
SOCIETY OF ACTUARIES
Enterprise Risk Management – Investment Extension

Exam ERM-INV

Date: Thursday, May 1, 2014

Time: 8:30 a.m. – 12:45 p.m.

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 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.** (9 points) The new CRO of Bayou National Investment Bank is reviewing the operational risks of the bank. You are a CERA on the team helping with this review.

Improper conduct by some investment bankers has resulted in government fines, shareholder lawsuits and lost business for their banks. In reaction to these developments Bayou instituted new internal controls a few years ago, designed to manage employee conduct.

The CRO wants to evaluate these operational risks in more depth. She specifically wants to assess the impact of operational risk on the bank's economic capital (EC).

EC is computed using an internal model and set using a VaR measure. The EC team develops scenarios based on prior internal events and survey data from competitor banks.

- (a) (2 points) Identify which shortcomings of VaR affect its use when determining EC for operational risk. Explain your answer.
- (b) (3 points) You are tasked with assessing whether the data used for these EC calculations is compliant with ASOP 23.
- (i) List three considerations the team should apply from the ASOP when selecting data.
- (ii) Explain the challenges involved in calculating EC for operational risk with the current data.
- (c) (1 point) The team has developed two preliminary estimates of the operational risk component of VaR, with the following results:
- Estimate 1: VaR = \$210 million with a 95% confidence band of \$50 million.
 - Estimate 2: VaR = \$250 million with a 95% confidence band of \$10 million.

Explain how estimation error affects how these estimates of VaR are interpreted.

- (d) (3 points) The team uses the quantile approach to calculate the estimation error in the operational risk component of VaR.
- (i) Explain an alternative approach for calculating the estimation error.
- (ii) Explain the advantages and disadvantages of these two approaches.
- (iii) Recommend to the CRO whether the alternative approach should be used instead of the quantile approach. Justify your response.

2. (10 points) You are an actuary for Biersch Corporation, a US-based property and casualty company that sells homeowners insurance primarily in the Midwest US.

The catastrophe modeling team developed a distribution of annual tornado-related losses based on historic tornado loss activity that was adjusted to be consistent with Biersch's current exposure. Based on the team's distribution, the table below shows the:

- Estimated number of times (out of 100) in which annual losses are expected to exceed several possible thresholds, and
- Corresponding scale and shape parameters of the Generalized Pareto Distribution (GPD) at each possible threshold.

Threshold Candidates: Associated Tails and GPD Parameter Estimates

Annual Losses (in millions \$)	Number of Annual Losses Exceeding Threshold	Scale Parameter	Shape Parameter
716	14	0.05	10.5
819	12	0.04	10.3
910	8	0.03	10.0
1,312	4	0.03	10.0
2,189	1	0.03	10.2

- (a) (1 point) Define Extreme Value Theory (EVT) and explain its purpose in statistics and modeling.
- (b) (3 points) You have been asked to recommend a threshold level based on the table above in order to fit an EVT distribution.
- Explain the tradeoffs, in general, of choosing among the possible threshold levels.
 - Recommend a threshold level for Biersch. Justify your choice.

The catastrophe modeling team decides to set the threshold at \$910 million. Given this threshold, the Chief Risk Officer (CRO) calculates that the probability of annual losses exceeding \$1 billion at least once over the next 30 years is 16%. She questions whether the estimated EVT distribution is producing reasonable results. She has asked you to review the modeling approach and provide additional analysis.

2. Continued

- (c) (5 points)
- (i) Demonstrate that the CRO's calculation of the 16% probability is correct based on the selection of the \$910 million threshold. Show your calculations.
 - (ii) Explain whether or not the 16% probability that losses will exceed \$1 billion at least once over the next 30 years is reasonable.
 - (iii) Explain the limitations of the current modeling framework, assumptions and data.
- (d) (1 point) Propose additional analyses to supplement the EVT analysis performed above.

3. (11 points) Jambalaya Life Insurance Company has two major lines of business (LOBs).

- The primary risk for LOB A is mortality risk
- The primary risk for LOB B is longevity risk

You are a newly hired actuary responsible for calculating Economic Capital (EC) for insurance risk for both LOBs. Currently the EC for insurance risk is calculated using the fixed diversification percentage method with a diversification factor of 40%.

