, the 1-day volatility in GARCH model is strongly impacted by the initial condition of Y_0. In this case, Y_0 is 0.05 (at 3 standard deviations away from the mean of 0), which creates a larger Day-1 volatility of 2.66% comparing with the long term volatility of 1.6%, thereby creates a much larger 1-day VaR.

4. Learning Objectives:

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

Learning Outcomes:

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

(4d) Demonstrate how derivatives, synthetic securities, and financial contracting may be used to reduce risk or to assign it to the party most able to bear it.

(4g) Demonstrate the use of tools and techniques for analyzing and managing credit and counterparty risk.

Sources:

Derivatives: Practice and Principles, Recommendations 9-24 and Section III
Financial Enterprise Risk Management, Sweeting, 2011 Ch. 16 Responses to Risk

Commentary on Question:

This question about master agreements, netting, and counterparty exposure tests the candidate's ability to apply the material to a specific situation. In many parts, candidates were expected not to provide general definitions, but to make specific applications relevant to the University Endowment Fund.

Solution:

(a) Explain a potential risk that the UEF could have been intending to mitigate for each of the four contracts.

Commentary on Question:

Many candidates performed well on this part. One common mistake candidates made was that the CDS insulated the UEF from the counterparty risk of LIB.

In order to receive full credit, answers needed to be specific risks that could be applicable to the UEF. General definitions of the risks were not sufficient for full credit. Many possible answers warranted full credit and the solution provided below is just one example of a correct answer.

<u>I. Interest Rate Swap</u>

The "fixed for floating" swap provides a more predictable investment income, to better align with the fixed expenses of student scholarships and infrastructure.

<u>II. Credit Default Swap</u>

This is a hedge against the default of a corporate bond held by the UEF.

4. Continued

III. Put Option
This is a hedge against a sudden, large market decline, providing some protection to the UEF's equity portfolio.

IV. Currency Swap
The UEF likely holds investments denominated in Euros, although most of its expenses are denominated in US dollars. This is a hedge against the weakening of the Euro, better aligning fund income with outgo.

(b) The UEF currently operates separate agreements for each of the four contracts. LIB is proposing that the separate agreements be replaced with a Master Agreement.

Explain the advantages and disadvantages, if any, to the UEF of this change.

Commentary on Question:
A variety of answers were acceptable for full credit. Disadvantages were not required, although credit was awarded for any legitimate disadvantages provided.

Advantages:
- A single master agreement provides the greatest legal certainty that transactions will be netted in the event of a default by LIB.
- A master agreement with full two-pay payments provides for the greatest certainty of value of the net position.

Disadvantages:
- If the UEF is the defaulting party, netting could be disadvantageous.

(c)

(i) Explain why this description gives the market value of the swap.

(ii) You are given that the current risk free rate of interest is 3% per year, compounded continuously.

Show that the current market value of the interest rate swap to the UEF is $2.7 million to the nearest $0.1 million.

4. Continued

(iii) You are given that the Euro payments under the currency swap are valued at a flat rate of interest of 1% per year, compounded continuously. The U.S. dollar payments are valued at a flat rate of interest of 3% per year, compounded continuously. The current exchange rate is \$1.06 to €1.00.

Show that the current market value of the currency swap is $\$-2.7$ million, to the nearest \$0.1 million.

Commentary on Question:
Candidates generally did well in subpart (i). However, some candidates chose not to utilize the formula provided in subpart (i) to solve subpart (ii), and instead discounted the annual net cash flows. While full credit was possible for alternate approaches, few candidates who attempted to calculate the value of the swap another way did so successfully.

There is an error in the question stem of subpart (iii). The exchange rate is inverted. As a result, papers received full credit for this section.

A common mistake made in the calculations of subparts (ii) and (iii) was the use of compound interest instead of continuous interest as specified.

(i) The cash flows of the swap are the same as the cash flows generated by holding long a fixed rate bond combined with a short floating rate bond. If the swap market value were different, theoretically an arbitrage could be constructed (ignoring credit spreads and default risks).

(ii) $V_{SWAP} = B_{FIXED} - B_{FLOAT}$
$B_{FLOAT} = \$100m$
$B_{FIXED} = (\$4m)\, e^{-0.03} + (\$4m)\, e^{-0.06} + (\$104m)\, e^{-0.09}$
$V_{SWAP} = \$102.7m - \$100m = \$2.7m$

(iii) $V_{SWAP} = B_{FIXED} - s\,(B_{EURO})$
Where B_{FIXED} is the dollar-denominated bond from subpart (ii),
B_{EURO} is a 3-year 5% coupon Euro bond (€100m par),
s is the \$/€ exchange rate.
$B_{EURO} = (€5m)\, e^{-0.01} + (€5m)\, e^{-0.02} + (€105m)\, e^{-0.03} = €111.75m$
$V_{SWAP} = \$102.7m - (\$1.06 / €)\,(€111.75m) = \$-15.8m$

4. Continued

(d) The UEF is concerned about counterparty risk.

