

ERM Model Solutions

Fall 2023

1. Learning Objectives:

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

Learning Outcomes:

- (3a) Demonstrate how each of the financial and non-financial risks faced by an organization can be amenable to quantitative analysis.
- (4a) Determine risk exposures using common risk measures (e.g., VaR and TVaR) and compare the properties and limitations of such measures.
- (4b) Analyze quantitative financial and non-financial data using appropriate statistical methods to assist in quantifying risk.
- (5i) Choose appropriate techniques to measure, model and manage various financial and non-financial risks faced by an organization.
- (6a) Demonstrate a conceptual understanding of economic measures of value and capital requirements (e.g., EVA, embedded value, economic capital, regulatory measures, and accounting measures) and their uses in decision-making processes.
- (6b) Apply risk measures and demonstrate how to use them in value and capital assessment.

Sources:

ERM-151-22: Developing Key Risk Indicators to Strengthen Enterprise Risk
Risk Appetite: Linkage with Strategic Planning Report

1. Continued

Commentary on Question:

Overall, candidates did reasonably well on the written part of the question and very well on the calculation part of the question. Most candidates struggled with the part a (ii).

Solution:

- (a)
- (i) Explain the value each of the existing metrics MCEV and EVA adds to the New Business Budgeting process.
 - (ii) Describe how RAROC fulfills each of the six core elements of a well-designed KRI.
 - (iii) Assess whether RAROC provides additional value to CDE's existing New Business Budgeting Process.

Commentary on Question:

Most candidates received partial credit for parts (i) and (iii). For part (ii), most candidate failed to recall the six core elements of the well-designed KRI and apply the list to the RAROC.

- (i) MCEV is a good candidate for measuring economic value. It accounts for the cost of nonhedgeable risks, the cost of options and guarantees offered in the insurance contracts, and the frictional cost of capital. MCVE represents the present value of shareholders' interests in the earnings distributable from assets allocated to the covered business after sufficient allowance for the aggregate risks in the covered business.

EVA is a risk-adjusted measure that focuses on value rather than return. It encourages senior management to take opportunity cost of capital into consideration and maximize shareholder's value given their risk appetite.
$$EVA = \text{earning} - \text{opportunity cost} * \text{capital allocated.}$$
- (ii)
 - 1. RAROC is a standard calculation based on present value of profits & required capital, both of which are established concepts
 - 2. Standardization (i.e. consistency) of the RAROC KRI is possible across the organization
 - 3. The RAROC formula is simple, intuitive, and easy to understand how profits are risk-adjusted
 - 4. RAROC has clear inputs allowing for measurement and comparison across time without ambiguity
 - 5. RAROC can be evaluated at a business line or product level and tracked over time. Product and business line profits can then be compared on a risk-adjusted basis.

1. Continued

6. Since the components are common calculations, the development and monitoring of RAROC would be efficient (i.e., consume little extra resources).

- (iii) EVA is risk based, but it requires multiple departments and many assumptions from each department. In short, EVA is not simple and may be difficult to explain. It likely would require workshops with senior management to get their buy-in and help them understand the concepts. RAROC adds value in that it is simpler to calculate and understand. MCEV accounts for some risks (cost of nonhedgeable risks, cost of options and guarantees, and frictional cost of capital) explicitly, but RAROC explicitly captures the company's risk profile through the inclusion of required capital.
- (b) The Company agrees to adopt RAROC as a KRI and adjusts its Risk Appetite to include:
 - The aggregate RAROC must exceed 8%.
 - The RAROC for each product line must exceed 5%.
- (i) Verify the Term Life RAROC of 7.4% using the data provided in the “Q1.b.i” tab of the accompanying Excel spreadsheet.
- (ii) Critique the Company’s New Business Budgeting plan.

Commentary on Question:

Most candidates did well on the calculation section of the question, part (i). Candidates did reasonably well on part (ii) by recognizing the shortfalls of the New Business Budget plan.

- (i) Model Solution is in Excel file attached.
- (ii) VA does not meet the RAROC target. The low RAROC for VA implies the company may want to consider lowering its new business premium projections for this line of business. The Company will need to consider de-risking measures for VA to meet the RAROC target. The SPIA product has the highest RAROC. This implies that the product has a low risk profile. Due to the high RAROC on SPIA, the company could consider increasing the new business premium projections for this line if they are satisfied with the profitability.