You are given the following for your EC calculation:

	Expected Net Cash Outflow	Standard Deviation
LOB A	100 million	20 million
LOB B	120 million	16 million

- (a) (1 point) Explain why the risks for these two LOB's may not perfectly offset each other.
- (b) (2 points) Each LOB derives its required EC at VaR(99.5%).

Calculate the EC for the combined LOBs using the fixed diversification percentage method. Show your work.

The 40% fixed percentage was based on industry averages when it was originally set. You are concerned that this percentage may be dated and that the fixed diversification percentage methodology may be overly simplistic.

In order to evaluate the 40% factor, you decide to apply the variance-covariance methodology.

To develop the correlation coefficient, you shock mortality rates for both LOBs to simulate Expected Net Cash Outflows (ECF). You calculate the following values from the simulation runs:

$$E[ECF(LOB_A) \times ECF(LOB_B)] = 11,860$$

$$E[ECF(LOB_A)] = 100.8$$

$$E[ECF(LOB_B)] = 118.8$$

$$StdDev[ECF(LOB_A)] = 22.3$$

$$StdDev[ECF(LOB_B)] = 16.3$$

3. Continued

- (c) (1.5 points) Calculate the correlation for mortality/longevity risk between LOBs from the simulation runs. Show your work.
- (d) (1.5 points) Recalculate the EC for the combined LOBs based on the variance-covariance method. Show your work.
- (e) (5 points) The CRO of the company reviews your EC calculations and states, “Your analysis is flawed as correlation is a scalar measure of dependency. I believe there is more complexity to the relationship between mortality and longevity than you have captured here.”

He suggests correlating the mortality and longevity risks using a Clayton copula with a large parameter (θ) to reflect dependency in the lower tail and provides the following table of values:

u	$F_x^{-1}(u)$	$F_y^{-1}(u)$	$C_{xy}(u, u)$
1.00%	53	83	0.79%
5.00%	67	94	3.97%
15.00%	79	103	11.91%
25.00%	87	109	19.89%
...
75.00%	113	131	64.42%
85.00%	121	137	76.24%
95.00%	133	146	90.87%
99.00%	147	157	98.04%

You are given:

$$\text{Clayton Copula: } C(x, y) = (x^{-\theta} + y^{-\theta} - 1)^{-1/\theta}$$

- (i) Explain what the CRO means by his statement above.
- (ii) Estimate θ using the values provided in the table above. Show your work.
- (iii) Explain whether or not the Clayton copula is appropriate in this circumstance.

4. (10 points) Hamsik Insurance Company is a property insurer with most of its exposures located in the Midwest US. It currently has a reinsurance agreement with Bourbon Re on its property risks to cover weather-related losses. Bourbon provides indemnification for 75% of Hamsik's aggregate annual weather losses between \$50 million and \$300 million.

Recent increases in storms in the Midwest and Northwest US have deteriorated Bourbon's capitalization.

Hamsik is considering terminating its reinsurance treaty and instead forming a special purpose vehicle (SPV) as an alternative means of transferring risk. The SPV would raise capital by issuing catastrophe bonds to investors.

- (a) (2 points) Draw a diagram that represents a possible structure for Hamsik's SPV. Label all entities and cash flows.
- (b) (2 points) Hamsik management has asked you to review the provisions that need to be specified and negotiated with potential investors.

Explain key provisions that impact how closely the SPV's coverage matches Hamsik's existing reinsurance agreement.

- (c) (2 points)
- (i) Explain the potential advantages for Hamsik if it sets up an SPV instead of continuing with its reinsurance agreement.
- (ii) Explain the potential disadvantages for Hamsik if it sets up an SPV instead of continuing with its reinsurance agreement.
- (d) (2 points) Hamsik's primary rating agency (A.M. Best) is concerned with Hamsik's dependence on the existing reinsurance agreement.

State whether you expect the SPV to be viewed by A.M. Best as a positive or negative development for Hamsik's capitalization and operating performance. Explain your answer.

- (e) (2 points) Explain key risk exposures not addressed by the SPV that A.M. Best would also consider in its rating opinion of Hamsik.

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- 5.** (11 points) You are an actuary working for Mardi Gras Company, a financial services corporation with both life and general (property & casualty) insurance lines of businesses. Its ALM team uses the following six step framework to develop Strategic Asset Allocation (SAA).