(i) Define "current exposure" and "expected potential exposure" in the context of the UEF's credit risk exposure to LIB.

(ii) Calculate the current exposure of the UEF to LIB assuming full netting applies. Show your work.

(iii) Calculate the current exposure of the UEF to LIB assuming no netting. Show your work.

(iv) Explain the underlying premise that justifies using a netting approach.

Commentary on Question:
In subpart (i), most candidates defined "current exposure" correctly, but few correctly defined "expected potential exposure". In subparts (ii) and (iii), many candidates erroneously believed that the out-of-the-money put option did not contribute to current exposure. This is incorrect because there is still a replacement cost to be incurred in the event of a counterparty default. Very few candidates answered subpart (iv) correctly, although partial credit was awarded for other legitimate responses.

Note that for subpart (ii), the model solution below uses the incorrect amount of $-2.7 million provided in the stem of (c)(iii) because nearly every candidate used this amount in the netting calculation, which was understandable under the circumstances. Either this amount or the calculated amount of $-15.8m would have been acceptable for full credit.

(i) Current exposure – The cost of replacing the contracts at today's market values, in the event of an immediate default by LIB.

Expected potential exposure – The average replacement cost over the full future term, discounted to present value.

(ii) Exposure = $V_I + V_{II} + V_{III} + V_{IV}$

= \$2.7m [from (c)(ii)]
+ \$2m [given in question stem]
+ \$5m [given in question stem]
+ -\$2.7m [from (c)(iii)]
= \$7m

4. Continued

(iii) Exposure = $\Sigma \max(V_i, 0)$

= \$2.7m
+ \$2m
+ \$5m
+ 0 [since max(-\$2.7m, 0) = 0]
= \$9.7m

(iv) Netting assumes that there are no frictional costs associated with setting up new contracts, and that identical contracts are available for purchase.

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 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.

(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.

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

(2f) Analyze the importance of tails of distributions, tail correlations, and low frequency/high severity events.

Sources:

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

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

ERM-120-14: IAA Note on Stress Testing and Scenario Analysis (pp. 1-6 and 14-17)

ERM-125-15: Loss Models Further Topics, Klugman, Panjer and Wilmot, Ch. 10 Copula models

5. Continued

Commentary on Question:
The question tests candidates' understanding of risks, especially understanding of tail risks and the application of that knowledge. This is demonstrated both through discussion in parts (a) and (b) and through explanations and computation of copulas in parts c through e. Candidates should be able to explain the risks and interactions between risks, and also show basic understanding of a copula model, but not necessarily the intensive calculations involved.

Solution:

(a) Describe the company's exposure to the following risks:

(i) Interest rate risk

(ii) Equity asset value risk

(iii) Catastrophic mortality risk

(iv) Trend mortality risk (also known as longevity risk)

Commentary on Question:
Many candidates did very well on this question. Most candidates were able to describe catastrophic mortality risk and longevity risk, but interest rate risk and equity asset value risk were not well described in the context of the company. Some candidates did not consider the risks that apply specifically to level premium whole life or SPIA products.

(i) The value of the bond portfolio will increase if interest rates fall and decrease if interest rates rise. (A side consequence is that market value of liabilities will rise if interest rates fall.) However, the company may have ALM practices which would result in similar moves in asset and liability values due to changes in interest rates. An alternate solution could include risk that interest rates are lower when future whole life premiums are invested, or reinvesting when SPIA investments mature.

(ii) This is the risk that the equity portfolio loses value at a time when those assets are needed to meet liability demands, forcing the realization of losses. In extreme cases, assets may not be sufficient to cover liabilities. This also includes the risk that equity earns less than expected and the risk that asset values will be volatile relative to liabilities creating volatility in equity, capital ratios, etc. It is not clear how the equity exposure of 40% aligns well with the liability profile. It is difficult to tell given the information but it would seem that the sizable amount of equities is not appropriate asset to back WL or SPIA.

5. Continued

(iii) Catastrophic mortality risk impacts the Whole Life product. There would be an immediate demand for large amounts of cash to pay out death claims, which the company may not have anticipated. There is some diversification benefit that the annuity business will provide (known as the "natural hedge"), but it may be very small.

(iv) Trend risk is the risk that mortality rates improve at a rate different than what is assumed. This risk greatly impacts the SPIA block, where losses would occur if mortality decreases over time. There would also be a (likely minor) benefit for the whole life block if mortality decreases over time.

(b)

(i) A colleague suggests combining single factor sensitivity test results for each of the items in (a) to assess economic capital for the firm.

Critique this suggestion.

(ii) Explain why the company's liability valuation model may not be appropriate to use to evaluate the economic capital.

Commentary on Question:
Candidates were able to identify that single-factor sensitivity testing is inappropriate to measure economic capital, but many candidates could have benefitted from explaining further. Likewise, candidates were able to identify that the liability valuation model should not be used to calculate economic capital, but missed many of the reasons why. Many candidates confused a market-consistent valuation with regulatory reserves and economic capital with regulatory capital.

