ERM-INV Model Solutions
Fall 2020

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

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

Sources:
- SOA Monograph- A New Approach to Managing Operational Risk -Chapter 8
- Managing Investment Portfolios, Maginn, John L. & Tuttle, Donald L., 3rd Edition, 2007 Ch. 9: Risk Management (section 5)
- ERM-142-20: Data Quality is the Biggest Challenge

Commentary on Question:
Commentary listed underneath question component.

Solution:
(a) GED's ERM team proposes calculating the level of aggregate losses using raw empirical analysis. You are given the following information:

- GED has 50 years of annual data
- Target risk tolerance is based on the VaR(99.5) for a one-year time horizon

Assess whether GED should proceed with this approach.

Commentary on Question:
Some candidates did not make a conclusion (i.e., decide that GED should not proceed with the approach) which resulted in less than full credit.

GED should not proceed with this approach.
Estimating VaR(99.5) with historical data requires at least 200 years of relevant loss data, and preferably about 1,000 years of data. GED only has 50 years, which is not enough. Additionally, 50-year-old data may not be applicable today.

1. Continued

(b) To model the operational risk associated with vending machine failure, GED's ERM team proposes the following three approaches:

1. Use the most recent 24 months of GED's operation failure frequency and loss severity data, which has been collected by the GED's Data Management Team using a systematic process.
2. Use the most recent 10 years of operation failure frequency and loss severity data from Coca-Cola's media reports. Coca-Cola uses vending machines similar to GED's to distribute products, but it is much larger in size.
3. Use the most recent 24 months of GED electrician logs of machine failures and notes on losses. The data collection process by electricians on duty may not be robust, but the loss severity will be estimated based on reasonable inferences using notes.

Assess each of the three approaches.

Commentary on Question:
Justifications were required for full credit on each approach. Many candidates did not conclude whether each course of action should be adopted, and therefore did not receive full credit. Generally, candidates that recommended a combination of all three approaches received the highest scores. Candidates did not need to assume the data set was heavy-tailed to receive full credit.

The first-approach uses internal data, which is the most relevant data. However, if the risk is heavy-tailed then the data may be insufficient since there are only 24 months. GED should not use this approach in isolation. However, it can be used as a starting point for the model.

The second approach can be useful for risk analysis and may be used to supplement GED's internal data. However, GED should proceed with caution as external data may suffer from reporting bias. Additionally, they should consider scaling the data to account for the different size of the companies.

The third approach can be useful for risk analysis and may be used to supplement approaches 1 or 2. However, this process may yield only a few data points which may be insufficient on its own.

(c)

(i) Calculate the monthly VaR(95) and CTE(95) of the operational losses for running the machines using the historical method.

(ii) Evaluate quality of data provided in the ERM team's notes for operational risk modeling. Justify your response.

1. **Continued**

Commentary on Question:
Credit was also awarded for candidates that concluded VaR(95) is the 7th worst loss instead of the 6th worst loss.

An opinion of the data quality (e.g., good or poor) was required for full credit on subpart (ii). Many candidates provided justification but did not state whether the quality was good or poor.

95% VaR of the operational losses = 120 months x (1.00 - 95%) = 6. Therefore, the historical VaR would be about the 6th worst loss, or **$16,886.**

95% CTE of the operational loss is the average of the worst six losses = (16,886 + 17,907 + 18,237 + 19,133 + 19,140 + 19,157) / 6 = **$18,410**

The quality of the data is not good for operational risk modeling because:

1. Each entity or geographical region should be considered separately rather than lumped together.

2. The data combines routine execution errors with unauthorized activities for December 2001 and November 2014.

3. The ability to track and audit data lineage should be available on demand and be built into the data quality solution and this requirement was not included in the data.

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.

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.

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:

(2a)   Demonstrate how each of the financial and non-financial risks faced by an organization can be amenable to quantitative analysis.

(3b)   Analyze quantitative financial and non-financial data using appropriate statistical methods to assist in quantifying risk.

(4b)   Demonstrate application of the following responses to risk, including consideration of their costs and benefits: avoidance, acceptance, reduction without transfer, and transfer to a third party.

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

(4h)   Demonstrate possible risk management strategies for non-financial risks.

(4i)   Choose appropriate techniques to measure, model and manage various financial and non-financial risks faced by an organization.

(5b)   Apply risk measures and demonstrate how to use them in value and capital assessment.

Sources:
Financial Enterprise Risk Management, Sweeting, 2011, Ch.16
Value-at- Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion Ch. 12 Monte Carlo Methods
ERM-107-12: Strategic Risk Management Practice, Anderson and Schroder, 2010 Ch. 7
ERM-110-12: Derivatives: Practice and Principles, Recommendations 9-24 and Section III

2. **Continued**

Commentary on Question:
This question is testing candidates' ability to understand, value, and analyze the use of derivatives to manage risks for a non-insurance company, in this case, an airline.

Solution:
(a)
(i)   Explain how each risk is relevant to BlueSky's operations.

(ii)   Explain how BlueSky's risk mitigation approaches could be used to address the identified risks. Justify your answer.

Commentary on Question:
The vast majority of candidates received full credit for both sections of part (a). Two different methods of answering for subpart (ii) were accepted. The candidates could either explain how each of the named mitigation approaches could be used by BlueSky, or by explaining how each of the named risks from subpart (i) could be mitigated by one or more of the named mitigation approaches.

(i)
Engine failures - Increase in repair costs, might cause flight cancellation due to aircraft unable to fly, or potential fatal crashes if malfunction occurs during a flight. Possible reputational damage.

Climate change - Flight cancellations due to extreme weather conditions. Could cause shifts in travel sentiment as consumers recognize the impact of burning fossil fuels on climate change.

Fuel prices volatility - Directly impact BlueSky ability to control fuel costs and will lead to earnings volatility, especially with fuel being one of their largest expenses.

(ii)
Use of insurance - Buy third-party insurance with provisions covering cost of aircraft repair, potential passenger liability or aircraft replacement cost arising from crashes/accidents.

Use of derivatives - Implement hedging strategy using derivatives, such as purchasing future contracts for fuel, to manage oil prices volatility.