Framework Steps:

1. Investment Objectives and Constraints
2. Asset Universe and Assumptions
3. Liability Cash-flow Replicating Portfolio
4. Risk Measures
5. Risk-Return Tradeoffs
6. Strategic Asset Allocation and Associated Benchmarks

Your assignment at Mardi Gras focuses on just the first four steps of the framework.

- (a) (2 points) Describe the processes and considerations involved in implementing each of the first four steps in the SAA framework above.

Mardi Gras has access to numerous investable asset classes, including US Treasury bonds, corporate bonds of varying credit qualities, preferred stock, common stock of domestic and international companies, private equity, hedge funds, real estate, and derivatives on most of the aforementioned assets.

Your analysis of Mardi Gras will focus on the first four steps of the framework for the following blocks of business, each of which has its own investment strategy and separate SAA:

- I. Guaranteed Investment Contracts (GICs)
 - 5 year maturity
 - Fixed guaranteed interest rate at issue equal to the then current 5-year US Treasury bond yield + 25 basis points
 - 3 year declining surrender charge schedule of 10%, 5% and 2%
- II. Lifetime Single Premium Immediate Annuities (SPIAs)
 - Non-surrenderable
 - Guaranteed annual payment for life
- III. Hurricane insurance
 - Annual coverage
 - Frequency of claims are relatively low, but the severity of claims can be very high

5. Continued

- (b) (3 points) Explain how the attributes of the liabilities would influence each of the first four steps of the SAA process, for each of the three blocks of business.
- (c) (2 points) Mardi Gras has historically managed capital based on regulatory requirements, but is now considering using Economic Capital (EC).

Explain how this change in focus to EC could influence the SAA analysis.

- (d) (2 points) Explain the implications to the first four steps of the SAA process if Mardi Gras managed these three blocks of business in aggregate, instead of separately.
- (e) (2 points) The economic crisis of 2007-2009 resulted in sharp decreases in the equity markets, dramatic increases in credit spreads, a reduction in market liquidity and a sharp drop in risk free interest rates.

Explain how the perspective gained from the economic crisis of 2007-2009 may have impacted Mardi Gras' analysis in the first four steps of the SAA process.

6. (9 points) Calypso Consultants Inc. provides consulting services to its clients relating to strategic risk. Current clients include:

1. The Las Vegas Casino Association, which represents 90% of the casinos operating in the state of Nevada
2. The Print Media Corporation, which owns and publishes regional and national newspapers in Canada and the US
3. Acme Nuclear Power, which owns and operates nuclear power plants around the world

Each client is concerned with the ongoing viability of its business model. As a seasoned consultant, you have been offered the opportunity to work on any one of these three accounts.

Pick **one** of these three clients and respond to the following questions for **only** that client.

(a) (6 points)

- (i) Identify the steps in the Scenario Planning Approach used in strategic risk management.
- (ii) Apply the Scenario Planning Approach for the client you have chosen, showing your responses for each step in the process.

(b) (3 points) After analyzing the results of your scenario planning work, you recommend that your client consider the following best practices:

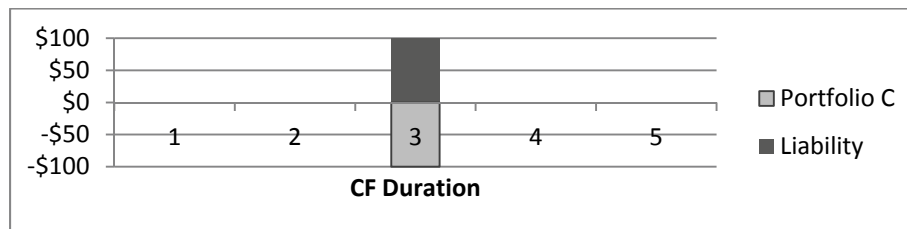
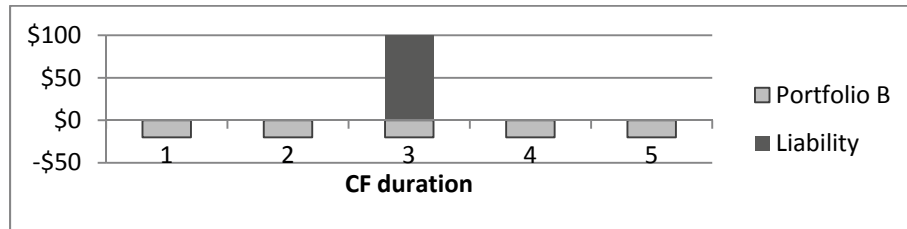
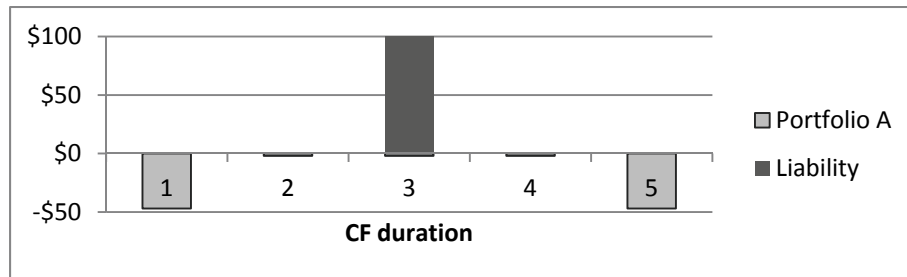
- Start a new environmental scanning task force
 - Develop key risk indicators for monitoring the changing environment
- (i) Explain what should be considered when choosing participants for the environmental scanning task force.
 - (ii) Recommend one approach for your client's task force to take when scanning the environment.
 - (iii) Recommend two specific key risk indicators to be monitored.