2. Learning Objectives:

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

Learning Outcomes:

- (1a) Recommend an appropriate framework for an organization's enterprise risk management and an acceptable governance structure.
- (1c) Demonstrate how to articulate an organization's risk appetite, desired risk profile, quantified risk tolerances, risk philosophy and risk objectives.
- (1e) Propose ERM solutions or strategies that effectively manage risk under different real (case study) and hypothetical situations facing financial and non-financial organizations.
- (2c) Identify and analyze specific risks faced by an organization, including but not limited to: financial, environmental, operational, legal, reputational and strategic risks.
- (3d) Demonstrate the use of scenario analysis and stress testing in the measurement of current and emerging risks.

Sources:

PSI ESG Underwriting Guide for Life & Health Insurance

Risk Appetite: Linkage with Strategic Planning

Commentary on Question:

The question was testing candidates' ability to recognize Social Risk in underwriting and recommend ways to mitigate it. Also, testing ability to construct a Risk Appetite Statement for a new category of risk. Finally, this question tests ability to brainstorm scenarios that could create risk events that are specific to social risk in underwriting.

Solution:

- (a)
 - (i) Describe three examples of potential Social Risks generated by ABC Life's proposed new underwriting program.
 - (ii) Recommend ways ABC Life can alleviate these Social Risks in the new underwriting program.

2. Continued

Commentary on Question:

Candidates generally did well on this part. Most candidates were able to describe at least one example of social risk in underwriting, although three were required for full credit. Any three acceptable examples would receive credit, not just the examples in this model solution. Some candidates described social risk as a reaction on social media, which did not get credit.

- (i) The use of credit scores can introduce bias against lower socioeconomic status customers

Using zip codes can also introduce racial and socioeconomic bias

People in hazardous occupations might be declined unfairly or charged too much or too little

- (ii) Consider alternatives to credit scores or removing them from the underwriting process

Zip codes – use more broad geographic info than zip codes to remove unintentional bias

Ensure underwriting and rates are fair for those in hazardous occupations, for new occupations and changes in workplace safety.

- (b) The CEO would like to develop a Risk Appetite Statement for ESG risks, incorporating both quantitative and qualitative components, which will make it clear to the Board where ABC Life stands on Social Risk

Construct a Risk Appetite Statement for ABC Life for Social Risk in underwriting that is responsive to the CEO's request.

Commentary on Question:

Most candidates got partial credit, describing quantitative or qualitative risks specific to social underwriting.

Risk Appetite Statement – This document assesses which risks the company will take on and the value that will be created for the company. This document uses both quantitative and qualitative risks to describe the maximum risk the company is willing to take.

- ABC Life will take on Social Risks because they can bring value to the company by lowering underwriting costs and decreasing time to issue.

2. Continued

- ABC Life is not willing to accept any significant losses due to social risk, defined by a decrease in capital of more than 10%.
 - ABC Life values its solid reputation, and will not take undue social risks that could result in bad PR.
 - ABC Life ensures that its algorithmic underwriting practices are fair, and do not produce results biased by race or socioeconomic status.
 - ABC Life will broaden zip code data to ensure no specific areas are declined coverage.
- (c) One of ABC Life's board members mentions that ESG risks might be prominent in newspaper headlines but are not as important as ABC Life's traditional risks.

Design scenarios, one for each category shown below, where ignoring Social Risks could have a large detrimental impact for ABC Life:

- Reputation
- Financial results

Commentary on Question:

Most candidates did well on this part, creating scenarios that could have an impact on ABC Life. Those that only mentioned social media risk received some credit.

Reputation Risk

If AI underwriting models are not screened and adjusted for bias, the result could be declining more of a certain class like ethnicity. This could produce bad PR or even a class action lawsuit.

Financial Loss

Prescription drug databases won't screen for recreational drugs, and a new recreational drug becomes available that kills many of its users. This would create high mortality and cause worse financial results.

3. Learning Objectives:

1. The candidate will understand the ERM framework and process and be able to apply them to organizations.
2. The candidate will understand the types of risks faced by an entity and be able to identify and analyze these risks.
3. The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.
6. The candidate will understand the concept of economic capital, risk measures in capital assessment and techniques to allocate the cost of risks within business units.

Learning Outcomes:

- (1b) Demonstrate an understanding of the perspectives of regulators, rating agencies, stock analysts, auditors and company stakeholders and how they evaluate the risks and the risk management of an organization.
- (1e) Propose ERM solutions or strategies that effectively manage risk under different real (case study) and hypothetical situations facing financial and non-financial organizations.
- (2c) Identify and analyze specific risks faced by an organization, including but not limited to: financial, environmental, operational, legal, reputational and strategic risks.
- (3f) Demonstrate an understanding of model and parameter risk.
- (6a) Demonstrate a conceptual understanding of economic measures of value and capital requirements (e.g., EVA, embedded value, economic capital, regulatory measures, and accounting measures) and their uses in decision-making processes

Sources:

Financial Enterprise Risk Management, Sweeting, 2017, Ch. 8 Risk Identification

Model Risk Management Practice Note

ERM-143-20: Internal Controls Toolkit by Christine H. Doxey, Chapter 1 pp.11-17, 27-35

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

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

3. Continued

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

ERM Exam Case Study

Commentary on Question:

The question focuses on the topic of model risk. The question is based entirely on the case study. -Big Ben Bank.-

Candidates received maximum points for being able to answer specific questions on model risk in the context of Big Bank as described in the case study.