(i) The purpose of single factor sensitivity testing is for calculating materiality of assumptions, or for delta type calculations. Summing up the results of several single factor sensitivity tests ignores the interaction and correlations between risks, and may not capture the tail risk that happens when multiple factors are shocked at once – there may be dependencies between different risks in a stressed scenario (such as an equity market crash causing interest rates to drop).

(ii) The liability valuation model is not fit for the purpose of calculating economic capital.

- Because the liabilities are valued on a market-consistent basis, they will focus on the mean or best-estimate result. Economic capital should focus on results of individual scenarios in the tail, such as VaR.
- The liability model likely uses risk-neutral scenarios. Economic Capital likely uses real-world scenarios.

5. Continued

- The liability model likely uses best-estimate assumptions, so the assumptions may not adequately capture behavior in tail scenarios.
- The liability model may not incorporate all of the company's risks, while economic capital should capture all risks.

(c) Describe the *t* copula and explain its main features.

Commentary on Question:
Candidates generally did well in identifying the key features of t-copulas. The candidate could alternately have provided a strong description of the t-copula if they did not provide the formula.

The t-copula (in 2 dimensions) is defined as $C(u,v) = t_{\rho,d}\,(t_d^{-1}(u), t_d^{-1}(v))$ where $t_{\rho,d}$ is the bivariate student's t distribution with, with parameters ρ and d degrees of freedom and t_d is the standard (univariate) t distribution with d degrees of freedom.

The t-copula is symmetric in 2 dimensions but asymmetric in higher dimensions. The t-copula has upper and lower tail dependency.

(d) You generate a 1-in-200 year stress event assuming each portfolio lies at its *q*-quantile for some *q* (the same *q* is used for both portfolios).

(i) Determine the quantile *q* which exactly satisfies this constraint. Show your work.

(ii) Calculate stressed values of the bond and equity portfolios in one year using *q* from (i). Show your work.

Commentary on Question:
Most candidates identified that a 1-in-200 year stress event was at the "0.005" level. Many candidates struggled to identify that the q at which the solution of the copula is 0.005. Candidates also generally struggled to convert the 0.009 into an appropriate "z" value. Candidates who solved for the "stressed" bond and equity value higher than the mean received little credit.

(i) A 1-in-200 year event is at the 0.005 level. In the table, the solution of the copula is 0.005 for u = v = 0.009.

(ii) For 0.009, the Normal table provides a result of -2.365.
P(z< (B - 630) / 60) = 0.009
B = 630 + z*60 = 630 + (-2.365)*60 = 488.10

P(z< (ln(E) - 6.0)/0.35) = 0.009
E = e^(6.0 + z*0.35) = e^(6.0 + (-2.365)*0.35) = 176.3

5. Continued

(e) Your colleague suggests using a Gaussian copula with $\rho = 0.8$.

Explain whether the resulting stress test would be more severe or less severe than the results using the *t*-copula above.

Commentary on Question:
Most candidates were able to identify that the Gaussian copula results in a less severe stress than the t-copula.

The resulting stress test under the Gaussian copula would be less severe than the results using the t-copula. The t-copula has tail dependencies, and the Gaussian copula does not (except in the case of perfect correlation $\rho=1$). This means that the t-copula's tails are thicker than a Gaussian copula's tails.

For example, it seems reasonable that one event could cause multiple stresses, such as an extreme natural disaster causing catastrophic mortality and a crash in the financial markets. The t-copula does capture this situation with its thicker tails and tail dependency.

6. Learning Objectives:

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

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

Learning Outcomes:

(3b) Analyze and evaluate the properties of risk measures (e.g., Delta, volatility, duration, VaR, TVaR, etc.) and their limitations.

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

(4d) Demonstrate how derivatives, synthetic securities, and financial contracting may be used to reduce risk or to assign it to the party most able to bear it.

Sources:

ERM-114-13 Introduction to Reinsurance

Summary of "Variance of the CTE Estimator"

Sweeting Ch 16

ERM-115-13 Creating an Understanding of Special Purpose Vehicles, PWC

Commentary on Question:

This question integrates the reinsurance and CTE readings. Overall, candidates performed well in parts a & b, average in parts d & e, and poorly in part c.

Solution:

(a) Describe the following types of reinsurance and assess the suitability of each for PDBI risks.

(i) Quota Share

(ii) Stop Loss

Commentary on Question:

*Common mistakes that candidates made were brevity in the description, not making an assessment of **each** reinsurance type, and not responding on how it can address the company's risks. To receive full marks, the assessment should look at whether the type of coverage transfers earthquake risk, and its impact on earnings volatility. To receive full marks on the description for Stop Loss, the description must specify coverage of **cumulative** losses; otherwise, it describes Excess Loss (XL).*

6. Continued

(i) Description:
Premiums, claims, profits, are shared proportionally between the insurer and the reinsurer, for each reinsured risk. There may be reinsurance commissions, profit sharing allowances.

