

# Exam ERM-INV

**Date:** Tuesday, October 30, 2018

**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 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.

*Recognized by the Canadian Institute of Actuaries.*

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) ReaLife Insurance Company sells life insurance products. The performance of different functions (e.g. Investment, ALM and Business Management) in the company is measured using the Economic Value Added (EVA) measure.

ReaLife’s investment policy defines the Strategic Asset Allocation (SAA) and the Tactical Asset Allocation (TAA) range which applies to the combined liability and surplus investment portfolio.

<b>Asset class</b>	<b>SAA</b>	<b>TAA range</b>
Short-Term Bonds	50%	45% to 55%
Long-Term Bonds	50%	45% to 55%

Investments in both asset classes must total 100%. No cash position is allowed.

The current investment portfolio, which matches the SAA, is given below.

<b>Asset Class</b>	<b>Market Value of Assets (\$ million)</b>	<b>Duration</b>	<b>Expected Return</b>
Short-Term Bonds	100	5	4.0%
Long-Term Bonds	100	20	5.0%
Total	200	12.5	4.5%

You are given the following information:

- The company’s Market Value of Liabilities is \$180 million with a duration of 15 years.
- The fixed income benchmark portfolio for the liabilities has a duration of 15 years and value of \$180 million.
- The expected return of the benchmark portfolio is 4.5%.
- Cost of capital is 4%.

The required capital for duration mismatch risk = \$10 million times the duration mismatch.

Assume the following interest rate changes occur at the end of the current performance measurement period:

- 5-year interest rate increases by 0.5%.
- 15-year interest rate decreases by 0.5%.
- 20-year interest rate decreases by 0.5%.

## 1. Continued

- (a) (4 points) The Investment function anticipated the market movement correctly and positioned the portfolio at the beginning of the measurement period to maximize the function's performance measure according to the limits imposed by the TAA.
- (i) Verify that EVA for the Investment function = 0.95. Show your work.
  - (ii) Verify that EVA for the ALM function = -6. Show your work.
  - (iii) Recommend an action to improve EVA for the ALM function.
- (b) (3 points) ReaLife's Business Management function manages new business and nonfinancial risk such as insurance and operational risks.

You are given the following information:

- During the measurement period, the market consistent embedded value of new business underwritten is \$1 million.
- The new business sales are at the maximum allowed by the available capital for new business.
- The experience of nonfinancial risk has an adverse deviation of -\$2.4 million from the best-estimate assumption due to unfavorable mortality experience.
- The maximum of statutory required capital, rating agency required capital and required economic capital at the desired probability is \$30 million.

- (i) Calculate EVA for the Business Management function.
- (ii) ReaLife's senior management is not satisfied with the performance of the Business Management function with regard to new business and has asked you to explore the use of these two types of reinsurance to improve it:
  - I. Pro rata
  - II. Excess of loss

Recommend one of these two types of reinsurance for this purpose. Justify your recommendation.

2. (10 points) You are a recently hired CRO at XYZ Company. XYZ has 30% of its invested assets in a mining company, MC. The investment has performed well, but XYZ is growing uneasy that volatility in the commodity market may reduce the value of XYZ's shares in MC.

You've been asked to investigate establishing a hedge of the MC shares.

- (a) (1 point) XYZ's Chief Investment Officer (CIO) is familiar with VaR and wants to use it as the risk measure. You would like to use Monte Carlo methods to evaluate the effect of the hedge but your department is struggling with computer runtime issues in trying to generate stochastic Monte Carlo results.

Propose an alternative technique that could lead to a faster and more accurate VaR estimate. Justify your response.

- (b) (3 points) The CIO is convinced that hedging is the right risk management approach. As there are no exchange-traded options for this commodity, the trade would be executed in the OTC market. There is concern from the Board of Directors (BoD) about managing the counterparty risk.

- (i) Explain how Expected Mark to Market, Expected Exposure and Potential Future Exposure quantify the company's counterparty credit exposure to the OTC counterparty. Use graphs to support your explanation.

You propose creating a Risk Dashboard to be reported monthly to the BoD.