Solution:

(a) Critique the proposed model governance process presented in the memo.

Commentary on Question:

To receive maximum points, candidates had to provide both positive and negative aspects of the overall model governance process at Big Bank.

Examples of possible statements. At least 4 statements were required to obtain maximum points.

Many candidates provided relevant comments. However, fewer related those comments to the specific context of the case study.

Potential Answer:

Objective of the review is too narrow: Focusing on the qualitative review of the model is a positive aspect. However, it could be expanded to include quantitative and other COSO ERM components - ex. intended purpose and consequences.

Risk-based control approach: The actual approach is only focused on a rating of High, Medium, and Low. Although it is a good base, it could be improved with a risk-based control approach - preventive, detective, corrective. - The business owners should participate in the review process to obtain their risk assessment of their models.

Riskiness of the models to be reviewed: There is some level of implied risk analysis done; however, it only focuses on models for financial reporting in order to be cost effective. There could evaluation of the riskiness of other models by exposure, impact, control.

3. Continued

Segregation of duties: The proposal is for an independent review from conception. It is OK but is not ideal and we could add more specific delegation authority for model changes.

Time horizon: There is consideration of the requirement of time. However, it is only done every three years. It is limited. An improvement would be to do a review for material changes to the model or business environment more frequently.

Overall governance of the model review features: There is a valid tone from the top as management will review material model changes and a proposed sign-off by management after model changes is required.

Documentation of the review process: There is a summary of controls, which is positive. However, it is focused on a limited set of controls, only those that are sufficient. It could be expanded.

Model Validation: There is no formal testing of the models results. We could add performance monitoring as well.

Use of formal risk identification techniques: The proposed review is qualitative, which is a good start. We could integrate other techniques: risk-based process, gap, brainstorming. etc.

- (b) As part of your engagement, you are asked to devise a detailed validation plan for Big Ben's Economic Capital model as described in Section 1.5 of the Case Study. Your proposed validation plan includes the following steps:

- Step 1: Planning phase
- Step 2: Review of model inputs
- Step 3: Review of the calculation engine
- Step 4: Review of model outputs

Recommend specific tasks for Big Ben for each of the steps shown above.

Commentary on Question:

To receive maximum points, candidates had to recommend specific tasks relevant to Big Bank for each step. As in the previous question, many candidates provided valid statements that are generic but fewer related to specific aspects of the situation at Big Bank as described in the case study.

3. Continued

Step 1: Planning phase: Some specific actions: set up goal and objectives, have kick-off meetings, plan steps, establish teams and contact persons, owners of models in all business groups.

Case study examples: There should be an explicit identification of the owners of models at the business level and overall. For example, for credit model, how does the EC model relate to the actual credit scoring of customers? Is Corporate treasury the only group that should be involved in the overall EC model as it impacts many areas of the organization?

Step 2: Review of model inputs: Obtain and review documentation, analyze data, verify, and validate assumptions, review product specifications.

Case study examples: Many assumptions are used in the credit and market risk models. There should be explicit validation of these assumptions with the sources of risk within each business unit from which the risk arises.

Step 3: Review of calculation engine: review testing done by owners, review code, replicate results, perform sensitivity testing, compare calculations to standards, if necessary, document findings.

Case study examples: There should be an explicit review of the stress tests used for the evaluation of strategic risks. Compare to previous experience, external cases.

Step 4: Review of model outputs: output, fitness of model results, compare results to actual reports, document findings.

Case study examples: There should be an explicit review of the output results, which is not undertaken. Ex. Allocation of EC to the business units is based on a simple rule of thumb. Big Ben uses frequency tests to validate models. This is somewhat limited. It seems to relate only to the review of the calculation engine, which is just one step in a total validation of models. There should be an explicit effort to document all the previous EC steps.

- (c) Big Ben has asked you for feedback on the Economic Capital model approach described in Section 1.5 of the Case Study. Management knows there are many improvements they could make, but they want to focus their efforts.
 - (i) Identify three areas where model risk could have the biggest impact on Big Ben's Economic Capital results. Justify your selections.
 - (ii) Assess the diversification benefit methodology and results in Big Ben's Economic Capital model.