Assessment:
This type of coverage does not focus narrowly on the earthquake risk, therefore not directly transferring earthquake risk. Since profits are shared proportionately, regardless of total amount of claims, this does not reduce earnings volatility.

(ii) Description:
Insurer pays cumulative claims up to a fixed quantity/priority, reinsurer pays excess amount above priority up to the capacity.

- Similar to an excess of loss agreement but on the whole portfolio.
- There may be a copayment for claims in excess of the priority.
- Risk is transferred when there are cumulatively high claims for the year, regardless if it's due to high severity and/or high frequency, regardless if the claims are due to earthquake or not.

Assessment:
This type of coverage does not focus narrowly on the earthquake risk, therefore not directly transferring earthquake risk -- but will capture earthquake losses better than QS.

- Reduces insurer's earnings volatility when claims are in excess of priority, but volatility returns once claims reach capacity.

(b) Calculate the 98% CTE of the net losses after reinsurance recoveries for each reinsurance option. Show your work.

Commentary on Question:
Many candidates received full marks in this part. A small number of candidates forgot to calculate the "No reinsurance coverage" option. A few used 5 loss values as opposed to only 4, and some applied the reinsurer's losses as opposed to the company's net losses. Some candidates did not understand how to apply the stop loss capacity limit of 40M.

6. Continued

I. No insurance Coverage

CTE = average of the highest 4 = [200*(1-98%)]
CTE = (50.2 + 57.5 + 65.6 + 90) / 4 = 65.8

II. A quota share reinsurance arrangement under which Grandview cedes 35% of the risk

CTE = average of the highest 4 model losses multiplied by 65% quota share where 65% = (1-35%)

CTE = (50.2 * .65 + 57.5 * .65 + 65.6 * .65 + 90 * .65) / 4 = 65.8 * .65 = 42.8

III. Stop loss reinsurance arrangement with a 12 million priority and a 40 million capacity

L_197 = 12 as it is less than 52 (12 + 40)
L_198 = 12 + (57.5 – 52) = 17.5
L_199 = 12 + (65.6 – 52) = 25.6
L_200 = 12 + (90 – 52) = 50

CTE = (12 + 17.5 + 25.6 + 50)/4 = 26.3

(c)

(i) Estimate the standard error of the CTE estimator in (b) for the Quota Share Reinsurance.

(ii) Estimate the standard error of the CTE estimator in (b) for the Stop Loss Reinsurance.

Show your work.

Commentary on Question:
Overall, candidates performed poorly in this part. Common mistakes were incorrectly applying 2% (but 98% is the correct number to use in the calculation), and using N (normal distribution) values as opposed to correctly using to N to be the number of modelled losses. Some incorrectly applied the no-reinsurance Q_hat and CTE_hat for both VAR calculations in (i) and (ii).

6. Continued

(i) Estimate the standard error of the CTE estimator in (b) for the Quota Share Reinsurance

Q_hat = estimated VAR at 98% = L_196 (using unsmoothed estimation for quota share) = 47.5 * 65% = 30.9

CTE_hat = CTE from part (b) above = 42.8
Var[[L|L>30.9] = $[(32.6-42.8)^2 + (37.4-42.8)^2 + (32.6-42.8)^2 + (58.5-42.8)^2] / \mathbf{3}$
Var[[L|L>30.9] = 126.6
SE = ((126.6+.98(42.8-30.9)^2)/4)^(0.5)=66.3^.5=8.1

(ii) Estimate the standard error of the CTE estimator in (b) for the Stop Loss Reinsurance

Q_hat = estimated VAR at 98% = L_196 adjusted for stop loss = 12.0
CTE_hat = CTE, using top 3 values greater than 12 = (17.5+25.6+50.0)/3 = 31.0
Var[L|L>12.0] = Var using top 3 values = [(17.5-31.0)^2+(25.6-31.0)^2+(50-31.0)^2]/2 = 286.2
SE = ((286.2+0.98*(31-12)^2)/4)^(0.5)= 160.0^.5=12.6

Alternate Solution:

Q_hat = estimated VAR at 98% = L_196 adjusted for stop loss = 12.0
CTE_hat = CTE from part (b) above, using top 4 values = 26.3
Var[[L|L>30.9] = [(12-26.3)^2+(17.5-26.3)^2+(25.6-26.3)^2+(50-26.3)^2]/3
Var[[L|L>30.9] = 281.4
SE = ((281.4+0.98(26.3-12)^2)/4)^(0.5)= $120.45^{.5}$=11.0

(d)

(i) Explain why the Quota Share contract is cheaper than the Stop Loss, per unit of expected reinsurance claim.

(ii) Critique the CFO's statement.

Commentary on Question:
Some candidates were too brief with the explanation and critique. A few repeated the data that was provided in part d question.