Transferring costs - Transfer costs related to climate change, such as flights cancellation due to extreme weather, to costumers by raising ticket prices/charging for carbon offsets.

2. **Continued**

(b)

(i) Calculate the modified duration and convexity of each bond and for the reference portfolio. Show all work.

(ii) Determine the number of futures contracts BlueSky should enter into. Show all work.

(iii) Describe the shortcomings of this hedging strategy.

Commentary on Question:
Students generally did well on calculating the reference portfolio and duration but struggled with convexity and calculating the correct PVBP$_p$. A common mistake seen with calculating the PVBP$_p$ was only using duration, but not convexity.

If a student struggled to get the correct answers, it greatly increased their chances of receiving partial credit if they provided commentary as to what they were attempting to do in different sections of their spreadsheet.

Students that did not receive full credit for subpart (iii) typically gave either only one shortcoming (instead of multiple) or they stated the shortcoming(s), rather than describing it/them.

(i)
The solutions for this subpart is located in cells B22:D23 of the part b tab of the accompanying Excel file. The work used for these final calculations is in rows 31 to 42. There, the values needed to calculate modified duration and convexity for each time step are calculated. This is not the only way to come to the correct answers and this level of detail was not required to receive full credit, but is meant to clearly outline calculations needed to reach the final answer.

The reference portfolio was the weighted average of bond 1 and bond 2. While the intent was to use 50%/50% for each bond, answers considering the price of each bond were also accepted.

A common error made by some candidates was to copy formulas from cell D22 to D23, without using absolute references or adjusting the references to the weights, which resulted in the wrong answer.

2. **Continued**

(ii)
A solution for this question is located in cell D25 of the part b tab of the accompanying Excel file. The work used for these final calculations is in rows 45 to 53. The question is asking how many contracts are to be entered into, and while the calculation gives a negative number, both positive and negative answers were awarded full credit.

A common error on this part was not scaling to the total portfolio value of $100M.

(iii)
Because this strategy only hedges on duration and convexity, it will only be effective if the changes in interest rates are small. If they changes are large, this strategy will not fully protect BlueSky. Additionally, there are margin requirements to enter into futures contracts. This would be a potential additional cost that is not being incorporated in the current analysis.

(c)

(i)   Calculate the expected risk-neutral payoff of each option under Strategy B. Show all work.

(ii)   Determine the total cost of Strategy B. Show your work.

(iii)   Elon says that Strategy A is more appropriate as there is no cost of entering a forward contract. Critique his assertion.

(iv)   Calculate the profit or loss of this hedge under each strategy, relative to an unhedged position, assuming cash flows are accumulated at the risk-free rate. Show all work.

Commentary on Question:
While many will see this as obvious, it is clear that students should be reminded that bps means basis points and that a basis point is 1/100th of a percentage point. 0.01% or 0.0001 would be ways to numerically show 1 bps. Even more important is that multiplying 100,000,000 by 0.0001 in one's head involves moving the decimal place enough for it to be prone to error. One or a combination of these two mistakes was seen extensively when calculating the transaction costs of the options, with few students showing evidence of doing the calculation in their Excel file.

2. **Continued**

(i)
A solutions for this question are located in cells B24 and B25 of the part c tab of the accompanying Excel file.   The work used for these final calculations is in rows 29 to 40.

A common error was not recognizing that 0.065 was the simulated value to use in the calculation of the hundredth S(T) and students instead found the normalized value of 0.065. Answers were still reviewed for accuracy given this error to receive partial credit. For mistakes like this, it was very helpful to the graders for the students to clearly label where they calculated the simulated value to award partial credit.

Another common error was taking the average of the values shown in cell B19 and B20 and the appropriate simulated values, instead of weighting it 99 and 1 as the values in B19 and B20 were the average of the first 99 scenarios.

(ii)
Many candidates used the Excel file to their advantage for the calculations in this part of the question. Most candidates forgot to discount the risk neutral payoffs to get the present value.

Call value = 0.0750*e^(-5%*0.5) = 0.0731
Put value = 0.0798*e^(-5%*0.5) = 0.0778

The total cost of the hedge was the cost of purchasing the put, selling the call, and 2 transaction fees. The fee is where the note about bps in the commentary above came into play. Some students only used 1 transaction fee.

Cost of purchasing the put and selling the call:
        = 100,000,000*(0.0778 - 0.0731) = 470,000
Cost of the 2 transaction fees:
        = 2.5 bps * 100,000,000 * 2= 50,000
Total cost = 470,000+50,000 = 530,000

(iii)
The SOA guide for FSA exams defines critique as "analysis that covers both strengths and weaknesses. It may also include listing alternatives." Very few students were able to achieve full credit for this question as they would typically not cover both the strengths and weaknesses of Elon's statement. Comparing strategy A to strategy B was also given credit.

Elon is only partially correct as it is possible to offset the upfront cost in Strategy B with upside gains in a scenario where the exchange rate is lower than 1.49. There is also counterparty risk with entering into a forward contract, which may not have an explicit cost but does have implicit ones.

2. **Continued**

Strategy A works well if the exchange rate is higher than 1.5. The company is protected against a rise in the exchange rate but will not capture the benefit from favorable movements in the exchange rate (lower than expected exchange rate values).

Strategy B allows to capture benefits from lower exchange rates if the rate is less than 1.49. The company will get the current the exchange rate is the values are between 1.49 and 1.51, but offers no protection if exchange rates are higher than 1.51.

(iv)
Like subpart (ii), many students used the Excel file to their advantage for the calculations in this part of the question. The main reason students did not receive full credit was neglecting to accumulate the cost of the hedge at the risk-free rate. The text in the below solution was not required to receive full credit.

If BlueSky hadn't entered into some type up hedge, in 6 months they would be able to exchange their 100M Euros for $152M.

Strategy A:
BlueSky will receive $150M in 6 months from the forward contract in exchange for the 100M Euros.
The payoff would be $150M - $152M = -$2M.

Under the forward contract resulted in a $2M loss relative to an unhedged position.