- (ii) Recommend which one of the metrics in part (i) you would reflect in the Risk Dashboard. Justify your recommendation.

- (c) (2 points) The BoD has asked you to create a plan for implementing the commodity hedge. The company has an existing hedge program to manage its interest rate risk exposure. Your colleague sends you a brief email:

"Great news on the board approving the hedge plan! Now we just need additional master agreements with our counterparty to reflect this new risk, and since we were already hedging interest rate risk there's no need to update the firm's risk tolerance statement."

Critique your colleague's message.

## **2. Continued**

- (d) *(4 points)* In preparation for your annual report to the BoD on the company's solvency and risks, your Risk Management Team is reviewing the list of key risks on the company risk register.

Identify and describe four risk exposures that have changed because of the new commodity hedge. Justify your response.

3. (14 points) You are a risk actuary working in insurer ABC's ERM department. Your task is to improve operational risk assessment at ABC. Two potential approaches are being proposed to model operational risk exposure – the Risk Map approach and the Actuarial approach – as outlined below.

	<b>Risk Map Approach</b>	<b>Actuarial Approach</b>
<b>Owner</b>	Individual business line manager	ERM department
<b>Operational Risks</b>	<ul style="list-style-type: none"> <li>- Routine Operational Risks               <ul style="list-style-type: none"> <li>• People</li> <li>• Process</li> <li>• IT/Systems</li> </ul> </li> <li>- Exceptional Operational Risks               <ul style="list-style-type: none"> <li>• External events</li> <li>• Sales and business practices</li> </ul> </li> </ul>	
<b>Model Components</b>		
Exposure / Capital measure	<ul style="list-style-type: none"> <li>• Expected loss</li> </ul>	<ul style="list-style-type: none"> <li>• VaR</li> </ul>
Calculation method	<ul style="list-style-type: none"> <li>• <u>Frequency</u>: not defined</li> <li>• <u>Severity</u>: impact on ABC's financial condition</li> </ul>	<ul style="list-style-type: none"> <li>• <u>Frequency</u>: no statistical assumption defined yet</li> <li>• <u>Severity</u>: direct and indirect impact</li> <li>• <u>Interaction</u>: historical correlation matrix</li> </ul>
Data and assumptions	<ul style="list-style-type: none"> <li>• Based upon business line manager's own loss experience / expert judgment</li> </ul>	<ul style="list-style-type: none"> <li>• Internal data only</li> </ul>
Business environment	<ul style="list-style-type: none"> <li>• Line manager believes that their model is appropriate both for routine and exceptional risk events</li> </ul>	<ul style="list-style-type: none"> <li>• Control indicators based upon on each business line manager's input</li> <li>• Appropriate both for routine and exceptional risk events</li> </ul>



### 3. Continued

- (a) (6 points) The following six principles are relevant to assess the validity of any model used for risk purposes.

<b>Model Feature</b>	<b>Principle</b>
Design	Consistent with intended purpose
Validation	Part of an independent process
Owner	Accountability stated and applied
Complexity & Materiality	Proportional to context
Elements	Inputs, calculation, output, and limits must be validated
Documentation	Analysis of supporting details produced

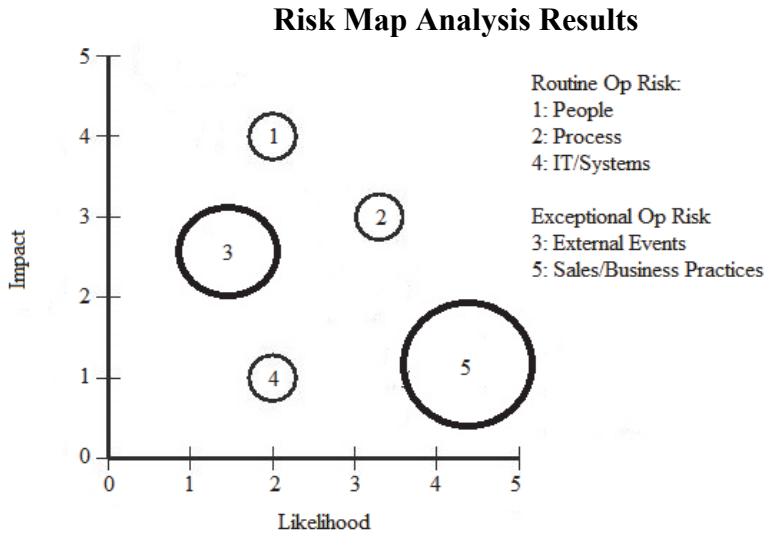
Compare and contrast the application of each principle relative to both proposed operational risk modeling approaches. Justify your response.