6. Continued

(i) To the reinsurer, the Stop loss (SL) risk > the QS risk to reinsurer, as measured by: 98% CTE (40 for SL vs 23 for QS)

- If reinsurer uses CTE to set economic capital, then SL economic capital > the QS economic capital, then the reinsurer would require a greater premium.

QS may be cheaper because there is a moral hazard in the stop loss contract (insurer has less incentive to manage losses above retention/priority, until they reach maximum/capacity).

(ii)

- If insurer uses CTE to set economic capital, then QS requires much more capital, which costs money in servicing.
- Stop loss (SL) has better risk mitigation than QS; CTE reduces from 42.8M under QS to 26.3M under SL. (Answers part b.)
- The number of simulations is quite small and if the tail is not adequately represented, the potential for loss is not properly modeled.

(e)

(i) Explain briefly how Grandview could use securitization instead of reinsurance for its earthquake risk.

(ii) State one advantage and one disadvantage of using securitization instead of reinsurance for Grandview's earthquake risk.

Commentary on Question:
Some candidates were too brief in their description and statement of one advantage and one disadvantage. Some candidates provided more than one advantage and more than one disadvantage; no credit was given for more than one valid response. Some candidates incorrectly stated that the using securitization provided risk transfer while the reinsurance did not; thereby, they were not answering the question's "how" and "instead of."

(i) Turn risk exposure into an investment that can be bought and sold, where investors take risk exposure (potential loss of capital) in exchange for risk premium.

Partial marks were given for when candidates provided examples, such as:

- Catastrophe bond which pays high levels of interest but payments to investors are reduced if losses rise above a certain level.
- Put option that allows a firm to raise capital at a predetermined price in the event of a pre-specified catastrophe.

6. Continued

(ii) Marks were given for one advantage:

- Insurance risk may be uncorrelated with other risks in the economy, making it attractive to investors for diversification purposes, thus making it potentially more cost-effective.
- Can be a quicker way of raising capital depending on how it is structured.
- Price of security can be used to provide a market-based price for the risk; mark-to-market is important in Base II and Solvency II.
- May reduce counterparty/concentration risk.

Marks were given for one disadvantage:

- Success is vulnerable to changes in capital market conditions.
- Lose other benefits of reinsurance, such as technical support.
- Layers of securitized assets can be complex, making it hard to monitor and track level of risk involved and who it lies with.

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.

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:

(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.

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

Sources:

Risk Appetite: Linkage with Strategic Planning Report

Commentary on Question:

This question tests the candidates' understanding on identifying the liquidity risk for different line of business, setting risk tolerance limits, and implementing best practices for managing liquidity risk. To obtain maximum points on this question, candidates should answer according to the verbs used for the sub-parts and provide appropriate level of depth in answering the sub-questions, demonstrate comprehension, analytical skills and written communication ability.

Solution:

(a) Explain three high-level weaknesses of the current liquidity policy.

Commentary on Question:

Candidates overall did well for this sub-part and were able to point out the three weaknesses at high level.

- The policy does not define liquid assets.
- The current policy was based on past cash flow experience, which may not adequately address the liquidity needs or risks in the future.
- The risks are caused by both the liability structure and the exogenous market changes and current policy does not contemplate exogenous factors.
- Asset yield may not be optimized; for an example, if over-conservative, company will earn a lower yield on the liquid assets.

7. Continued

(b)

(i) Describe how each of the five sources impacts liquidity risk.

(ii) Determine whether each of the sources of risk is high, medium, or low impact for each of the above four product lines. Justify your responses.

Commentary on Question:
The intent of this part is to analyze the liquidity risk exposure inherent in a specific business segment. Some candidates failed to explain or justify the high/medium/low rating. Ratings other than the ones listed below were given credit if the candidate justified the rating.

Credit rating downgrade impact:

- Additional cash payment demand from surrender increase.
- Relative high risk for UL due to increased risk of surrender as policyholders seek safety for their investment. Relative low for Term and Auto insurance. Credit downgrade might lower cash inflow (lower NB premium) for DI depending on resulting credit level.

Normal Operational cash flow volatility:

- Net cash flow = benefit outgo + expense – premium income.
- Credit rating downgrade may have impact on NB premium
- Medium risk for all four lines. Depends on size of block and range of outcomes that have been observed in terms of premiums, benefits, and expenses.

Catastrophe risk:

- Additional cash payment demand due to unexpected severity and unpredictable occurrence of catastrophes.
- Relative high for term and possibly UL, depends on the net exposure of net amount at risk and the type of cat scenario that would result in increased liability demands. Low for disability and auto insurance (auto insurance could have some extent of exposure).

Interest Rate Risk:

- When new money rate rises, disintermediation risk could result in higher lapse which can create additional liquidity requirements.
- Relative high risk for UL. Low liquidity risk for term, disability and auto. "

7. Continued

Adverse mortality, morbidity and claim experience:

- Relative significant for all four lines of business, as more liquidity will be required to pay the extra/unexpected benefits.

