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**SOCIETY OF ACTUARIES**  
**Enterprise Risk Management – Investment Extension**

**Exam ERM-INV**

**Date:** Tuesday, November 1, 2016

**Time:** 8:30 a.m. – 12:45 p.m.

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**INSTRUCTIONS TO CANDIDATES**

**General Instructions**

1. This examination has a total of 80 points.

This exam consists of 8 questions, numbered 1 through 8.

The points for each question are indicated at the beginning of the question. Questions 7 and 8 pertain to the extension readings and/or the Case Study, which is enclosed inside the front cover of this exam booklet.

2. Failure to stop writing after time is called will result in the disqualification of your answers or further disciplinary action.
3. While every attempt is made to avoid defective questions, sometimes they do occur. If you believe a question is defective, the supervisor or proctor cannot give you any guidance beyond the instructions on the exam booklet.

**Written-Answer Instructions**

1. Write your candidate number at the top of each sheet. Your name must not appear.
2. Write on only one side of a sheet. Start each question on a fresh sheet. On each sheet, write the number of the question that you are answering. Do not answer more than one question on a single sheet.
3. The answer should be confined to the question as set.
4. When you are asked to calculate, show all your work including any applicable formulas.
5. When you finish, insert all your written-answer sheets into the Essay Answer Envelope. Be sure to hand in all your answer sheets because they cannot be accepted later. Seal the envelope and write your candidate number in the space provided on the outside of the envelope. Check the appropriate box to indicate Exam ERM-INV.
6. Be sure your written-answer envelope is signed because if it is not, your examination will not be graded.

Tournez le cahier d'examen pour la version française.



## **CASE STUDY INSTRUCTIONS**

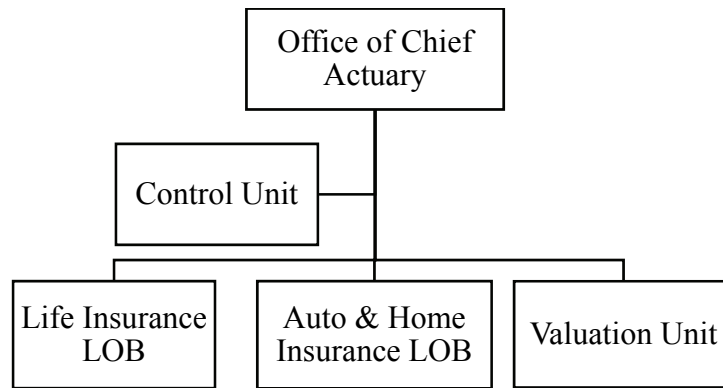
**The case study will be used as a basis for some examination questions. Be sure to answer the question asked by referring to the case study. For example, when asked for advantages of a particular plan design to a company referenced in the case study, your response should be limited to that company. Other advantages should not be listed, as they are extraneous to the question and will result in no additional credit. Further, if they conflict with the applicable advantages, no credit will be given.**

**\*\*BEGINNING OF EXAMINATION\*\***

**1.** (7 points) You are a Risk Management actuary for ABC, a multi-line life insurance company with both life and annuity business. ABC is acquiring XYZ which has two lines of business (LOB):

- Life insurance
- Auto and homeowner's insurance

You have gathered the following information about XYZ's risk management structure before the acquisition:



- Each LOB is responsible for its own product pricing, assumptions setting and profit projections.
- Valuation Unit calculates reserves using pricing assumptions provided by LOBs.
- Control Unit calculates Economic Capital based on the pricing model and assumptions.
- Control Unit also conducts periodic reviews of LOBs and Valuation Unit which are provided to Chief Actuary.

(a) (3 points) ABC considers adoption of the three lines of defense approach as the risk governance and internal controls system.

- (i) Compare XYZ's risk management structure to the three lines of defense framework.
- (ii) Recommend improvements to enhance risk governance.

