

ILA LRM Model Solutions

Spring 2018

1. Learning Objectives:

2. The candidate will demonstrate an understanding of the various sources of risks faced by an insurer.

Learning Outcomes:

- (2a) Identify, categorize and evaluate potential sources of risk in products including but not limited to mortality, morbidity, and lapse.
- (2b) Identify, categorize and evaluate potential sources of risk in investments including but not limited to credit risk, liquidity, equity-based exposure and asset-liability matching.
- (2c) Describe and evaluate the other risks an insurance company faces including operational, marketplace and expense risks.

Sources:

LRM-105-14: Mapping of Life Insurance Risks, AAA Report to NAIC (same as ERM - 401 - 12)

LRM-106-14: Moody's Looks at RM & the New Life Insurance Risks – 2000

A New Approach for Managing Operational Risk - SOA Research 2008

Commentary on Question:

Overall most candidates conveyed that they understood several of the key points.

Some candidates who were not confident about the material tended to give facts or knowledge that were not relevant to the question being asked. For example, in part d) i) where candidates were asked to evaluate characteristics there were many who just listed information without any explanation of why it was applicable.

Solution:

- (a) Identify the risk category for each of the following risks:
 - Mortality rate experience turns out to be worse than planned for
 - The Internal Revenue Service (IRS) passes a new law removing some of the tax benefits from life insurance

1. Continued

- Risk that a company incurs losses due to a rating agency downgrade
- Risk that reinvested cash flows will earn less than expected as a result of decreasing interest rates

Commentary on Question:

This part was generally done well with candidates identifying most of the risks. Few correctly identified every risk.

1. Mortality Risk
2. Regulatory Risk
3. Reputation Risk
4. Reinvestment Risk

- (b) Your company utilizes a Modern Operational Risk Management framework.
- (i) Explain the difference between risk measurement and risk assessment.
 - (ii) Explain situations in which risk measurement or risk assessment would be more appropriate than the other.

Commentary on Question:

Candidates usually got most of the key points but failed to fully explain the differences or situations in which one or the other was more appropriate.

- (i) Risk measurement uses hard data and typically relies on sophisticated models to measure the risk. In contrast, risk assessment relies on soft data and expert judgment or opinion to create an assessment of the potential risk. The technique in risk assessment is also less sophisticated than risk measurement and relies on less complex calculations or parameter estimation.
- (ii) Where sufficient hard data are available, risk measurement is often more reliable than risk assessment. When sufficient hard data are not available risk assessment based on soft data may produce results that are more reliable. Risk assessment techniques may also be used for scenario analysis and stress testing. Soft data/risk assessment can be more useful if the goal is to estimate rare even such as one occurring once in a hundred years.

1. Continued

- (c) You are in charge of modeling operational risk due to a tornado demolishing the company's building foundation severely enough to halt all work activity. The number of tornadoes is known to vary drastically from month to month.

Recommend a frequency distribution to use for operational risk management and justify its use.

Commentary on Question:

This part was done well by the majority of candidates, who could recommend an appropriate distribution and were able to justify its use.

The number of tornadoes generally varies drastically from month to month which suggests the variance of the distribution is greater than the mean. Because of this, the negative binomial distribution is appropriate because it has a variance greater than the mean, as opposed to the Poisson or binomial distributions, which have variance equal to or less than the mean respectively.

- (d) Moody's is reviewing their assessment of ABC Life, whose risk management has the following characteristics:
1. Management has a long-standing track record of knowing its risks and how to manage risks to the desired tolerance level.
 2. Risk management processes are in place to quantify risk but not all major risks have a mitigation plan.
 3. Investment guidelines are in place, and there's effective collaboration between the investments area and other areas of the company.
 4. ABC Life has an average life insurance policy size of 250,000 and reinsures amounts in excess of its retention of 50,000.
 5. A plan is in place to hold a certain amount of cash and liquid assets to ensure liquidity at a high level of confidence.
- (i) Evaluate how each characteristic contributes to Moody's opinion of ABC Life's risk management capabilities.
- (ii) Recommend changes to ABC Life's risk management to improve the outcome of Moody's assessment of their capabilities.

Commentary on Question:

Many candidates earned credit for some of the key points but fewer managed to clearly express enough for full credit.