- (b) (4 points) Assess the appropriateness of the proposed actuarial approach to adequately model both routine and exceptional operational risk exposures. Justify your response by discussing the suitability of each model component.

*Question 3 continued on the next page.*

**3. Continued**

(c) (4 points) You obtained the following results for the risk map approach as compiled by one of the business line managers.



In addition, the ERM team has just performed the following operational analysis.

**Operational Risk Analysis Results**

Risk Category	Annualized frequency	Direct impact on ABC equity	Indirect impact on ABC
1. People	Fraud: 0.1%	Legal fines: 10%	Not assessed historically
2. Process	Claims failures: 0.5%	Corrections: 2%	Negative social media suspected
3. External events	Terrorism: N/A internally	Lost sales: 10%	Highly negative short-term on traded ABC stock
4. IT/Systems	IT failures: 0.1%	Downtime: 0.1%	Not likely
5. Sales and business practices	Selling inadequate products: 1%	Legal fines: 20%	Highly negative on reputation

Recommend improvements to the individual business line manager based on the ERM department’s analysis with respect to each of the following items. Justify your response.

- I. Collection of data relevant to modeling of operational risk losses
- II. Ensuring accuracy of operational risk loss data
- III. Setting of assumptions for variables used in operational risk modeling.

**THIS PAGE INTENTIONALLY LEFT BLANK**

4. (10 points) The National Cardiologist Medical Association (NCMA) is currently insured with PQR, an insurance company licensed in the U.S. PQR specializes in liability insurance against medical malpractice of its members. Due to the constant rise of premiums charged by PQR, NCMA, along with other medical associations, has created a pure captive Risk Retention Group (RRG) to self-insure against malpractice claims.

RRG is domiciled in the United States and is also responsible for claims handling and administration.

You are a consulting actuary working for RRG and are responsible for setting premiums rates and implementing its risk management framework.

- (a) (3 points) Compare and contrast the characteristics of PQR and RRG as they relate to the following:

- Target Market
- Required Risk Capital
- Regulation
- Policyholder Protection

- (b) (2 points) Explain how the exposure to each of the following risks will affect the associations participating in RRG. Justify your response.

- Catastrophe Claim
- Investment Risk
- Operational Risk
- Legal Risk
- Regulatory Risk

#### 4. Continued

- (c) (3 points) You decide to use Economic Capital as the primary tool to quantify material risks and assess performance for pricing. Your team provided projection of selected RRG's income statement and balance sheet items for the first year (in \$ million).

Income Statement	Year 1
Premium	11
Maintenance Expenses	2
Expected Claims	5

Balance Sheet	At Issue	Year 1
Policy Liability	20	25
Market Value Assets	80	90
Available Economic Capital	50	55
Required Economic Capital	40	40

You are also given:

- Risk adjusted net income is assumed to be 70% of net income before tax
- Tax rate is 25%
- Interest on reserve and available capital is 5%
- Only cash and short-term notes back the required capital; therefore, investment income on required capital can be ignored

- (i) Calculate the following metrics. Show your work.

- ROE
- RAROC

- (ii) Propose an additional risk metric appropriate for assessing RRG's performance based on the data given. Justify your response.

- (iii) After assessing the metrics produced by your analysis, your colleague makes the following statement:

"I recommend we adopt RAROC as the primary risk metric for evaluating the performance of RRG as it currently produces a higher return than all other metrics considered."

Critique your colleague's recommendation.

*Question 4 continued on the next page.*

**4. Continued**

- (d) (2 points) Based on the metrics considered, RRG is not performing well after one year of operation.