**1. Continued**

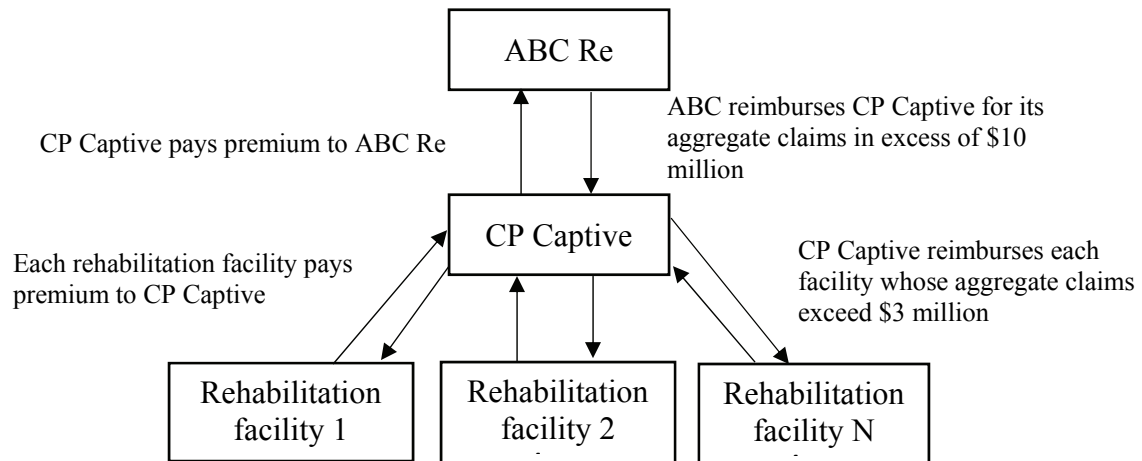
- (b) (2 points) Assess XYZ's existing Economic Capital modeling considerations in light of the acquisition.
- (c) (2 points) You prepared the Own Risk and Solvency Assessment (ORSA) for ABC before the acquisition.

Describe the potential issues, excluding XYZ's Economic Capital modeling considerations from part (b), to address when preparing the ORSA for the combined company after the acquisition.

2. (13 points) You are the CRO of ABC Re, a U.S. group benefits reinsurance company that assumes medical stop-loss business.

A group of rehabilitation facilities has formed a captive insurance company, CP Captive. CP Captive enables each facility to participate in the collective experience. CP Captive is a large enough group to apply for stop-loss coverage.

The chart below illustrates the reinsurance arrangement.



- (a) (4 points)
- Describe the essential elements of captive insurance.
  - Determine whether CP Captive qualifies as a captive insurance company. Justify your response.
  - Determine what type of captive CP Captive most resembles. Justify your response.

## 2. Continued

(b) (4 points) You identified the following top four risks for ABC Re in this captive arrangement:

- Reinsurance treaty negotiation
- Insurance
- Legal and regulatory
- Operational

Describe approaches for ABC Re to manage each of these risks.

(c) (5 points) As a means to manage capital efficiently, ABC Re proposes ceding a portion of the assumed risks from CP Captive to an offshore affiliate in the Cayman Islands called Retro Life.

- (i) Describe key advantages and disadvantages of entering into a reinsurance agreement between ABC Re and Retro Life.
- (ii) Recommend a course of action with regard to this proposal. Justify your response.

- 3.** (12 points) DirectComp is an insurer that sells an annuity product with benefits linked to the S&P 500 index. The product has a very long liability-duration profile. Premiums are collected in the first two policy years, and most benefit payments occur after fifteen years.

DirectComp's economic reserve is calculated using the CTE70 measure of the accumulated deficiency via Monte Carlo simulation. The accumulated deficiency is defined as present value of future benefits minus present value of future premiums.

In 2006, DirectComp and Reinsurer entered into a 90% quota share coinsurance agreement whereby the Reinsurer would receive the annuity premiums from DirectComp and pay benefits when they occur. In addition, the Reinsurer was required to hold collateral equal to DirectComp's economic reserve in a trust account.

- (a) (1 point) Describe the steps to compute DirectComp's economic reserve requirement using Monte Carlo simulation.
- (b) (2 points) Explain the advantages and disadvantages of using Monte Carlo simulation to determine DirectComp's economic reserve.
- (c) (1 point) Determine whether a risk-neutral or real world model is more appropriate when performing DirectComp's economic reserve calculation. Justify your response.