3. Continued

Commentary on Question:

To receive maximum points, candidates had to answer these two questions as they relate to the situation at Big Ben Bank. Again, many candidates failed to relate their answer to the specific situation at Big Bank.

c(i)

Credit risk component: Credit risk is by far the largest component in the current EC model and given that it is based on a Monte Carlo simulation of systematic risk factors and correlations in a joint normal distribution, there is a lot of space for misestimations or errors in the credit risk model.

Since this risk is already large, a relatively minor change could lead to meaningfully higher losses from credit risk and therefore higher capital requirements.

It is also interesting to see that the credit risk is so stable in the tail. We're only seeing the worst 1.5% of scenarios, so the results could be reasonable, but the stability in the tail could also be a function of the use of a normal distribution when it should be a fat-tailed one. Additional testing and validation of the credit risk model is strongly recommended.

Market risk component: The tail risk of the market risk component has a lot of volatility. This leads to concern that the formulation of the model as a VaR measure instead of CTE or TailVaR is questionable and might significantly understate the tail risk and hence, economic capital. For example, the 99CTE for the market risk component is 364, but the VaR at the 99.5th percentile is only 223. This change is larger than the entirety of the operational or business risk components.

Diversification benefit: Credit and market risk are estimated independently and then aggregated using a variance-covariance matrix. By their own admission, Big Ben finds these correlations difficult to obtain and updates them infrequently.

There are two potential model risk issues embedded here that could impact economic capital. First, the uncertainty around the appropriate correlation assumptions means that the diversification benefit, which reduces overall required capital by more than 15%, could be uncertain, meaning economic capital would be understated or overstated. And secondly, the fact that the market and credit risk components are independent ignores the possibility that a combination market-credit event could cause larger losses than the sum of the VaR for each risk independently (which would be the largest value possible in this model if the correlation were 1 and the diversification benefit was zero). This is another factor potentially contributing to understated economic capital.

3. Continued

Mis-estimation for operational risk: Using a simple add-on model likely underestimates this risk as it doesn't consider operational risk present in the other risk categories.

Given that the credit and market risk appear to be driven by economic and market forces and are not a function of losses experienced by Big Ben in the past, a reasonable conclusion is that operational risk impacts on market and credit losses are being ignored, which is likely resulting in an underestimation of overall risk and insufficient economic capital.

It is difficult with the information given to quantify the impact of missing out on this aspect of operational risk, but past examples of company failures have almost invariably been linked to a negative event combined with an operational failure.

Lack of model validation: In Big Ben's writeup, they admit that the various component models of the EC calculation haven't been validated (validation is scheduled for next year) and the developers haven't completed the model documentation, including implementation and change management testing.

The EC results are incorporated in the financial reporting, but the models aren't documented, and no testing was done when they were implemented. This is a significant failure of model risk management that would raise red flags with auditors and examiners if it were known, and raise questions about appropriate levels of economic capital. Documentation and testing should be prioritized.

Other potential issues:

Liquidity risk is a huge risk for the banking industry and for Big Ben Bank. The economic capital model does not consider liquidity risk which could severely impact the economic capital results by understating economic capital. Liquidity risk should be included in the economic capital for Big Ben Bank.

Economic Capital Allocation to the Business. This is only done upon request and not updated regularly. Economic Capital should be allocated to each business line on a yearly basis. This will put a few constraints on management and incentivize them to use the capital available most effectively.

Demographic risk If the underlying mortality is set incorrectly, level risk is exposed and the financials will be skewed because of it. Similarly, trend risk can be exposed if future mortality does play out as projected. This assumption is usually found in the EC for ALM or as part of market risk. It could be determined more explicitly.

3. Continued

c(ii)

The diversification benefit would have to be questioned - ex .use of assumptions - particularly based on the existing model used. It is known that var/cov models are not appropriate for extreme events, a situation recognized by Big Ben themselves, resulting in some level of unknown model risk. Based on the existing numbers, it does represent a large component of the overall net EC values.

Additionally, the diversification methodology needs to be improved. Correlations are updated infrequently due to difficulty in obtaining correlations. This is inappropriate, especially given that the current diversification benefit appears to be rather volatile from year to year (-147 an EOY 2021 vs -114 at EOY 2022), as well as it being relatively large and helps reduce overall required capital sizably. 750M without div benefit vs 636M with div benefit.

A variance-covariance- matrix also only captures any linear dependence between risks and does not include any potential non-linear dependencies which a copula (that they suggest exploring) might successfully do. Increased tail-dependence would result in higher economic capital.