(c)

(i) Describe ~~Grandview's~~ Oakridge's liquidity position relative to the current policy.

(ii) Describe ~~Grandview's~~ Oakridge's liquidity position relative to the proposed policy.

Commentary on Question:
The name of the company in the question was incorrect. It should be Oakridge, not Grandview. A notice was included in the exam stating that "Oakridge is the company referenced at the beginning of Question 7, and should be the company mentioned in part (c) and (d) of the question."

(i) Oakridge is meeting current liquidity policy requirement by maintaining liquid assets no less than 50% of total assets. (Current: 50% of total assets = 50%; Actual: 96/189 = 50.79% > 50%.)

(ii) However, (Proposed: 110% x required liquidity assets = 90 x 1.1 = 99; Actual: 96 < 99.) Oakridge would fail under proposed policy with the available liquidity less than 110% of required liquidity.

(d) Explain three actions that ~~Grandview's~~ Oakridge's could take to improve its liquidity risk position.

Commentary on Question:
See the comment in (c) regarding the correct name being Oakridge.

Most of the candidates were able to touch on some aspects of the actions that the company can take, but some failed to demonstrate their depth of analysis applied to this situation and did not fully make a recommendation with the best course of actions to mitigate the specific risks.

The current liquidity level is below the level required by the risk tolerance. This could trigger some corrective actions to mitigate the risks, including:

Reduce catastrophe risk: This seems to be the largest component of the required capital. Need to identify the Cat risk, such as geographic concentration for certain business line or other factors. This risk is usually addressed through monitoring of concentration limits and transferring excess risk through reinsurance.

7. Continued

Reduce downgrade risk and interest rate risk: For new business planning, include product features to reduce chances of mass lapses, such as MVA adjustment for surrender.

Adjust Strategic asset allocation to move assets with lower liquidity to assets with higher liquidity gradually.

Establish contingency funding sources to increase flexibility to meet the cash needs in a stressed situation.

8. **Learning Objectives:**

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

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

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

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

Learning Outcomes:

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

(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.

(2f) Analyze the importance of tails of distributions, tail correlations, and low frequency/high severity events.

(3c) Analyze quantitative financial data and insurance data (including asset prices, credit spreads and defaults, interest rates, incidence, causes and losses) using modern statistical methods. Construct measures from the data and contrast the methods with respect to scope, coverage and application.

(4d) Demonstrate how derivatives, synthetic securities, and financial contracting may be used to reduce risk or to assign it to the party most able to bear it.

(4e) Develop an appropriate choice of a risk mitigation strategy for a given situation (e.g., reinsurance, derivatives, financial contracting), which balances benefits with inherent costs, including exposure to credit risk, basis risk, moral hazard and other risks.

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

8. Continued

(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.

Sources:
Constant Volatility Framework
Value-at- Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion Ch. 9 Forecasting Risk and Correlations
Financial Enterprise Risk Management, Sweeting, 2011 Ch. 16 Responses to Risk

Commentary on Question:
The goal was for candidates to demonstrate an understanding of how the predictability of equity volatility can be used to effectively manage equity tail risk exposure within risk appetite levels. Candidates did better on demonstrating knowledge retrieval and comprehension of the study materials, than on utilizing and applying their knowledge to design specific strategies to manage equity tail risk exposure.

Solution:
(a)

(i) Explain the term "volatility clustering" to the Committee.

(ii) Describe why equity volatility clustering can be used to reduce tail risk.

Commentary on Question:
Most candidates did well and the sample answers below have more detail than was necessary to receive full credit.

(i) Equity volatility is not constant, so equity portfolio risk is not constant. Large changes in returns tend to be followed by large changes in returns of either sign, and small changes tend to be followed by small changes.
(ii) As equity exhibits volatility clustering, its recent, realized volatility can provide useful information about near-term risks/volatility.

(b)

(i) Identify and describe one OTC contract and one exchange-traded instrument that could be used to hedge equity volatility exposure.

(ii) Describe the advantages and disadvantages of each.

8. Continued

Commentary on Question:
Most candidates understood OTC versus exchange-traded instruments in the generic sense, but they could not identify specific available instruments for each to hedge equity volatility exposure. These candidates received partial credit.

(i) OTC: Variance swaps, in which buyer agrees to swap a fixed variance level on a particular market index for actual realized variance from purchase until the maturity date.
Exchange: VIX futures contracts, which will profit if the level of implied volatility increases over the holding period

(ii) Variance swaps are relatively illiquid, offer limited capacity, and are subject to counterparty risk.
VIX futures contracts have less counterparty risk, but have a fixed maturity and must be rolled, resulting in significant costs.

(c) Forecast the one-month volatility of the S & P 500 index. Show your work.

Commentary on Question:
Most candidates did well overall but many just provided the predicted variance rather than the predicted volatility and received a small deduction.