### 3. Continued

- (d) (5 points) In 2016, Reinsurer is performing a retrospective analysis of this reinsurance arrangement as a case study.

At pricing (in 2006), DirectComp conducted the following stress test for Reinsurer and showed that the biggest increase in CTE70 was 25%, which Reinsurer considered to be within its tolerance.

Account Value Shock	CTE70 (Million)	% of Baseline
Baseline	100	
-10%	104	104%
-20%	110	110%
-30%	125	125%

When it received the 2008 annual reinsurance report in early 2009, Reinsurer observed that its collateral asset requirement had increased by 80% during the 2008 financial crisis.

- (i) Analyze the adequacy of the provided stress test.
- (ii) Evaluate whether the collateral asset increase is reasonable.
- (iii) Identify the risks DirectComp is exposed to from the reinsurance arrangement.
- (iv) Recommend actions DirectComp could have taken in advance to mitigate risks from the reinsurance arrangement that you identified in (iii).

*Question 3 continued on next page*

### 3. Continued

- (e) (3 points) Following the increase in the collateral requirement in 2009, Reinsurer became skeptical about the reserve amount quoted by DirectComp and requested annual validation of the model DirectComp uses to calculate the reserve.

The following steps were taken by DirectComp to complete the annual model validation:

- DirectComp’s chief actuary assigned the writing of the report for Reinsurer to the department that developed the model.
  - The annual validation report was included in the department’s “critical date” list so that whoever could work it into his/her work load around the time it was due would complete the task.
  - The report writer worked from audit reports, results of tests that were run to check on certain calculations performed in the model, or any other existing documentation that had been created throughout the year.
- (i) Evaluate the adherence of DirectComp’s model validation process to key model validation principles.
- (ii) Recommend any changes or enhancements that DirectComp should make to this process.

4. (8 points) You are a portfolio manager and are responsible for making investment decisions on behalf of one of your company's biggest clients – Mr. Jackson. Mr. Jackson currently has \$5 million invested entirely in Fund A and he wishes to invest an additional \$3 million into either Fund B or Fund C in order to reduce portfolio volatility. Characteristics for each fund are listed in the table below.

Fund	Fund Variance	Correlation Coefficient – Relative to Fund A
A	1.00%	1.0
B	4.00%	-0.3
C	2.25%	-0.2

- (a) (2 points) Demonstrate that investing the \$3 million in Fund C results in a lower 95% VaR for the aggregate portfolio than investing in Fund B. Show your work.

Mr. Jackson's aggregate portfolio now includes \$5 million in Fund A and \$3 million in Fund C.

- (b) (1 point) Calculate the diversification benefit for Mr. Jackson's aggregate portfolio.
- (c) (1 point) Describe two factors, besides the diversification effect, that an investor should consider when adding funds to a portfolio.
- (d) (4 points) At the end of the following month, Mr. Jackson plans on making an additional contribution in the amount of \$100,000 to either Fund A or Fund C.
- (i) Calculate  $\beta$  for each of these two funds before the additional contribution.
  - (ii) Estimate, for each of the two funds, the marginal impact to the 95% VaR of investing \$100,000.
  - (iii) Discuss the limitations of using the calculated  $\beta$  to estimate marginal VaR.
  - (iv) Recommend an alternative method to estimate marginal VaR .

5. (11 points) Bank XYZ is concerned about its vulnerability to losses due to cyberliability risk. Such losses may result from fraud, settlement with account owners, or government fines after a hacking event.

You are developing a model for quantifying cyberliability risk for Bank XYZ. Below is a table of losses for known hacking events at companies of similar size over the past five years. All these cyber loss events were reported in major news media when they occurred.

Company Hacked	Loss Amount from Individual Hacking Event Millions of \$
A	45
A	276
B	102
C	330
C	700
D	19
E	557

- (a) (3 points)
- (i) Describe challenges that you would encounter in developing a cyberliability risk model for Bank XYZ.
  - (ii) Explain how you would address these challenges.