4. Learning Objectives:

3. The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.
4. The candidate will understand how the risks faced by an entity can be quantified and the use of metrics to measure risk.
5. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

Learning Outcomes:

- (3b) Demonstrate organization-wide risk aggregation techniques that illustrate the concept of risk diversification by incorporating the use of correlation.
- (4a) Determine risk exposures using common risk measures (e.g., VaR and TVaR) and compare the properties and limitations of such measures.
- (4b) Analyze quantitative financial and non-financial data using appropriate statistical methods to assist in quantifying risk.
- (5b) 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.
- (5c) Demonstrate the use of controls for retained and residual risks.

Sources:

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

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

Financial Enterprise Risk Management, Sweeting, 2017 Ch. 16 Responses to Risk

ERM-147-21: Working with Inherent and Residual Risk

ERM-119-14: Aggregation of risks and Allocation of Capital (Sections 4-7 Excluding 6.3)

Risk Appetite: Linkage with Strategic Planning Report

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

Article: Modeling Tail Behaviour with Extreme Value Theory, Risk Management, Sept 2009

4. Continued

ERM-104-12: Study Note on Parameter Risk, Venter and Sahasrabuddhe (Except Section 3)

ERM-145-21: IAA Paper: Importance of Climate-Related Risks for Actuaries (Pages 2-14)

Commentary on Question:

Commentary listed underneath question component.

Solution:

(a)

- (i) Calculate the following risk metrics for each segment and in total, gross and net of reinsurance
 - Relative VaR (99.6) assuming the data follows a normal distribution
 - Relative VaR (99.6) using the distribution implied by the simulation data
- (ii) Recommend the VaR risk metric in part (i) that would be most appropriate for these lines. Justify your response.
- (iii) Determine the following:
 - The business segment with the highest inherent risk
 - The business segment with the lowest residual risk

Justify your responses.

Commentary on Question:

Candidates performed generally well on parts (i) and (iii) but struggled with part (ii).

A common mistake in part (i) was calculation of total VaR, and not relative VaR including subtraction of the mean loss. There were multiple ways to approach the calculation from an Excel standpoint, including selecting the specific 99.6th percentile simulation as opposed to using a built-in function, for which credit was still given.

Those who did well in part (ii) recognized that simulated losses reflected significant tail risk for the Property Catastrophe line, and thus a normal distribution was not appropriate, despite the results being close on other lines.

4. Continued

In part (iii), some candidates lost points for discussing the highest residual risk, despite the question prompting for the lowest residual risk.

- (i) Refer to Excel template for solution.
 - (ii) Refer to Excel template for solution.
 - (iii) Refer to Excel template for solution.
- (b) CapitalSim models correlation between business segments using a Student's t copula. The CRO ask you to use Spearman's correlation and the simulation outputs to validate the results.
- (i) Calculate the Spearman's correlation for all 10,000 simulations of gross losses between each segment of business.
 - (ii) Determine which segments appear to be correlated with regard to gross loss using Spearman's correlation from part (i). Justify your response.

Commentary on Question:

Many candidates performed well and received credit on the correlation calculations in part (i) but not as many did enough to justify their responses in part (ii).

On the calculation, some candidates ran into issues if they sorted the data separately by coverage and then applied rank correlation incorrectly, which would result in non-sensical results such as perfect correlation between products.

In part (ii), more credit was given not just to point out which lines had the highest correlation but to note that other lines were uncorrelated. The best responses also justified the results by speaking to the nature of the products and why they might experience correlation, or lack thereof. The minority of candidates justified their responses enough to receive full credit.

- (i) Refer to Excel template for solution.
 - (ii) Refer to Excel template for solution.
- (c) Pryde's reinsurance treaties are coming up for renewal in three months and Ebony is concerned about the risks in the Property Catastrophe segment of business given the recent hurricane events and news about climate change.

4. Continued

You are given the following information:

- Pryde has Property Catastrophe reinsurance for aggregate losses for a year with retention of \$20M and limit of \$150M
 - Pryde's risk tolerance for property catastrophe risk is to have annual Property Catastrophe modeled net losses at VaR (99.6) to be less than 2% as a percentage of surplus
 - Pryde's 2024 projected statutory surplus is \$1,052,864,000.
- (i) Assess whether the property catastrophe risk exposure is within the risk tolerance.
- (ii) Recommend whether Pryde should increase its property catastrophe reinsurance retention. Justify your response.

Commentary on Question:

The large majority of candidates did well enough on the risk tolerance calculation to receive close to full credit. However, responses in the recommendation (part (ii)) were often lacking justification and thus did not receive as much credit. In many instances a recommendation was provided with little to no justification to support it.