Strategy B:
BlueSky will exchange to receive $152M
The call option will be exercised and the holder will receive $1M from BlueSky:
    ($1.52-1.51)*100M = $1M
The put option will not be exercised and is worth $0
The cost of the hedge is accumulated at the risk free rate:
    $530,000*e^{(0.5*0.05)} = \$543,417$
The payoff would be ($152M – $1M - $543,417) - $152M = -$1,543,417

The option contracts resulted in a $1,543,417 loss relative to an unhedged position

3.   **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:
(2f)   Demonstrate an understanding of model and parameter risk.

(3a)   Determine risk exposures using common risk measures (e.g., VaR and TVaR) and compare the properties and limitations of such measures.

Sources:
ERM-130-18: AAA Model Governance Practice Note
ERM-140-20: Risk Adjustments for Insurance Contracts under IFRS 17: Chapter 3: Risk Adjustment Techniques & Chapter 7: Validation Of Risk Adjustments

Commentary on Question:
Parts (a), (b)(iii), (d) are the "describe" questions and most candidates did well on those. Parts (b)(ii) and (e) of the question test the candidates' ability to evaluate and assess, and that is where candidates struggled the most.

Solution:
(a)   Describe two reasons why it may be appropriate for IL to use VaR instead of CTE as a risk measure for its economic capital calculation.

   Commentary on Question:
   Majority of candidates received at least partial credit. To receive full credit candidates needed to provide two reasons that addressed IL's specific situation. Candidates received partial credit for answers not related to IL such as "VaR is easier to understand for management." No credit was given for "coherency of the measure". Alternative answers were accepted such as "IL believes the risks are not "heavy tailed." Two reasons were required for full credit.

   1.   The tail of the distribution is unknown, or the tail of the empirical data is unreliable. Since this product is being sold in the new market, the internal data may not fully reliable for IL. External data is also limited as mentioned in the stem.

   2.   Good models for the tail risk are not available. IL may not have a risk model or distribution that adequately captures the shape of the tail.

3. Continued

    3. VaR may be more desired from a consistency perspective as it presents a confidence level and is not driven by the shape of the tail, which could be volatile. For example, IL wants to calculate a "probability of ruin", in which losses after a certain point really don't matter. For example, if IL had $50,000 in capital, losing 60,000 and losing 5,000,000 would still result in insolvency. IL management may also have an easier time understanding VaR.

(b) Assume IL's cost-of-capital rate is 6.0% and a risk-free discount rate of 1.8%.

    (i) Calculate the total risk adjustment for the term insurance product using the cost-of-capital technique according to IFRS 17. Show all work.

    (ii) Interpret what this risk adjustment would represent for IL's shareholders.

    (iii) Describe two alternative approaches that could be used to calculate the risk adjustment under IFRS 17.

Commentary on Question:
Most candidates got partial credit on subpart (i). To receive full credit candidates needed to calculate the risk adjustment correctly. Most candidates failed to recognize that capital amount is the difference between 99% confidence level and expected value of cash flow. Using either expected cashflow or 99% confidence level cashflow instead of capital amount resulted in partial credit. Most candidates struggled with part ii. Any one of the solutions provided below received full credit. Partial credit was given to less complete answers. Candidates performed very well on subpart (iii). Full credit was awarded for adequate description of any two of the methods described in the solutions below.

    (i) Model Solution is in the accompanying Excel file. Note that the work shown in cells D9:F13 is not required but may be helpful in awarding partial credit if the final answer is not correct.

    (ii) - The difference between the present value of future cash flows at a selected confidence level and the probability-weighted expected value of those cash flows represents the amount of capital that the entity would hold. Holding this amount above the expectation comes at a cost. This Cost of Capital risk adjustment calculates this cost.

       - The concept of the cost-of-capital risk adjustment focuses on the amount of capital an entity must hold for bearing a risk with unknown but estimable consequences. The cost of that amount is the risk adjustment, which is based on a return on the shareholder's capital to compensate for the risk to that capital.

3. **Continued**

- It can also be thought of as the compensation that an entity requires for bearing the uncertainty about the amount and timing of the cash flows that arises from non-financial risk as the entity fulfills insurance contracts.

(iii) **Quantile Technique:** Confidence level (percentile or value at risk or VaR)—With this technique, the risk adjustment is calculated as the amount that must be added to the expected value of the insurance liabilities, such that the probability that the actual outcome will be less than the liability (including the risk adjustment) is equal to a targeted probability (i.e., confidence level). The risk adjustment is the difference between the corresponding result at the selected percentile of the probability distribution and the probability-weighted expected value. Other equivalent concepts of quantile risk measurement include the terms probability of sufficiency (PoS) and probability of adequacy (PoA).

Quantile Technique: Conditional tail expectation, or CTE (tail value at risk or TVaR)—This is a modification of the confidence level technique. The risk adjustment is calculated as a conditional mean of the cash flows for all points of the probability distribution in excess of a chosen confidence level. The amount of the risk adjustment is the difference between the probability-weighted expected value (an estimate of the mean over the whole distribution) and the probability-weighted expected value of cash flows only for those points of the distribution beyond a selected percentile of the probability distribution.

Wang Transform: This type of risk model (Proportional hazard transforms) uses risk preferences to adjust the probability distribution. Lower preference probability values are assigned to more favorable outcomes, and higher preference-adjusted probability values are assigned for unfavorable outcomes. This allows for a probability weighted based calculation of a risk adjusted value of uncertain future liabilities and can be tailored specifically to the company's risk appetite and profitability objectives.

Explicit Margin: The risk margin may also take the form of an explicit margin added to individual assumption, or an adjustment made to the discount rate. Each individual key assumption would have to be evaluated to develop an appropriate underlying margin.

3. Continued

(c)   IL's CRO has reviewed your results and is uncomfortable with the cost-of-capital rate used in the risk adjustment calculation for the new term life business. Based on her experience, she says it should be higher than the 6% that IL uses for other blocks of business.

Evaluate the CRO's assertion.

Commentary on Question:
Candidates performed moderately well on part (c). Full credit was awarded for either side of the argument so long as adequate support was provided. Some candidates failed to demonstrate understanding of CoC rate.