Recommend two risk mitigation strategies that could improve RRG's performance.

**THIS PAGE INTENTIONALLY LEFT BLANK**

- 5.** (10 points) OSZ, a life insurance company in Country A, is considering offering a product linked to the return on a pool of cryptocurrencies. Premium and benefit payments are denominated in Country A's currency, ACU.

Historically, the pool of cryptocurrencies has experienced excessively high volatility.

Country A regulators have indicated to OSZ that capital requirements for such a product would be extremely high, which would not allow OSZ to meet profit targets for this product.

OSZ is considering the use of a Special Purpose Vehicle (SPV) to finance the new product. The SPV would have the following structure:

- Separate legal entity from OSZ
  - Payments to investors are proportional to their initial investments
- (a) (1.5 points) Identify three key benefits to OSZ from using an SPV for the new product. Justify your response.
- (b) (2 points) The following risks are generally associated with the use of SPVs:
- Liquidity and funding risk
  - Reputational risk
  - Lack of transparency
- (i) Describe each risk as it pertains to an SPV.
- (ii) Rank the risks based on relevance to OSZ's proposed SPV. Justify your ranking.



## 5. Continued

OSZ decided to offer the product using an SPV.

Benefit payments,  $B_t$ , occur at the end of each year as follows:

- Initial Benefit Payment:  $B_1 = \frac{80\% \text{Single Premium}}{120 - \text{Issue Age}} \max(1, 1 + 40\%R_1)$
- Subsequent Benefit Payments:  $B_t = B_{t-1} \max(1, 1 + 40\%R_t)$ ,

$R_t$  is the percent return in year  $t$  on the pool of cryptocurrencies.

You are given the following information:

- 10 policies were issued on the same day exactly two years ago; all policies are in force today
- Each policy was issued at age 65 for a single premium of 1,000,000 ACU

You are also given the following capital management policy:

- The only changes in capital are from payments to policyholders, distributions to investors and investment returns on capital
- Required Capital (per policy)
  - For  $t = 0$ : 200% Single Premium
  - For  $t > 0$ :  $\max(B_t, 200\%(120 - \text{Attained Age})B_t)$
- Capital is invested in an annually rebalanced portfolio containing 40% of the cryptocurrency pool earning  $R_t$  and 60% earning a fixed 6% return
- At the end of each year, after payments have been made to policyholders, any capital in excess of 125% of required capital is distributed to the investors

(c) (4 points) You've created a table to track capital and distribution to investors.

$t$	Attained Age	$R_t$	$B_t$	Capital Requirement	Capital Before Distribution to Investors	Distribution to Investors	Capital After Distribution to Investors
0	65	N/A	N/A		25,000,000	N/A	
1	66	25%					
2	67	-75%				0	

- Determine the missing values. Show all work.
- Explain why there was no distribution to investors in year two.

*Question 5 continued on the next page.*

## 5. Continued

- (d) (2.5 points) SPV investors are unhappy with the capital position of the SPV at the end of year two.

The Head of Capital Management has sent you an e-mail containing the following arguments and recommendation:

- Since the SPV is a separate legal entity, OSZ has no legal obligation to transfer additional capital.
- Transferring OSZ's capital to the SPV would have a negative impact on earnings and thus is not in the best interest of their shareholders.
- Allowing the SPV to default could impact OSZ's ability to access capital markets for future projects, which would have a negative long term impact.
- Recommendation: OSZ should make a one-time transfer of 1,000,000 ACU to the SPV, contingent on the investors agreeing to the following restructuring:
  - Distributions to investors will be changed from the excess of capital over 125% of required capital to the excess of capital over 250% of required capital
  - No future transfers of capital from OSZ to the SPV will occur under any circumstances.

Critique each of the arguments and the recommendation.

**THIS PAGE INTENTIONALLY LEFT BLANK**

6. (9 points) You are the CRO for JKL, a health insurance company. JKL is looking to diversify its risk exposure through strategic acquisition. The company is evaluating the purchase of a closed block of variable annuities (VA) from LifeCo, a life insurance company.