- (i) Refer to Excel template for solution.
- (ii) Pryde should not increase the reinsurance retention. The current retention (\$20M) is close to the maximum retention before the tolerance would be breached (\$24M) and thus an increase would put Pryde even closer to the risk tolerance of 2%. Additionally, the recent trend in hurricane activity may suggest that the actual risk may be higher than indicated by the catastrophe models. Given that Ebony James is concerned about the recent activity and exposure, keeping the retention as is protects Pryde from increased activity and within the risk tolerance. Any unexpected reduction in future surplus could also cause a breach of the risk tolerance, even without increasing the current retention level.

5. Learning Objectives:

1. The candidate will understand the ERM framework and process and be able to apply them to organizations.
5. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

Learning Outcomes:

- (1c) Demonstrate how to articulate an organization's risk appetite, desired risk profile, quantified risk tolerances, risk philosophy and risk objectives.
- (1d) Assess the overall risk exposure arising from an organization's current and emerging risks.
- (5a) Demonstrate risk optimization and analyze the risk and return trade-offs that result from changes in the organization's risk profile.
- (5b) 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.
- (5f) 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 (excluding Appendices)

ERM-119-14: Aggregation of risks and Allocation of Capital (Sections 4-7 Excluding 6.3)

Embedding Cyber Risk in Risk Management: An Insurer's Perspective By Kailan Shang (pp.12 -15 of Cybersecurity: Impact on Insurance Business and Operations)

Commentary on Question:

This question tested the candidate's understanding of cyber risk and related mitigation strategies to either reduce the risk or transfer it. Candidates were also tested on their ability to quantify counterparty credit risk in the context of risk transfer. Candidates were then asked to make a recommendation to the ERM Committee through the lens of VaR reduction while also incorporating information from parts (a) and (b). Candidates performed reasonably well, but few received full credit.

5. Continued

Solution:

- (a) Your team's initial review of cyber risk finds that GAK's system security is not up to today's standards, leaving GAK vulnerable to data breaches and network outages. Your team has modeled GAK's potential cyber losses and has assessed annual VaR(99.6) at \$100 million dollars. To reduce the potential losses, your team has presented two strategies:

Strategy A - Educate GAK's workforce on hacking and phishing attempts, while improving its cyber security and controls on sensitive data. The estimated cost of this strategy is \$8M-\$10M in aggregate over the first two years and \$1M annually thereafter for maintenance.

Strategy B - Purchase a cyber insurance policy that covers both data breaches and network outages. Annual premium for these policies ranges from \$3M-\$4M and depends on GAK's current security standards, the deductible for each incident, and the coverage limit for the policy. The policy could be put in place almost immediately.

Describe two advantages and two disadvantages for each of the strategies.

Commentary on Question:

Candidates performed reasonably well on part (a). Most were able to list two advantages and disadvantages for each strategy, but very few candidates received full credit since the question asked to "describe" two of each. Many candidates listed brief bullets when the Guide to SOA Exams states, "A description is not a list; each item needs supporting information." The syllabus reading, Embedding Cyber Risk in Risk Management: An Insurer's Perspective, included clear advantages and disadvantages of each strategy, but any reasonable answer could receive credit as long as it was properly described and the relevance was made clear.

Strategy A has the advantage of being a known, established mitigation technique for helping employees understand the sources and formats of cyber attacks, detect the existence of these attacks, follow precautionary procedures and be able to take timely actions to mitigate their impact. Another advantage of Strategy A is it is proactive. Like other operational risks, proactive management is important to ensure a company's cyber risk tolerance level is not exceeded and Strategy A is an effective way to permanently reduce cyber risk.

Strategy A has the disadvantage of being slow to implement, so it will take some time to effectively reduce GAK's cyber risk and hence, VaR. Another disadvantage of Strategy A is that it has a high upfront cost, which could be spent on more direct or efficient risk mitigation strategies.

5. Continued

Strategy B has the advantage that cyber insurance is an established and effective strategy for transferring severe impact of cyber risk events to a counterparty. Even with heavy investment in technology, training and active risk monitoring, unexpected cyber risk events can still happen, and cyber insurance adds an extra layer of protection to cover unexpected losses. Another advantage of Strategy B is that it is relatively efficient when compared to Strategy A, since the risk mitigation is immediate.

Strategy B has the disadvantage however, of introducing moral hazard. If financial impacts are covered by an insurance policy, GAK has less incentive to improve internal controls. Another disadvantage of Strategy B is the introduction of counterparty credit risk with the transfer of large loss amounts. The insurer's ability to pay the promised benefits needs to be assessed since cyber events can affect many companies and personal users at the same time.