$h'_{t-1} = \lambda h'_{t-2} + (1-\lambda)s^2_{t-2}$

$0.1892\% = 0.1895\% \lambda + 0.1791\% (1 - \lambda)$
$0.0101\% = 0.0104\% \lambda$
$\lambda = 0.97$

$h'_t = \lambda h'_{t-1} + (1-\lambda)s^2_{t-1}$

$h'_t = 0.97*(0.1892\%) + (1-0.97)*0.1960\%$

$= 0.1894\%$

Thus the predicted variance is 0.1894%, and therefore the predicted volatility, equal to square root of variance, is 4.352%.

(d) With respect to a "Constant Volatility" strategy:

(i) Describe the principle underlying the constant volatility strategy.

(ii) Explain the rationale for maintaining a constant volatility.

Commentary on Question:
Most candidates received partial credit by identifying either the principle or the rationale.

8. Continued

(i) To systematically adjust exposure to a given asset portfolio conditional upon its current volatility, in order to maintain a pre-specified risk level.

(ii) Most bull markets have been characterized by extended periods of below-average volatility. Markets generally trend upward in an organized, relatively smooth pattern. During these periods, investors should maximize asset exposure, taking advantage of a favorable risk-reward trade-off. As volatility increases, decrease asset exposure to maintain the desired risk/volatility level.

(e)

(i) Design the constant volatility overlay required to achieve the Plan's target volatility using long/short investments in cash.

(ii) Design the constant volatility overlay required to achieve the Plan's target volatility using one-month S&P Futures contracts.

Show your work.

Commentary on Question:
Very few candidates received full credit. They received partial credit by correctly illustrating the steps required for a full calculation.

(i) The DB Plans equity fund will have a forecasted monthly volatility exposure of 1.1*4.8114%, or 5.2925%.
Cash has a volatility of 0 and zero correlation with equity, so need to find allocation to cash, such that:
$4.33\% = \text{sqrt}(a^2 0^2 + b^2 (5.2925\%)^2 + 2*0*a*b*0*5.2925\%)$, $a+b = 1$
$4.33\%^2 = (5.2925\%b)^2$
b =81.814% in equity, or $204.535 million in equity, and $45.465 million in cash.

(ii) Want to purchase enough futures to hedge the excess volatility exposure relative to target level:
Fund is forecasted to have a monthly volatility exposure of 1.1*4.8114%, or 5.2925%.
This produces an excess volatility ratio of (5.2925/4.33 – 1) = 0.2222%.
N_h = excess volatility Y/X = (0.2222% * $250 million)/(2000*$25)
= $5,557,159.4/$50,000 = 111.14 or 111 contracts should be purchased

8. Continued

(f) The Plan's Pension Consultant has recently recommended that the Committee consider a new allocation to a U.S. equity portfolio manager who runs a "Constant Volatility" fund. You feel that the constant volatility overlay strategy using futures is a better choice for the plan.

Identify two key advantages of the constant volatility overlay strategy compared with a new investment in the Constant Volatility fund.

Commentary on Question:
Most candidates received points for one key advantage. They received points for other possible key advantages that are not in this sample answer as well.

The overlay would not impact the current strategic-asset-allocation or the manager-allocation decisions of the Plan.

The overlay would not affect the portfolio's alpha component (keep excess active manager returns), it would simply smooth market/ beta risk

9. **Learning Objectives:**

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

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

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

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

Learning Outcomes:

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

(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.

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

(2f) Analyze the importance of tails of distributions, tail correlations, and low frequency/high severity events.

(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.

(3c) Analyze quantitative financial data and insurance data (including asset prices, credit spreads and defaults, interest rates, incidence, causes and losses) using modern statistical methods. Construct measures from the data and contrast the methods with respect to scope, coverage and application.

(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.

9. Continued

(4k) Apply best practices in risk measurement, modeling and management of various financial and non-financial risks faced by an entity.

Sources:
ERM-604-12 The Impact of Skewness and Fat Tails on the Asset Allocation Decision

Case Study – SLIC DB Pension Plan

Commentary on Question:
This question tested the understanding of the shortcomings of VaR/MVO (mean variance optimization) and how CVaR/M-CVaR, i.e. using return distributions that capture skew and kurtosis and CTE can improve on those. Most candidates showed understanding that skewness and kurtosis are not accounted for in MVO but are accounted for in M-CVaR. However, most candidates struggled to properly use the information from the study in parts a – d to support their recommendation in part e.

Solution:
(a) Explain the objective of each of your four scenario tests.

Commentary on Question:
For the most part, candidates did well on this question. Some candidates simply stated Scenario 1 was the "base case", which was not given credit. Credit was given for Scenario 1 if it was mentioned that it represented the current methodology.