CoC rate is not Appropriate:
If the capital amount is established at a high confidence level, a lower rate of return might be more appropriate. However, given the uncertainty and timing involving the life contracts and the nature of the business (New block, high sales, fully retained risk) the CRO's comments are justified given the level of uncertainty. The cost of capital rate should be higher than 6% because IL's shareholders would expect a higher return (more compensation for the higher risk) for a new product being sold in a new market.

CoC rate is appropriate:
The risk in insurance contract cash flow is already accounted for in the selected capital amount. (99th percentile cash flows) Therefore, and appropriate cost-of-capital rate should not be risk-loaded because doing so would result in the risk adjustments that would double count for risk and would not be appropriate compensation for bearing the uncertainty in the insurance cash flows. 6% is also consisted with what Solvency II uses for its cost of capital calculation.

(d)   IL wishes to establish a robust validation process to ensure that the results are accurate and calculated in accordance with IFRS 17 guidelines. Mary wants you to develop additional validating procedures beyond just validating the model output.

Describe three general validation aspects that could be implemented into the framework.

Commentary on Question:
Candidates performed very well on part (d). Full credit was awarded for general description of any three of the validation aspects listed below.

3. Continued

Validation of Data - Island Life should validate both raw and transformed data. Raw data includes policyholder and contract information. Transformed data are intermediary outputs, such as smoothed yield curves, lapse rates, and claims ratios, or liability model points. The validation will ensure accuracy, completeness, and appropriateness of the data.

Validation of Assumptions – Assumptions are parameters determined based on internal or external data, and often involve the use of judgment. Island Life must ensure that assumptions are set in a realistic manner, derived consistently form year to year, credible for the purpose used, and subject to appropriate governance that included peer review and signoffs.

Validation of the Process - This would ensure that the underlying framework of Island Life's capital and risk adjustment calculation was functioning as expected and generating complete and coherent results. This can be done through documentation, process management, entity policy, controls, and audits.

Validation of the Computation Model – This involves validation of the underlying mechanics and assumption implementations. This would include checking if the expected values from the stochastic models are materially different from the central estimates, checking if cash flows projected from the model are consistent with the stated assumptions, and verifying that the change in results form period to period can be attributed to changes in method, assumption, or data.

Ensure that the model if fit for purpose - The model could be reviewed by going over the business requirements for the model and having discussion with the model design team to ensure the modes is fit for purpose. I.e. in this case. Is it fit for the purpose of calculating the adjustment under IFRS 17.

Design Methods / Processing – Ensure that the model's methods and processes are appropriate and compliant with accepted practices. Reviews could include evaluation model design documentation and model code. Results of unit and regression testing could also be reviewed. The model methods and procession could be compared against regulatory requirements.

3. Continued

(e) After four reporting cycles, IL's management has raised concerns regarding the volatility of the reported economic capital for the new term product. In response, Mary suggests the following methods to help explain the volatility of the final results:

> I. Sensitivity Testing
> II. Analysis of change in risk adjustment
> III. Benchmarking or Proxies

Assess the appropriateness of each method for analyzing IL's term business.

Commentary on Question:
Majority of candidates received partial credit. For Sensitivity Testing, candidates struggled to identify main assumptions for testing. Some candidates didn't demonstrate understanding of this method. For Analysis of change in risk adjustment, only few candidates correctly understood that it's not a point in time analysis and period over period change was required. For Benchmarking or Proxy, most candidates did well and received full credit.

I. Sensitivity Testing

For a life insurance contract, mortality and lapsation shocks would be very appropriate. Given that it's a new market, sensitivity tests are very important because there could be a lot of uncertainty around the assumptions due to lack of company experience.

Alternative answer:
Sensitives should be conducted on assumptions that will highlight the parameters that have the most material impact on the level of risk adjustment. For this product, mortality, lapse, (and discount rate) would be appropriate.

Island Life could shock the mortality and lapse rates in the cash flow model to see the impact on the risk adjustment.
Knowing the proper shock could also be hard to determine for Island Life.

II. Analysis of change in risk adjustment

This method would be very appropriate for Island Life to perform. Given that the historical risk adjustment has shown volatility from period to period, and Island Life would benefit from a step by step analysis showing why things changed the way they did.

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3. **Continued**

Alternative answer:
Island Life could perform an analysis that shows how the risk adjustment changes from period to period, where each step in the analysis would quantify the impact of each assumption update made between the calculation dates. This would show IL what assumption changes had the most impact on the results and would allow them to gage the reasonableness of every update. This method would be very appropriate for Island Life to perform.

III. **Benchmarking or Proxies**
IL could compare the final results of the calculation to an internal or external benchmark. This would be useful and appropriate for IL to do because any unexpected (very high or very low) value, or deviation from this benchmark from period to period could indicate a possible error in the calculation.

Alternative answer:
IL could also compare its results to others in the industry if that information was available. However, given that this is a new market, industry information could be limited or unreliable making benchmarking less appropriate. Proxies may not be available or unreliable because of similar reasons.

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

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

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

Learning Outcomes:
(1a) Describe different definitions and concepts of risk.

(2a) Demonstrate how each of the financial and non-financial risks faced by an organization can be amenable to quantitative analysis.

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

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

Sources:
Value-at- Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion
Ch. 18 Credit Risk Management
Financial Enterprise Risk Management, Sweeting, 2011, Ch. 14 Quantifying Particular Risks
ERM-106-12: Economic Capital-Practical Considerations-Milliman
Risk Appetite: Linkage with Strategic Planning Report

Commentary on Question:
This question was testing the concept of credit risk, looking at the sources of credit risk in a company's asset portfolio, different approaches to measuring that risk, and methods for managing this risk. Candidates generally were able to attempt most parts of this question, and performance on the calculation portion was generally very good. Some parts asked for recommendations, which allowed for several acceptable answers; graders were looking for sufficient support for any given recommendation as well as sufficient detail on the recommendation.

Solution:
(a)
    (i) Define three risk factors of credit risk related to an asset portfolio.

    (ii) Identify which credit risk factor is the most likely driver of the unexpected losses given XYZ's compliance with its RAS. Justify your response.