1. Continued

In part (i), candidates frequently struggled with the high level nature of the information provided in the question and speculated about potential unknown details rather than evaluate the specific characteristics described in the question..

In part (ii), in addition to supplying valid points, candidates frequently provided irrelevant details or, similarly to part (i), made speculative recommendations that were not closely tied to the characteristics provided in the question.

- (i)
 - 1. Management having a long-standing track record of knowing and managing its risks would be seen as a favorable by Moody's.
 - 2. Having risk management processes in place would be perceived as favorable; however, lacking a mitigation plan for some major risks would be viewed unfavorably.
 - 3. Linkage between investments and other key areas, as well as the existence of guidelines (such as exposure limits), would all be seen by Moody's as favorable characteristics.
 - 4. Risk transfer via the use of reinsurance would likely be viewed favorably; however, the retention limit of 50,000 seems quite low relative to the average policy size. This may raise the question of whether there is too much exposure to the reinsurer's financial condition and thus may be unfavorable to Moody's view of ABC Life.
 - 5. Having a plan to hold cash and liquid assets to ensure a high level of liquidity at a high confidence level would be viewed favorably.
- (ii) ABC Life should put in place mitigation plans for all of its major risks. This is a current weakness and doing so should improve Moody's view of their capabilities.

ABC Life should review its use of reinsurance as a risk management tool; the low retention limit opens ABC Life it up to counterparty exposure with the reinsurer. A potential option is to consider increasing the retention limit in accordance with its risk appetite while reducing exposure to reinsurance.

Another option would be to review the number of reinsurers being used to consider whether the risk should be split among more or fewer reinsurers and also to consider if there needs to be a limit on the creditworthiness of each reinsurer to ensure they have sufficiently high rating. Having a firm understanding of these items and making any justifiable improvements should help improve Moody's opinion of ABC Life.

2. Learning Objectives:

4. The candidate will demonstrate an understanding of the principles of modeling, cash flow testing and asset-liability matching, and perform related calculations.

Learning Outcomes:

- (4a) For an ALM model
 - (i) Select appropriate assumptions and scenarios
 - (ii) Model dynamic behavior of both assets and liabilities
 - (iii) Model and explain various strategies, including hedging
 - (iv) Analyze and evaluate results (including actual v. projected differences)
 - (v) Recommend appropriate strategies
- (4b) Define and calculate duration, convexity and key rate durations including the rationale for matching as a means to manage risk

Sources:

LRM-120-14: Chapter 14 of Life Insurance Products and Finance, Atkinson/Dallas
Section 14.4 only on ALM Matching

LRM-117-14: Key Rate Durations: Measures of Interest Rate Risk

SOA – Society of Actuaries, 2002: Ch. 3 – Why Did ALM Become Important?

Commentary on Question:

Most candidates who attempted this question answered part (b) well, but many had difficulty with part (c). Most candidates derived the correct formulas and performed the calculations correctly; if candidates used the wrong values for the calculations, they were given partial credit and not penalized multiple times.

Solution:

- (a) Calculate the net earnings exposure if assets backing the liabilities are purchased based on each of the following ALM strategies:
 - (i) Duration matching only
 - (ii) Duration and convexity matching

Commentary on Question:

Most of the candidates wrote the correct formulas for duration, convexity and the change in value under the two ALM strategies. The majority did not understand what the 11,600 represented. Several candidates backed into the duration by setting the change in liability formula equal to 11,600. Several did not calculate the net earnings exposure, nor did they demonstrate an understanding of it.

2. Continued

Part i:

Step 1. Calculate liability cash flows

$$\begin{aligned}CF(0) &= -200,000 \\CF(1) &= 100,000 \\CF(2) &= 100,000(1 - q_{x+1}) = 90,000 \\CF(3) &= 100,000(1 - q_{x+1})(1 - q_{x+2}) = 81,000\end{aligned}$$

$$\text{Present value of liability cash flows} = \sum_{t=0}^n v^t CF(t) = 46,842$$

Note: The value of cash outflows is 246,842.

Credit was given if a candidate used only the liability outflows in this calculation.