- Scenario 1 tested a normal distribution, i.e., with 0 skew and kurtosis of 3.
- Scenario 2 tested the impact of adding asset returns with non-normal or fat tailed distribution/high kurtosis
- Scenario 3 tested the impact of adding asset returns with non-normal, negative skewness
- Scenario 4 tested the impact of different combinations of non-normal, or realistic kurtosis/skewness

(b) Sketch and describe the change in the distribution of returns for Scenario 4 relative to your Scenario 1 plots with respect to:

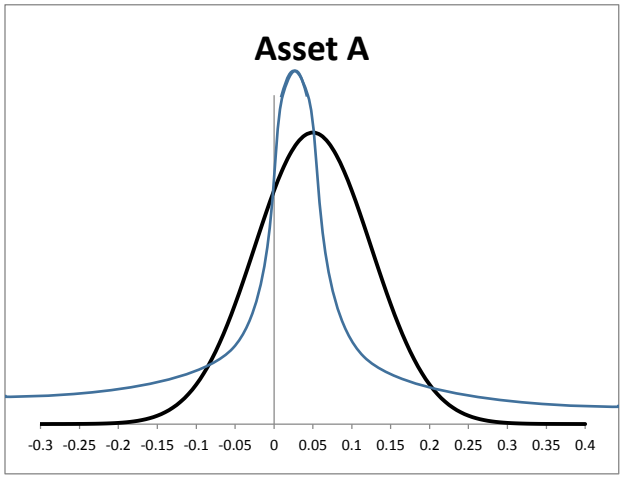
(i) Asset A

(ii) Asset C

9. Continued

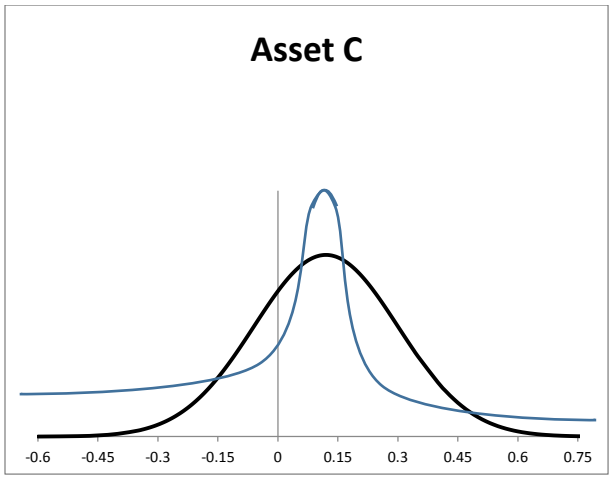
Commentary on Question:
For the most part, candidates did well on this question. Most common area where points were deducted was for Asset A not describing either that distribution would have the same mean or median, or that the peak was higher in Scenario 4.

(i)



Asset A distribution would still be symmetric and have the same mean, but have fatter tails

(ii)



Asset C distribution would not be symmetric, but have negative skew/higher probability of low values as well as fatter tails.

(c) Provide four key observations about the impact of skewness and kurtosis on asset allocation differences that result from MVO and M-CVaR optimization using your Scenario results above.

9. Continued

Commentary on Question:
Most Candidates were able to provide at least 3 key observations. Other answers than the ones listed below were accepted.

1) MVO approach leads to a similar result in all four scenarios
2) MVO and M-CVaR give same result in scenario 1 (Normal Distribution)
3) Scenario 2 suggests that kurtosis has a significant impact on M-CVaR
4) Scenario 3 suggests that skewness has a significant impact on M-CVaR

(d) Compare and explain the Scenario 2 risk exposure results for each of the MVO and M-CVaR portfolio optimization frameworks.

Commentary on Question:
Most Candidates were able to make at least one insightful comment, but most failed to truly compare the two approaches and their differing results

- The MVO approach resulted in a lower volatility as its goal is to optimize the volatility/return trade-off.
- The M-CVaR approach resulted in a lower CVaR despite having a higher volatility as it minimizes tail exposure, taking into account the higher moments of asset returns
- Tail risk is lower under M-CVaR than MVO, while VaR(volatility) is lower under MVO than M-CVaR. This indicates that as the MVO attempts to lower VaR, it inadvertently increases the tail risk. This unwanted result is due to the fact that VaR is not a coherent risk measure.

(e) Your report to the Pension Committee recommends adoption of both of the Plan Actuary's suggestions.

Draft the rationale for your recommendation, making reference to your efficient frontier study results.

Commentary on Question:
Most candidates mentioned that returns have not historically fit a normal distribution, and some also made solid comparisons between M-CVaR and MVO. However, few candidates did a good job of relating back to the results from the earlier parts of the question.

Using MVO method instead of M-CVaR relies only on VaR as the risk measure (a function of asset return volatility or second moment), which is not a coherent risk measure. As can be seen in the Scenario 2 test, when using MVO you can inadvertently increase your tail risk (CVaR) while decreasing VaR.

9. Continued

As seen in Scenario 1 test, using the M-CVaR approach with a normal distribution will result in the same allocation as MVO. It is important when using Mean-CVaR optimization to capture the higher moments of asset returns in generating return distributions t in order to more accurately measure and minimize tail risk exposures present in the asset allocation decision.