4. **Continued**

> (iii)   Explain why XYZ is still exposed to credit risk, even if it complies with its RAS.
>
> (iv)   Recommend an additional requirement XYZ could add to its RAS that would account for the risks identified in part (iii). Justify your response.

Commentary on Question:
Most candidates were able to answer some parts of the question, and there were multiple acceptable answers for subparts (ii), (iii),and (iv) if sufficient support was given. A common issue was listing risks for subpart (i) instead of defining the risks. For part(iv), some recommendations were not realistic or were recommendations appropriate for swaps and not for corporate bonds.

(i) Default Risk - the risk that the issuing company is unable to pay the full debt back to the asset holder

Credit Exposure Risk – the risk of fluctuations in market value of an asset due to the market's view of the creditworthiness of the issuing company

Recovery Risk – The exposure to the unknown amount that the asset holder is able to recover at default

(ii) The most likely risk is **credit exposure risk**, as the other two risks are not as likely. Due to the requirement of A- or AA-rated bonds, default risk is low. The recovery rate assumption is not that impactful, as it occurs only upon default.

(iii) The RAS requires high-rated assets, but there is still a non-zero chance of default in those assets, or the chance of downgrades. Default or downgrade risk is specific to the issuer of the bond, not a specific rating. If XYZ holds a lot of bonds from one company, if there is a credit loss from that issuer, that provides a lot of risk.

(iv) To reduce credit risk concentration from being exposed to a specific issuer, the RAS could be updated to indicate no more than 0.5% of XYZ's assets can be invested in a given issuer.

4. **Continued**

(b)

    (i)   Calculate the expected credit losses from default in the next year using the credit migration model. Show all work.

    (ii)   Calculate the expected amount of bonds that need to be sold after one year in order to satisfy the RAS. Show all work.

    (iii)   Explain a source of portfolio losses, other than defaults, that is captured in the credit migration model.

Commentary on Question:
The solutions for subparts (i) and (ii) are in the accompanying spreadsheet. Common errors on subparts (i) and (ii) were to extend the migration model farther than one time step. Another common error on (ii) was to include the outcome of defaulted bonds, not simply downgrades to BBB. For (i) and (ii), it was possible to achieve full credit with a single formula in the answer cell. However, providing additional detail such as sub-steps often resulted in partial credit was the answer was not fully correct. This approach is shown in the model solution.

(iii) The credit migration model captures credit losses from asset downgrades. If a bond is downgraded, it loses market value due to extra credit spread reflecting its increased risk of default.

(c)   A portfolio manager determines XYZ's expected losses based on the Merton model, and you notice the results are different than the losses you calculated in part (b)(i).

    (i)   Explain how each input used in the Merton model affects the calculated probability of default.

    (ii)   Explain why the differences between the credit migration model and the Merton model could result in different estimated defaults.

    (iii)   Recommend which model XYZ should use going forward in order to address XYZ's unexpected losses. Justify your response.

4. Continued

Commentary on Question:
For subpart (i), some candidates listed the inputs and the Merton model formula, but did not answer the question about how each input affects the probability of default. There were several acceptable answers for both (ii) and (iii). For subpart (iii), either model could be recommended, as long as there was appropriate support.

(i) Five inputs to Merton model:
Amount of firm's debt – The higher the debt, the higher the probability of default

Firm's value – the higher the value, the lower the probability of default

Risk free rate – the higher the risk-free rate, the lower the probability of default

Volatility of the firm's value – the higher the volatility, the higher the probability of default

Time horizon for the issue – the longer the time horizon the higher the probability of default

(ii) Under the credit migration model, all companies with the same credit rating are assumed to have the same probability of default.

For the Merton model, the firm's value and volatility will be the key drivers of the probably of default, and can differ a great deal between companies with the same credit rating.

So, a company with lower value/higher volatility, but favorable credit ratings could look better under the credit migration model.

(iii) The credit migration model should be used – it is simpler to implement and easier to explain. It is also easier to design a RAS around credit ratings than having different credit risk assessments for each issuer. The inputs to use in a Merton model may not be as readily available as the inputs for the credit migration model.

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.

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 specific risks faced by an organization, including but not limited to: financial, environmental, operational, legal, reputational and strategic risks.

(4b) Demonstrate application of the following responses to risk, including consideration of their costs and benefits: avoidance, acceptance, reduction without transfer, and transfer to a third party.

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

Sources:
ERM-107-12: Strategic Risk Management Practice, Anderson and Schroder, 2010 Ch. 7 Strategic Risk Analysis
Financial Enterprise Risk Management, Sweeting, 2011, Ch. 8 Risk Identification
Embedding Cyber Risk in Risk Management: An Insurer's Perspective By Kailan Shang
Internal Controls Toolkit by Christine H. Doxey, Chapter 1
ERM-115-13: Creating an Understanding of Special Purpose Vehicles, PWC
ERM-128-17: The Breadth and Scope of the Global Reinsurance Market and the Critical Role Such Market Plays in Supporting Insurance in the United States, Ch. III, IV, and VI
ERM-122-14: Chapter 1 of Captives and the Management of Risk, Kate Westover

Commentary on Question:
Candidates generally did better on part (b) of this question, identifying advantages and disadvantages of retaining and transferring cybersecurity risk and recommending a mitigation option for each. The candidates who performed better on parts (a) and (c) generally utilized specific information on Big Ben from the case study and applied their analysis directly to Big Ben's particular situation and objectives.

Solution:
(a) Big Ben's strategic plans include the expansion of its Asset Management Business client base by lowering the minimum investable assets requirement. Big Ben also plans on formulating a one-stop shopping interface for its globally mobile clientele.

5. Continued

Assess how this strategy may affect Big Ben's:

    I. Strategic risk
    II. Business risk and its impact on profitability
    III. Operational/technology risk in general and cybersecurity risk in particular

Commentary on Question:
Full credit on this part required examples that related directly to Big Ben's risks. Candidates who provided a generic assessment of each risk without relating it to Big Ben and/or provided limited analysis of each risk received minimal credit. Some candidates only addressed the benefits of the strategic plan without identifying the downside risks, which resulted in significantly less credit.