- (b) You've decided to recommend a blend of Strategies A and B to the ERM committee. You have identified a cost-effective pool of insurers to provide this coverage. The pool of insurers would provide a total of \$60M of coverage. Their ratings are listed below.

Reinsurer	Coverage provided in cyber event	Credit Rating
Insurer Blue	\$10M	Ba
Insurer Green	\$20M	B
Insurer Red	\$30M	Caa

The ERM Committee is concerned that the selected insurers do not meet GAK's internal counterparty credit risk standards.

You have the following table from Kelly Rating Agency:

Rating	Annual Default Rate	Recovery on Default
Aaa	0.01%	25%
Aa	0.03%	25%
A	0.06%	25%
Baa	0.14%	25%
Ba	0.82%	20%
B	3.16%	15%
Caa	11.40%	10%

5. Continued

- (i) Calculate the cumulative default rate over 5 years for each insurer using the annual default rates shown above. Assume no rating transitions for simplicity.

The ERM Committee is also concerned about collectability if a cyber event occurs. They ask you to assess the expected losses in the following scenario:

Assume that a cyber event occurs at the full coverage limit and the three insurers each owe GAK their full coverage amounts.

- (ii) Calculate GAK's expected credit loss for this cyber event scenario. Assume a one-year default rate for simplicity

Commentary on Question:

Candidates generally performed very well on part (b) with many candidates receiving full credit. Multiple approaches were possible and full credit was awarded to any method used to arrive at the correct answer. Candidates that provided a single, incorrect calculation with no explanation were awarded little to no credit.

See Excel Document

- (c) GAK has decided to accept your recommendation and move forward with a combination of Strategies A and B.

Your modeling shows that Strategy A would reduce the cyber VaR(99.6) by \$25M. GAK would like to use insurance to reduce the VaR by an additional \$50M to come down to GAK's enterprise risk tolerance level.

To estimate the reduction in VaR provided by the insurance, assume the VaR decreases by the amount paid by the pool net of defaults and deductibles in a \$60M loss event.

GAK is considering three alternative deductible structures that the group of insurers have proposed:

Deductible	Annual Cost
\$0 per event	\$4.0M
\$5M per event	\$3.5M
\$10M per event	\$3.0M

You have been given a total budget of \$30M over five years to achieve the implementation of both Strategies A and B.

5. Continued

Recommend a deductible structure to the ERM Committee using all information provided and your responses from parts a and b. Justify your response.

Commentary on Question:

Candidates generally performed poorly on part (c) and very few received full credit. The directions stated to use all information and responses from parts a and b. Several candidates focused only on the information in part c to form their recommendation. Some candidates failed to mention either the \$30M budget or \$50M VaR reduction in their recommendation. Many candidates also failed to provide a clear recommendation and instead listed pros and cons of each deductible choice. Although only one deductible satisfied all of the decision-making constraints to be considered, other recommendations could receive partial or close to full credit depending on the support provided for the candidate's recommendation.

I recommend the \$5M per event deductible to the Committee. The Committee has provided a budget of \$30M over five years to fund both strategies A and B. Based on the information provided, assume the highest cost of strategy A will be \$13 million, \$10 million in the first two years, and \$1 million per year thereafter. Thus, \$17 million remains for strategy B. Since the question states that the VaR decreases by the amount paid by the pool, net of defaults and deductibles, a risk event of \$60 million in losses will have \$3.7 million of credit losses (answer from part b) netted against it. The resulting payment would be roughly \$56.3 million, prior to accounting for the deductible. The \$5 million deductible would also be netted, resulting in a total VaR decrease of \$51.3 million in a \$60M loss event. The goal of reducing the VaR by an additional \$50M would therefore be achieved. The annual cost would be \$3.5M per year, or \$17.5 million over 5 years which puts total cost for both strategies \$0.5M over the budget if Strategy A runs at its highest cost. The recommended \$5M deductible will thus satisfy both the VaR and budget constraints. The \$0 deductible will reduce the VaR even further, but will exceed the budget by \$3M or 10% which is likely undesirable. The \$10M deductible would keep costs \$2M below budget, but will fail to reduce the VaR by the targeted amount.

6. Learning Objectives:

1. The candidate will understand the ERM framework and process and be able to apply them to organizations.
3. The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.
5. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.
6. The candidate will understand the concept of economic capital, risk measures in capital assessment and techniques to allocate the cost of risks within business units.