(a) (2 points) You have asked your actuarial student to assist with developing a risk register for the VA block. Your student wants to organize a survey to complete the risk register based on the responses of the current staff.

- (i) Identify two key limitations generally associated with the survey approach.
- (ii) After discussing the limitations with surveys with your student, you recommended the Independent Group Analysis technique as an alternative to conducting a survey.

Explain how this recommendation addresses both limitations you identified in (i).

(b) (3.5 points) JKL’s CEO has hired a consultant to analyze the capital market risks embedded within the VA block. The consultant’s report included capital market correlations shown in the table below.

**Capital Market Correlations**

Asset Class	Sector		1	2	3	4
Fixed Income	US High Yield Bonds	1	1.0	0.8	0.7	0.3
Equity	US Large Cap	2	0.8	1.0	0.9	-0.6
Equity	Euro Large Cap	3	0.7	0.9	1.0	0.1
Alternatives	US Commodities	4	0.3	-0.6	0.1	1.0

The CEO has asked you to present on the capital markets modeling for the VA block. Your presentation will be to the Board of Directors (BoD).

Your actuarial student feels that the correlation matrix in the consultant’s report is too detailed for the BoD and wants to present this information as an influence matrix instead. The student identified the following qualitative observations about capital markets:

- Equity markets influence the fixed income markets
- Fixed income markets influence alternatives
- Alternatives influence equity markets
- Each sector influences the other sectors within the same asset class

## 6. Continued

Your student rounded all correlations to the nearest 0.5 for credibility (for example, 0.3 is rounded to 0.5) and has started populating the influence matrix as provided below.

<b>Asset Class</b>	<b>Sector</b>		<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
<i>Fixed Income</i>	<i>US High Yield Bonds</i>	<b>1</b>	N/A		0	
<i>Equity</i>	<i>US Large Cap</i>	<b>2</b>		N/A		
<i>Equity</i>	<i>Euro Large Cap</i>	<b>3</b>	1		N/A	
<i>Alternatives</i>	<i>US Commodities</i>	<b>4</b>				N/A

- (i) Determine the missing values (0, 1, or 2) in each cell. Show your work.
- (ii) Identify two sectors that will require direct risk mitigation based on the influence matrix. Justify your response.
- (c) (2 points) You are concerned that the consultant did not mention any VA operational risks in the risk report. You have identified the following key VA operational risks in the risk register:
- Regulatory risk
  - Technology risk
  - Process risk
  - Reputational risk
- (i) Evaluate whether the scenario planning approach is an appropriate risk management strategy for each operational risk identified.
- (ii) Recommend an alternative risk management strategy for each risk. Support your recommendation.

*Question 6 continued on the next page.*

## 6. Continued

- (d) *(1.5 points)* Several months have passed, and risk management strategies have been implemented for the operational risks. The consultant has assisted JKL in engaging an investment bank to assist with hedging the capital markets risks embedded within the VA block.

The BoD has scheduled a meeting for next week to review the proposed purchase and make a decision whether or not to purchase the VA block. They would like to review your risk analysis at that meeting.

Assess whether the influence matrix can help support your recommendation. Justify your response.

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

7. (5 points) You are constructing a portfolio of global equity investments from the following regions: United States, Canada, Europe and Asia.

The relative market capitalization of these regions is as follows:

<b>Region</b>	<b>Market Capitalization</b>
United States	55.0%
Canada	5.0%
Europe	30.0%
Asia	10.0%

You are considering two approaches to strategic asset allocation of this portfolio:

- Standard mean-variance optimization (MVO)
  - Black-Litterman approach
- (a) (2 points) Compare and contrast standard MVO with the Black-Litterman approach.
- (b) (1 point) Describe the three main steps to implement the Black-Litterman asset allocation model.

You construct two potential portfolios, one using the Black-Litterman approach incorporating two market views, the other one using standard MVO. The results are shown in the following table:

<b>Region</b>	<b>Portfolio 1</b>	<b>Portfolio 2</b>
United States	58.0%	58.3%
Canada	7.5%	5.3%
Europe	15.8%	23.4%
Asia	18.7%	13.0%

- (c) (1 point) Identify which approach was used to construct each portfolio above. Explain your rationale.
- (d) (1 point) Identify the two market views expressed with respect to the Black-Litterman Portfolio above. Justify your response.