You decide to model the cyberliability loss distribution using a two-parameter generalized Pareto distribution as below:

$$F(x) = 1 - \left( 1 + \xi \frac{x-u}{\beta} \right)^{-\frac{1}{\xi}}, x \geq u$$

## 5. Continued

- (b) (1 point) Explain why this distribution may be appropriate for fitting these data.
- (c) (1 point) Explain the considerations in setting the threshold parameter.

Assume:

- The threshold has been set at \$100 million
- The probability of exceeding the threshold is 5%
- Shape parameter equals 1
- The most extreme data point falls between the 98<sup>th</sup> and 99.5<sup>th</sup> percentiles of the full loss distribution.

- (d) (5 points)
- (i) Calculate the range for beta under these assumptions. Show your work.
- (ii) Calculate the range for the 99<sup>th</sup> percentile of the loss distribution under these assumptions. Show your work.
- (e) (1 point) Recommend two methods to validate inputs for the cyberliability model.

**6.** (9 points) You work as a financial analyst for ABC. During a recent review, one rating agency expressed concern over increased exposure to credit risk due to the prevalence of below investment grade bonds in the company's investment portfolio.

- (a) (1 point) Describe three components of credit risk.
- (b) (1 point) Your manager states that because VaR and CTE are used extensively in ABC's risk management activities, these are appropriate risk measures for credit risk analysis.

Critique your manager's statement.

(c) (2 points) The CFO recommends that ABC establish a special purpose vehicle (SPV) into which many of the below investment grade bonds would be transferred. The CFO claims that this arrangement would move these risks off ABC's balance sheet.

- (i) Explain bankruptcy remoteness and off-balance sheet accounting as they relate to the CFO's proposal.
- (ii) Recommend alternatives for managing ABC's credit risk.

(d) (3 points) The CFO has provided the following details:

- ABC is subject to IFRS rules.
- The SPV would be established as a U.S. limited liability corporation.
- The SPV would only act on behalf of ABC.
- ABC would be the sole investor in the SPV.

The CFO doesn't want the SPV to be considered "controlled" under IFRS.

- (i) Describe the term "controlled" in the context of SPV accounting under IFRS
- (ii) Explain why the SPV is considered "controlled" under IFRS
- (iii) Propose changes to the SPV so that it will not be considered "controlled" under IFRS.
- (e) (2 points) The CFO states that an SPV will address the concerns expressed by the rating agency.

Critique this statement.

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**Questions 7 and 8 pertain to the Case Study and/or extension readings.  
Each question should be answered independently.**

- 7.** (9 points) Plan contributions and strong investment performance of the assets backing SLIC's Defined Benefit Pension Plan (DB Plan) have greatly improved the Plan's funded status since the 2015 valuation report. You have been asked to analyze the current interest rate risk exposure of the DB Plan and to investigate strategies to minimize this risk.

You have summarized the Plan's asset portfolio into three asset classes. Plan asset and liability profiles are as follows:

	Market Value (\$000s)	Duration	Key Rate Durations (KRD)		
			KRD Short	KRD Mid	KRD Long
Plan Total Liabilities	736,325	10.00	0.57	4.41	5.02
Equity	461,600	0	0	0	0
Bonds	302,100	17.46	0.14	6.47	10.85
Other Assets	10,900	3.63	0.44	2.05	1.14

- (a) (1 point) Calculate the overall duration and key rate durations of the asset portfolio.
- (b) (2.5 points) You are assessing the plan's interest rate exposures on a key rate 100 (KR100) basis, measuring the dollar value impact of a 100 bp shift in the key rate.

Calculate the dollar durations for each key rate and the overall dollar-duration exposure of the DB Plan surplus. Show your work.