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

7. (11 points) You have recently become the Investment Actuary for SLIC’s SPIA product line. You are concerned about the product line’s current ALM risk exposures. You recognize the importance of locking in the yield spread on this business. Near term cash flows for the SPIA product have been fairly predictable.

- (a) (1 point) Identify three specific shortcomings in the current management of SLIC’s SPIA ALM risks.
- (b) (1.5 points) Describe the conditions that must be met to immunize a single-period liability using a portfolio of coupon-bearing bonds.
- (c) (2 points) You wish to match a single-period \$100 liability with duration of 3 years. The following charts illustrate the cash flows and durations of this liability and of three possible portfolio structures of coupon-bearing bonds, each with an aggregate duration of 3 years.



Identify and describe each of the portfolio structures A, B and C above.

7. Continued

- (d) (2.5 points) SLIC's Investment Department has proposed a laddered fixed income portfolio structure to back the SPIA product.
 - (i) Describe three key features of a laddered portfolio structure.
 - (ii) Explain why a laddered portfolio would not be the most efficient portfolio structure for the SPIA product line.

- (e) (2 points)
 - (i) Describe the combination-matching variation of immunization.
 - (ii) Explain the advantages and disadvantages of the combination-matching variation over a basic immunization strategy.

- (f) (2 points) Recommend which form of immunization in (e)(ii) is more appropriate for SLIC's SPIA. Justify your response.

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

- 8.** (9 points) You are assessing the current risk exposures of SLIC’s Defined Benefit pension plan (DB Plan). The DB Plan’s liabilities are currently valued at \$701.168 million, while the market value of assets has grown to \$708.410 million.

You have summarized the DB Plan’s current 1-year performance data by asset class and its corresponding passive benchmark as follows:

Portfolio	Market Value (\$ millions)	Return	Benchmark	Normal Policy Allocation	Return
U.S. Equity	375.457	12.3%	S&P 500	45%	10.2%
International Equity	28.336	13.1%	MSCI EAFE	20%	12.5%
U.S. Fixed Income	304.617	7.0%	Barclays Agg. Bond	35%	7.1%

- (a) (1 point) Explain how the following two risks that a defined benefit plan sponsor bears relate to the plan’s surplus risk:
- (i) Cash-flow risk
 - (ii) Economic risk
- (b) (1 point) Define the following risk measures used to assess the DB Plan’s investment risks of the actively managed portfolios:
- (i) Absolute risk
 - (ii) Relative risk
- (c) (4 points) Calculate the current absolute risk of SLIC’s DB Plan and decompose it into:
- (i) Policy mix return
 - (ii) Policy decisions return
 - (iii) Managers’ performance return

Show your work.

8. Continued

- (d) (3 points) The DB Plan's funding risk is measured as the expected return on surplus, scaled by assets. The expected return on surplus is 6.5%. Surplus volatility is 10%.

SLIC's pension committee has proposed a surplus-at-risk budget of \$100 million at the 2.5% confidence limit.

Determine whether or not the current surplus risk is within the proposed budget. Show your work.

****END OF EXAMINATION****