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

**8.** (15 points) SLIC's investment committee is interested in revisiting the current variable annuity dynamic hedging program. The committee has asked you to make recommendations with regard to the equity hedges.

(a) (1.5 points)

- (i) Define dynamic hedging and static hedging approaches.
- (ii) Identify advantages and disadvantages of using each approach to hedge Guaranteed Living Benefit (GLB) variable annuity products, in general.

A junior actuary provided the following monthly liability Fair Value and Greeks to the hedging group based on the last quarter-end GLB inforce policy report.

	Changes Per	Value (in \$000s)
Fair Value		560.0
Delta	+1% Equity Price	-7.0
Gamma	+1% Equity Price	0.1
Rho	+0.01% Interest Rate	-1.2
Vega	+1% Volatility	24.0
Theta	+1 Month	1.0

The junior actuary states "This monthly report is all we need to run a great hedge program for our GLBs."

- (b) (0.5 points) Critique the junior actuary's statement.
- (c) (1 point) A half-month has passed since the hedge report was produced. The equity market has increased by 2.00%, the interest rate curve has increased by 0.10% and equity volatility has dropped by 0.50%.

Estimate the change in the fair value of the liability since the hedge report date.

To illustrate different hedging strategy options to the committee, you have developed a simulation model with the liability based on a group of GLB policies. On the hedge asset side you model three assets:

- An at-the-money put option
- An out-of-the-money put option
- Equity futures



## 8. Continued

For a deterministic stress scenario you have the following information for the total liability and a single option contract:

Quarterly Step	Market Condition	Liability		At-The-Money Put Option		Out-Of-The-Money Put Option	
		Equity Delta	Fair Value	Equity Delta	Market Value	Equity Delta	Market Value
0	2,500	(7,000)	560,000	(10)	300	(2)	100
1	2,000	(8,000)	950,000	(12)	600	(3)	120
2	1,600	(5,500)	1,300,000	(9)	950	(3)	150

The equity deltas for the equity futures and each of the put options are calculated based on 1% of S&P 500 movement. Assume the equity futures delta is equal to 1.

- (d) (3 points) SLIC's current equity dynamic hedging strategy uses only equity futures to hedge 100% of liability equity delta. The hedging program uses E-Mini S&P future contracts. The notional value of one E-Mini future contract is 50 times the value of the S&P 500 index.
- (i) Calculate the number of E-Mini future contracts needed at time period 0 and time period 1, respectively. Round to nearest whole number of contracts. Show your work.
  - (ii) Calculate the total hedge asset gain/loss at the end of time period 2 using your results from sub-part (i). Show your work.

*Questions 8 continued on the next page.*

## 8. Continued

- (e) (4 points) You model another hedging strategy using both put options and equity futures to hedge 100% of the liability equity delta. The at-the-money put options are used to hedge 50% of the liability equity delta at time period 0 and then are held constant through time. The equity futures are used to dynamically hedge up to 100% of the liability equity delta for all time periods.
- (i) Calculate the number of the at-the-money put options needed at time period 0. Show your work.
  - (ii) Calculate the number of E-Mini future contracts needed at time period 0 and time period 1, respectively. Round to nearest whole number of contracts. Show your work.
  - (iii) Calculate the total hedge asset gain/loss at the end of time period 2 under this strategy. Show your work.
- (f) (2 points) You are concerned with the initial cost of the hedging strategy in part (e).
- (i) Construct a hedging strategy using a put spread to hedge 50% of the liability equity delta at time period 0.
  - (ii) Calculate the initial cost. Show your work.
- (g) (3 points)
- (i) Recommend one of the dynamic hedging strategies to the investment committee. Justify your choice.
  - (ii) Propose two changes to SLIC's current GLB hedging process that would improve the hedging program.

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

**USE THIS PAGE FOR YOUR SCRATCH WORK**

**USE THIS PAGE FOR YOUR SCRATCH WORK**