Learning Outcomes:

- (1a) Recommend an appropriate framework for an organization's enterprise risk management and an acceptable governance structure.
- (1b) Demonstrate an understanding of the perspectives of regulators, rating agencies, stock analysts, auditors and company stakeholders and how they evaluate the risks and the risk management of an organization.
- (3b) Demonstrate organization-wide risk aggregation techniques that illustrate the concept of risk diversification by incorporating the use of correlation.
- (5i) Choose appropriate techniques to measure, model and manage various financial and non-financial risks faced by an organization.
- (6a) Demonstrate a conceptual understanding of economic measures of value and capital requirements (e.g., EVA, embedded value, economic capital, regulatory measures, and accounting measures) and their uses in decision-making processes

Sources:

ERM-137-20: ORSA and the Regulator by American Academy of Actuaries

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

ERM-153-23: Regulatory Capital Adequacy for Life Insurance Companies: A Comparison of Four Jurisdictions (Excluding Appendices)

ERM-135-20: Risk Management and the Rating Process for Insurance Companies by A.M. Best

ERM-119-14: Aggregation of risks and Allocation of Capital (Sections 4-7 Excluding 6.3)

6. Continued

Commentary on Question:

The question was designed to assess a candidate's understanding of ORSA and RBC capital adequacy requirements. After comparing the two and calculating the diversification benefits, candidates had the opportunity to demonstrate their knowledge by recommending and justifying a method appropriate for DEF.

Solution:

- (a) You explain that an ORSA starts with a description of the company's risk management framework.

Describe four characteristics of a risk culture that DEF could adopt, which AM Best would consider strong.

Commentary on Question:

Candidates who described each characteristic earned substantially more credit than those candidates who merely listed the characteristics. Candidates received credit for relevant responses that were outlined in the AM Best material. Responses that were not specific to risk culture did not receive credit.

- Senior management has a thorough understanding and is supportive of the risk culture.
 - There is a separate ERM department with a dedicated Chief Risk Officer.
 - Management's incentive compensation is tied to goals and objectives that are consistent with the risk culture.
- (b) You explain that Section 3 of an ORSA includes an assessment of risk capital. The CEO points out that DEF already calculates risk capital under NAIC Risk Based Capital (RBC).

Compare and contrast how capital adequacy is analyzed as part of an ORSA versus RBC.

Commentary on Question:

Most candidates did not identify any similarities between ORSA and RBC. Candidates who noted how they were different performed better than those candidates that simply listed key features.

- ORSA is calculated at Group Level whereas RBC is calculated at the company level
- ORSA is model based, whereas RBC is factor based
- ORSA is a prospective view, where is RBC is calculated at a point in time
- Both are regulatory requirements for most large companies
- Both attempt to identify how much capital a company should hold to prevent insolvency

6. Continued

- (c) You are discussing with the CEO possible assumptions for aggregating risks. The CEO would like you to consider both the diversification method used by the RBC formula and the Correlation Matrix method.

DEF has computed risk capital using the RBC method for the following risk components:

Risk Components	Values in \$millions
C1o Asset Risk – other	150
C2 Insurance Risk	30
C3a Interest Rate Risk	85
C3c Market Risk	20
C4a Business Risk	15

A consultant has suggested the risk correlation matrix shown below as appropriate for a company of DEF's size and type.

	Asset Risk Other	Insurance Risk	Interest Rate Risk	Market Risk	Business Risk
Asset Risk Other	1.00	0.50	0.80	0.70	0.50
Insurance Risk	0.50	1.00	0.50	0.50	0.20
Interest Rate Risk	0.80	0.50	1.00	0.50	0.90
Market Risk	0.70	0.50	0.50	1.00	0.80
Business Risk	0.50	0.20	0.90	0.80	1.00

- (i) Compute the diversification benefit for these risks under the RBC method (Authorized Control Level).

The response for this part is to be provided in the Excel spreadsheet.

- (ii) Compute the diversification benefit for these risks under the Correlation Matrix method.

The response for this part is to be provided in the Excel spreadsheet.

- (iii) Recommend which of these methods should be used to compute the diversification benefit for DEF's ORSA report. Justify your response.

6. Continued

Commentary on Question:

Partial credit was given in part (i) where candidates had the formula structure correct but had the incorrect components. Candidates did receive credit for their diversification calculations regardless of their solutions to the Authorized Control Level RBC and Total Risk using Correlation Matrix answers.

In part (iii), most candidates recommended the correlation matrix. Given what we know about DEF, the stronger response was to recommend the RBC approach. Either recommendation received credit so long as it was properly justified.

iii) The recommendation is to use the RBC approach when computing the diversification benefit for DEF's ORSA report.

ORSA suggests that you measure solvency the way you manage your business which would be consistent with the RBC approach.

The RBC approach is already computed, and management is familiar with measurement. Whereas the correlation matrix requires effort to compute and maintain.