Strategic Risk
Big Ben currently has a strong brand and a loyal customer base. Lowering the minimum investable asset requirement may diminish the brand reputation in the perception of the current customer base. Big Ben may also face new competition from non-high net worth clients. This might force them to reduce the expense ratio for all clients.

Business Risk & Impact on Profitability
Big Ben does not have enough experience to assess impact on profitability in models. Risk models and assumptions will have to be revised and sensitivity tested. They also will likely incur additional marketing, training, and administration expenses which will impact profitability, at least in the near-term.

Operational/Technology Risk
According to Caerus, the existing technology is inadequate. Introducing a one-stop shopping interface will expand the current technology risk. Building the new interface will likely require additional staff, training, and testing, which would increase the current operational risk.

Cybersecurity Risk
The new shopping interface would increase cybersecurity risk, as it could provide an access point for cyberattacks into Big Bank's systems. Lowering the minimum asset requirement may also expand the vulnerabilities for cyberattacks to steal client's data or other valuable information, thereby increasing cybersecurity risk as well.

5. **Continued**

(b) Big Ben is weighing a choice between retaining and transferring cybersecurity risks that would arise from the expansion strategy.

   (i) Describe the advantages and disadvantages of:

   - Retaining cybersecurity risk internally
   - Transferring cybersecurity risk externally.

   (ii) Recommend a mitigation / control option for each choice. Justify your response.

Commentary on Question:
Candidates who performed well on this part of the question properly described multiple advantages and disadvantages of retaining and transferring cybersecurity risk, along with providing a substantial justification for their recommended mitigation / control option. Candidates who listed an advantage for one approach as a disadvantage for the other would not receive credit for both. Candidates who misinterpreted (ii) to choose between retaining and transferring, as opposed to recommending controls for each, received minimal credit

(i)
Advantages of Retaining
Bank can control whole technology and invest in systems to control cyber risk
Can better monitor risk internally than if it is outsourced

Disadvantages of Retaining
Employees need to be trained in cyber risk to detect it
Retains liability in case cybersecurity breach happens

Advantages of Transferring
Impact of risk is shifted which would reduce capital required
May be cheaper in the near-term to transfer than to build up staff and technology

Disadvantages of Transferring
Introduces dependency on an external party for expertise, increasing counterparty risk
Less possibility to develop an internal risk culture about this particular risk

(ii)
Retaining
Implement thorough internal controls for data access, including testing and monitoring, to reduce the likelihood of a cyber breach.

5. Continued

Transferring
Purchase cyber risk insurance with a reputable third party to transfer financial responsibility while limiting counterparty risk.

(c) As part of Big Ben's strategy to expand its Investment Banking business, the company decided to transfer cybersecurity risk and plans on utilizing a Special Purpose Vehicle (SPV) as a way for its clients to raise capital and transfer specific risks.

(i) Explain how an SPV could be structured to meet Big Ben's goal.

(ii) Assess the benefits and risks to Big Ben of this particular mitigation option. Justify your answer by using information from the Case Study.

Commentary on Question:
Full credit required candidates to both explain how an SPV could be structured and how that structure related to Big Ben's goal, along with appropriately explaining the benefits and risks to Big Ben using information from the Case Study. Candidates who provided more generic responses or did not use information from the Case Study received minimal credit.

Many candidates who performed poorly on (i) missed key steps in the SPV process, mainly by not articulating how the assets moved between the key parties.

Some candidates' answers to (i) were more suited to (ii) responses. Credit was given for responses in (i) that pertained to (ii). However, these candidates generally did poorly as they missed (i) almost entirely.

(i)
Big Ben first creates an asset that will be transferred to the SPV with a payoff based on Big Ben's cybersecurity exposure. An example of such an asset would be a "cybersecurity bond" that pays a fixed rate coupon payment as long as no cybersecurity breach occurs. Big Ben creates an SPV in order to sell this asset on its balance sheet to the SPV and obtain financing through the SPV. The SPV obtains funds to purchase the asset by way of debt financing from independent equity investors. With the capital relief/funds raised through the SPV, Big Ben can invest more into cybersecurity. The cybersecurity bond does not pay off should a cybersecurity breach harm Big Ben's financials and/or reputation.

5. **Continued**

(ii)
Benefits
One benefit of an SPV is the isolation of financial risk. It would allow for cyber risk transfer from Big Ben to an external party and enables Big Ben to retain other risks. Another benefit is the clarity of documentation, as Big Ben has flexibility in defining the extensiveness of the coverage (e.g. definition of data breach event).

Risks
One risk of an SPV is the signaling effect, as external investors may interpret the SPV use as Big Ben's relative non-confidence in its ability to manage cybersecurity risk and necessitating the risk transfer. Another risk is reputational risk. Despite the SPV arrangement providing protection against a cybersecurity event, such event will nevertheless damage Big Ben's reputation that could extend to Big Ben's other businesses.

6. **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 specific risks faced by an organization, including but not limited to: financial, environmental, operational, legal, reputational and strategic risks.

(4b)   Demonstrate application of the following responses to risk, including consideration of their costs and benefits: avoidance, acceptance, reduction without transfer, and transfer to a third party.

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

Sources:
Financial Enterprise Risk Management, Sweeting, 2011, Ch. 8 Risk Identification (LO 1)

ERM-107-12: Strategic Risk Management Practice, Anderson and Schroder, 2010 Ch. 7 Strategic Risk Analysis (LO 1)

ERM-122-14: Chapter 1 of Captives and the Management of Risk, Kate Westover (LO 4)

ERM-128-17: The Breadth and Scope of the Global Reinsurance Market and the Critical Role Such Market Plays in Supporting Insurance in the United States, Ch. III, IV, and VI (LO 4)

Financial Enterprise Risk Management, Sweeting, 2011 Ch. 16 Responses to Risk (LO 4)

Commentary on Question:
This question deals with identifying Key Risks using SWOT and analyzing ways to mitigate the risks through insurance or captive. Comments on each part are provided below.

Solution:
(a)   Recommend whether CC is an appropriate company for DE to hire to perform the risk analysis based on CC's overview in the Case Study. Justify your response.