## 7. Continued

- (c) (2 points) The pension plan decides to enter into an interest rate swap to hedge against the duration mismatch. Consider a 30-year interest rate swap with a duration of 25.
- (i) Determine whether the Plan should be the receive-fixed or the receive-floating party and state why.
- (ii) Calculate the notional principal of the swap that would hedge the Plan's interest rate risk. Show your work.
- (d) (2.5 points) You want to test the effect of a non-parallel yield curve shift. The swap has the following KRD profile:

	Duration	KRD Short	KRD Mid	KRD Long
30-Year Swap	25.00	3.50	5.60	15.90

Consider the following yield curve shift impact on the Plan liabilities and asset portfolio including the interest rate swap:

Short-term: +10 bps  
Mid-term: -70 bps  
Long-term: +50 bps

- (i) Determine the impact on the Plan's surplus. Show your work.
- (ii) Explain whether this hedge meets the Plan's objective of minimizing interest rate risk.
- (e) (1 point) Recommend and justify an approach to more effectively mitigate the interest rate risk of the DB Plan.

**Questions 7 and 8 pertain to the Case Study and/or extension readings.  
Each question should be answered independently.**

**8.** (11 points) You are an Investment Actuary at SLIC. The VP, HR recently attended a Pension Investor conference. She learned that several insurance company pension plans are making the following substantive changes to their investment strategies:

- A significant reduction in the overall allocation to Equity
- A significant increase in the sub-allocation to Global Equity within the Equity allocation

You have been asked to investigate and report whether SLIC’s Pension Committee should also make either or both of these changes to the asset allocation strategy of its Defined Benefit Pension Plan (DB Plan).

You start by performing an asset allocation analysis using a simple two-asset portfolio and a liability index, based on the following assumptions:

	Expected Return	Volatility	Duration	Correlation		
				US Equity Index	US Long Bond Index	Liability Index
US Equity Index	6.00%	15.00%	0	1.00	0.20	0.20
US Long Bond Index	3.50%	7.00%	9	0.20	1.00	0.98
Liability Index	3.70%	8.03%	10	0.20	0.98	1.00

Using this data and a static one-year risk-adjusted change in surplus (RACS) framework, you analyze results for three hypothetical DB Plans at three different funding ratio levels – exactly funded, underfunded, and overfunded.

## 8. Continued

You explain to the Pension Committee that, under the RACS framework, the surplus risk is minimized when the equity allocation,  $\alpha$ , in this two-asset portfolio equals:

$$\frac{\left(1 - \beta \frac{L_t}{A_t}\right) (\sigma_B^2 - \rho \sigma_B \sigma_E)}{\sigma_E^2 + \sigma_B^2 - 2\rho \sigma_B \sigma_E}$$

You calculate the equity allocation that minimizes surplus risk for each of your hypothetical Plans A, B, and C to be:

	Equity Allocation
Plan A	3.1%
Plan B	-1.3%
Plan C	-3.7%

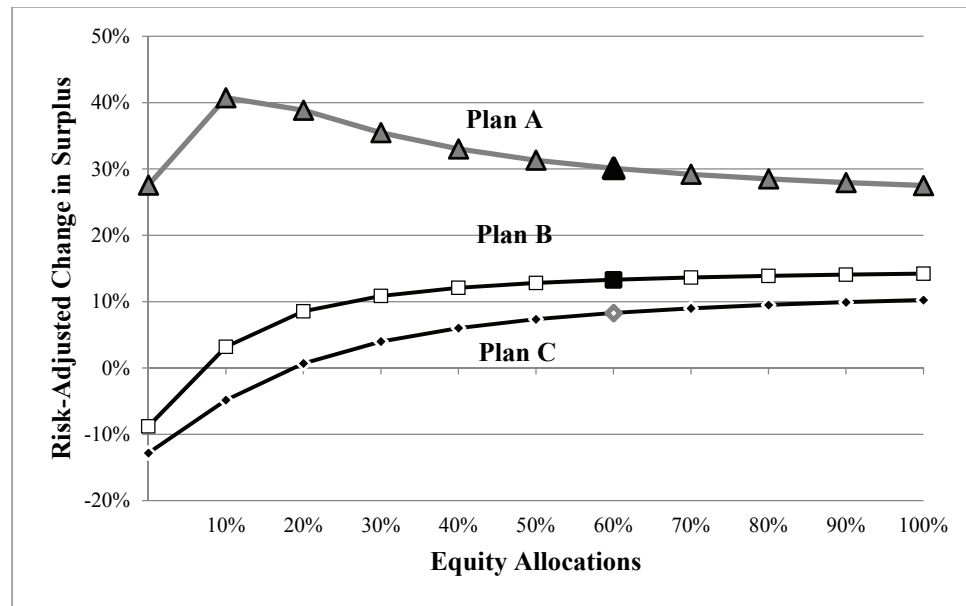
- (a) (3 points)
- Classify each hypothetical Plan A, B, and C as exactly funded, underfunded, or overfunded. Show your work.
  - Identify and explain which of the three hypothetical Plans most resembles SLIC's DB Plan.