6. **Continued**

Commentary on Question:
Candidates did a good job recognizing the experience that CC had with the auto industry. To get full credit candidates needed to recognize that there were some concerns with choosing CC.

I recommend DE hire CC to perform the risk analysis. CC has significant experience in the auto industry, having consulted with 20 clients, so it should know that market well. It also has expertise in the robotics industry, which likely has some synergies. On the negative side, CC was involved with an auto company that went bankrupt.

(b) An actuarial analyst at CC provides the following comments as part of the SWOT analysis for DE entering this new market.

- "(Strength) DE can quickly update all car systems via existing internet connections
- (Weakness) The market does not appear to be requesting artificial intelligence (AI) right now
- (Opportunity) Autonomous technology could easily be added to new products as they roll them out
- (Threat) DE currently doesn't have the expertise in house right now."

(i) Critique the comments provided.

(ii) Provide one additional item for each SWOT component.

Commentary on Question:
(i)   Most candidates identified that Strength and Weakness are internal, and Opportunity and Threat are external, and received minor credit. In order to get full credit candidates had to opine on the specific comment as well identify the comments that were classified incorrectly.
*(ii)   In order to get full credit, candidates needed to provide items that were relevant to DE **entering this new market**, not just relevant to DE.*

(i)
Strength –   Yes, this is a strength for DE
Weakness –   Weakness should be internal weakness, this is a threat, and a valid threat for DE.
Opportunity - An opportunity should be external. This is internal and does this really matter since they can update cars with new features?
Threat -   A threat should be external. This is internal and would be a valid weakness.

6. **Continued**

(ii)
Strength –   DE was the first significant manufacturer of battery-powered
              vehicles with performance and significant driving range.
Weakness -   DE has significant outstanding loan balances that could impact
              their ability to venture into a new market.
Opportunity - Worldwide customer demand growing. There is little competition
              in the autonomous vehicle market. DE would be one of the first
              competitors.
Threat -   External competitors may attempt to steal technology

(c)   The following three options for managing the risk associated with the indemnity
       plan were identified:

       - Do nothing to mitigate the risk
       - Set up a captive to insure this risk
       - Buy insurance coverage from a third party

       Evaluate each of these options for DE.

       Commentary on Question:
       Candidates seemed to struggle on this part.
       - *Many identified that doing nothing could lead to liquidity risk, but few*
         identified that it would be easy to implement.
       - *Several candidates incorrectly indicated that a high number of accidents*
         would have a reputational impact for only some of the options. A high
         number of accidents would have a reputational impact on the company
         regardless of how they insure the indemnity plan.
       - *Candidates would sometimes only describe the options, and not really*
         evaluate. Credit was awarded for evaluation of the options.
       - *Some candidates recommended a specific option, but the question didn't*
         ask for this, so no credit was awarded for the recommendation.

       Do nothing to mitigate this risk
       - Easier to implement than the other two
       - This risk would be difficult to quantify without any expertise and
         potentially high reserves would need to be held.
       Set up a captive to insure the risk
       - Limits financial exposure but not reputational risk.
       - DE has no expertise in this area
       - Could be costly to set up and DE already has loans due soon, although if
         AI is new to DE, the insurance could also be very costly, and the risk of
         being newly offered would be added to the premium.

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6. Continued

- Per the case study, investing in AI already has large upfront costs, so this would be an additional strain

Buy insurance coverage from a third party
- There would still be some reputational risk if the AI starts failing, but no reputational risk on both the Captive and AI failing
- This risk is difficult to quantify, and insurance companies will add this unknown as an additional cost
- Counterparty Risk would exist

(d) A decision was made to purchase insurance. The following insurance structures are under consideration:

- Insurance that covers all life insurance losses
- Insurance that covers losses on a 50% quota share basis
- Excess of loss insurance above a fixed annual limit of $X

Recommend which structure to implement.

Commentary on Question:
Most candidates were able to provide acceptable answers to this part. Some candidates explained why they were recommending one without including why the other options weren't good choices which earned them only minimal credit.

Insurance that covers all life insurance losses
- DE may not have the incentive to look into this as much as they would if they had some cost other than reputational cost.
- This would be expensive as you are transferring all the risk.

Insurance that covers losses on a 50% quota share basis
- Cheaper than the insurance that covers all life insurance losses.
- It provides some benefit relief at initial impact, but a major system failure could still cause a large issue for the company (doesn't cover all the tail risk)

Excess of loss insurance above a fixed annual limit of $X
- The company would have the incentive to look at each failure, but it would cover any major system failure.
- Would probably be the cheapest option.

I recommend using the Excess of Loss insurance above a fixed annual limit of $X. It will be the cheapest option for DE as the insurance company will realize that DE has some skin in the game (less moral hazard risk). It will help DE protect against the tail risk, which is the biggest concern.

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

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:
(2c)   Evaluate and select appropriate copulas as part of the process of modelling multivariate risks.

(2g)   Evaluate and select appropriate models to handle diverse risks, including models that use a stochastic approach.

(3a)   Determine risk exposures using common risk measures (e.g., VaR and TVaR) and compare the properties and limitations of such measures.

(3b)   Analyze quantitative financial and non-financial data using appropriate statistical methods to assist in quantifying risk.

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

Sources:
Value at Risk, Jorion, Chapter 8, Multivariate Models
Value at Risk, Jorion, Chapter 17, VAR and Risk Budgeting in Investment Management (excluding 17.3 and 17.4)
ERM-617-19: Chapter 19 (pp 397-425) of Options, Futures, and Other Derivatives

Commentary on Question:
Candidates performed poorly on this question. This required many calculations to be performed in excel, and candidates struggled to properly show and explain their work in an excel format. This made it difficult to assign partial credit when answers were incorrect. While not required, it is recommended to clearly show sources of inputs and break down calculation steps as clearly as possible when presenting solutions in excel, similar to what would be expected for a written response. This approach is what has been taken in the model solution.

7.   Continued

Solution:

(a)   Calculate the expected surplus return for 2020, as a percentage of the initial asset value. Show your work.

Commentary on Question:
Few candidates recognized the need to use the portfolio beta to calculate the asset expected return, or where to find the correct asset and liability values for the portfolio.

See Excel for solution

(b)
(i)   Calculate the volatility of the asset portfolio. Show your work.

(ii)   Critique the use of the model used in (i) to estimate volatility.

Commentary on Question:
Candidates were mostly able to set up the equation to calculate the portfolio weights but did not recognize to use the diagonal model to produce the portfolio variance.

See Excel for part (i)

Part (ii)

The Diagonal model is simple and reduces the number of factors for the covariance matrix from $N(N + 1)/2$ to $2N + 1$. However, a diagonal model assumes only one risk factor and could be insufficient to estimate risk. A multi-factor model may be needed.

(c)
(i)   Calculate the 95th percentile of the expected surplus position at 12/31/2020. Show your work.

(ii)   Describe the relationship between asset-liability correlation and the funding risk of the pension plan.

(iii)   Assume the correlation between asset and liability is now 0.95. All other variables remain unchanged.

Calculate the optimal funding ratio (A/L) to minimize surplus volatility. Show your work.

7. Continued

Commentary on Question:
Problems with this question stemmed from candidates being unable to recall and manipulate the formula relating surplus return to asset and liability return.

See Excel for parts (i) and (iii)

Part (ii):
Based on the formula
σs 2 = σa2+ σl 2 x (L/A)2 – 2 x σa x σl x (L/A) x correlation:

When the correlation is negative, volatility of surplus increases, which means higher funding risk for the pension plan. Liabilities will increase when assets decrease, reducing surplus further.

(d)

(i)   Calculate the portfolio weight for each manager. Show your work.

(ii)   Calculate the overall portfolio information ratio. Show your work.

See Excel

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.

Learning Outcomes:
(2c)   Evaluate and select appropriate copulas as part of the process of modelling multivariate risks.

(3b)   Analyze quantitative financial and non-financial data using appropriate statistical methods to assist in quantifying risk.

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

Sources:
ERM-103-12: Basel Committee - Developments in Modelling Risk Aggregation

ERM-615-19: The devil is in the tails: actuarial mathematics and the subprime mortgage crisis

Commentary on Question:
Commentary listed underneath question component.

Solution:
(a)
(i)   Describe the steps necessary to simulate a loss distribution given random variables X_1, X_2, ..., X_n with distributions F_1, F_2, ..., F_n, and a copula $C(u_1, ..., u_n)$.

(ii)   Compare and contrast the use of rank correlation and linear correlation for copula calibration.

Commentary on Question:
Few candidates were able to describe all the steps correctly. Some missed the last step of repeating the process to get enough samples to produce a simulated distribution. Others didn't seem to understand how to apply copula in a simulation.

Most candidates showed that they understood what rank correlation is, but many failed to provide a comparison covering what the two correlations have in common and the differences.

8. **Continued**

    (i)   1. Based on the copula distribution, draw a sample of joint uniform random variables $(u_1, u_2, u_3, \ldots, u_n)$.
    2. For each uniform calculate the u-th percentile as $F_i^{-1}(u_i)$.
    3. Sum the percentiles to get the total loss $\sum F_i^{-1}(u_i)$.
    4. Repeat steps 1-3 for enough samples to produce the simulated loss distribution.

    (ii)   1. Both are simple scalar measure of dependency. They, together with marginal distribution functions, don't uniquely determine the joint distribution functions.
    2. The standard correlation matrix of the joint distribution varies with marginal distributions, whereas rank correlation is invariant under increasing functions.

(b)   Your coworker reviews your results and states:

    1. The underlying default dependence structure is not a function of tranche seniority.
    2. The correlations should be identical for all tranches.

    Critique your coworker's statements.

Commentary on Question:
Overall, candidates did not do very well on this part. Many candidates confused the underlying dependence structure with priority of payments for different tranches.

    1. The coworker's first statement is correct. The underlying default dependence structure is a function of the underlaying assets only.
    2. The second statement is partially correct. The correlation figures for different tranche are expected to be the same, because correlation is a function of the underlying portfolio and not of the tranches. However, using different correlations for each tranche allows the model to fit to market prices.

(c)   Assess the appropriateness of each copula to quantify the risks of this CDO.

    •   The Gumbel copula is symmetric, so fails to account for asymmetry requirement. It does exhibit tail dependence.

    •   A Gaussian copula can be asymmetric with more than two dimensions. A Gaussian copula exhibits no tail dependence, so fails the tail dependence requirement.

8. **Continued**

- A t-copula has tail-dependence and can be asymmetric with more than two dimensions, which addresses both concerns. The t-copula is acceptable.

(d) Describe one advantage and one disadvantage of evaluating risks using scenario-based aggregation.

Advantage: Scenario-based risk aggregation relates directly to the firm's unique risk-exposures, their risk-drivers and relationships between them.

Disadvantage: Requires significant technical expertise and/or expert judgment

(e) Assess the effectiveness of each action in meeting the company's objectives.

Commentary on Question:
Many candidates considered hedging as an effective action in limiting credit losses, which is incorrect.

Shifting to super-senior tranches
- Effective in limiting credit losses: It is very unlikely that super-senior tranches would experience any credit losses or material impacts from single-name defaults, even in a financial crisis like 2008.
- Not effective in maintaining liquidity: The value of the positions could still decrease substantially and may require posting collateral and result in limited liquidity.

Reducing allocation to CDOs
- It is the best action to meet the company objectives.
- Effective in limiting credit losses: it limits direct credit exposure.
- Effective in maintaining liquidity: high-quality bonds provide regular interest income and maintain liquidity in crisis events.

Hedging
- Not effective in limiting credit losses: During the financial crisis, mezzanine tranche hedges often failed. Standard models sometimes gave hedge ratios with the wrong sign. Current standard models still suffer most of the same defects.
- Purchasing a CDS hedge requires regular premium payments, and potentially delayed timing to settlement can limit liquidity.

(f) Recommend the most appropriate action. Justify your recommendation.

Recommend reducing allocation to CDS, because it is effective in limiting credit losses and maintain enough liquidity.