*Question 8 continued on next page*

## 8. Continued

You plot the 1-year RACS across varying equity allocations for each of the three hypothetical DB Plans.

Assume that each Plan currently has a 60% allocation to equity.



The graph shows that RACS will improve:

- with a reduction in equity allocation for Plan A
- with an increase in equity allocation for Plan B and Plan C

(b) (2 points)

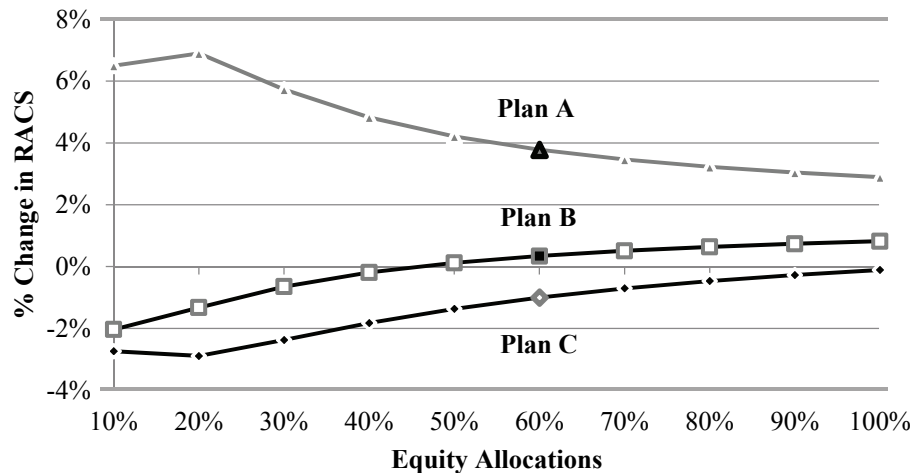
- Explain the 1-year static RACS measure to the Committee.
- Explain the reasons leading to the relationship between RACS and the equity allocations for Plan A and Plan C.

Next you assess investing the Plan's entire equity allocation in Global Equity instead of U.S. Equity using your simple two-asset portfolio. The assumptions using a Global Equity Index compared to a U.S. Equity Index are as follow:

	Expected Return	Volatility	Correlation	
			U.S. Long Bond Index	Liability Index
U.S. Equity Index	6.0%	15.0%	0.20	0.20
Global Equity Index	6.0%	14.0%	0.05	0.10

## 8. Continued

The percentage change in RACS in moving to Global Equity from U.S. Equity at each equity allocation level for each of your hypothetical Plans A, B, and C plots as follows:



You observe:

- For Plan A, RACS improves for all allocation levels to Global Equity, and improves more as the allocation to Global Equity is reduced.
  - For Plan C, RACS deteriorates for all allocation levels to Global Equity, and deteriorates less as the allocation to Global Equity increases.
- (c) (3 points) Explain the reasons leading to the relationship between the change in RACS in moving to Global Equity and the equity allocation levels for Plan A and Plan C.
- (d) (3 points) Conclude whether or not SLIC should modify its asset allocation strategy with respect to each of the two proposed changes in investment strategy that you have considered, using your RACS analysis. Justify your response.

**\*\*END OF EXAMINATION\*\***

**USE THIS PAGE FOR YOUR SCRATCH WORK**