Step 2. Calculate modified duration of liability cash flows

$$\begin{aligned}\text{Macaulay Duration } MacD &= \frac{\sum_{t=0}^n t v^t CF(t)}{\sum_{t=0}^n v^t CF(t)} = 10.00 \\ \text{Modified Duration } ModD &= \frac{MacD}{1+i} = 9.52\end{aligned}$$

Note: If only liability cash outflows are considered, the macaulay and modified durations are 1.90 and 1.81 respectively.

Credit was given to both sets of values.

Step 3. Calculate change in liability value for the interest rate change = -11,600

(Note: this is given in the problem)

Step 4. Calculate change in asset value for interest rate change

$$\% \text{change in } PV CF(i) = -ModD \times \text{Change in } i$$

$$\text{Change in value} = -11,153$$

Step 5: Calculate net earnings exposure = change in the value of assets less the value of liabilities = -11,153 - (-11,600) = 447

2. Continued

Part ii:

Step 2. Calculate convexity of liability cash flows

$$\text{Convexity} = \frac{\sum_{t=0}^n t(t+1)v^{t+2}CF(t)}{\sum_{t=0}^n v^t CF(t)} = 29.43$$

Note: If only liability cash outflows are considered, the convexity is 5.59.

Credit was given to both values. Some candidates missed '+2' in the exponent getting partial credit for the formula.

Step 4. Calculate change in asset value for interest rate change

$$\begin{aligned} \text{\%change in PV CF}(i) \\ = -\text{ModD} \times \text{Change in } i + \frac{1}{2} \text{Convexity} \times (\text{Change in } i)^2 \end{aligned}$$

$$\text{Change in value} = -11,584$$

Step 5: Calculate net earnings exposure = $-11,584 - (-11,600) = 16$

- (b) Each type of zero coupon bond contributes the same amount of interest rate sensitivity to the index.
- (i) Calculate the key rate duration of the Index.
 - (ii) Construct a portfolio of zero-coupon bonds to replicate the block of new SPIAs.

Commentary on Question:

Nearly all candidates successfully answered part (i). In part (ii), some candidates failed to provide dollar values.

Part i: KRD of the index is the sum of the KRDs = 1.95

Part ii: The weights for the zero coupon bonds associated with the i th key rate duration = $W(i) = D(i)/T(i)$. Here $D(i)$ is the i th KRD and $T(i)$ its term. Weight for cash $W(0) = 1 - \sum_{i \neq 0} W(i)$. Value for each $VW(i) = V \times W(i)$, where V is the value from part (a).

2. Continued

Term (years)	W(i)	VW(i)
0.25	0.4	18,737
0.5	0.3	14,052
1	0.2	9,368
2	0.15	7,026
5	0.1	4,684
10	0.07	3,279
Cash	-0.22	-10,305

Credit was given if candidates used the value they calculated in part a).

- (c) A return of premium (ROP) feature is being proposed for the SPIA, and would be calculated as follows:

$\text{Premium} \times (3 - t) \div 6 \times (1 + i\text{Floor})^t$, where $i\text{Floor} < \text{annual interest rate} = 5\%$.

Assess how adding this ROP feature would impact the interest rate risk of the product.

Commentary on Question:

Some candidates struggled with the qualitative and open-ended nature of this question. Most grasped that there was additional risk and most noted interest rate risk as a consequence of the option. Other candidates simply defined disintermediation and disinvestment risk, while a few said that the interest rate risk would decrease. Some candidates made assumptions regarding when the option would become effective, e.g. only upon death, and some wound up contradicting themselves while trying to explain there would be an increase in interest rate risk.

Inclusion of the interest rate floor amounts to an embedded option like derivative to the liability. This will increase the value and lengthen the duration of the liability as interest rates fall. The opposite is true as interest rates rise.

This creates a mismatch with the assets of the insurer as they will depreciate faster than the liability.

This guarantee is equivalent to a policyholder having the right to purchase a bond paying the interest rate floor (ie, a bond call). Policyholders also hold a bond put (the right to surrender the policy for a cash payout).

This will increase the sensitivity to shorter-term KRD changes

2. Continued

Credit was given if candidates justified why the feature increases interest rate risk by explaining the emergence of a mismatch between assets and liabilities, or the sensitivity to shorter term interest rates.

Several candidates were able to articulate the first two - increase in interest rate risk and the mismatch – but only a few commented on the increase in sensitivity to shorter term interest rates.

3. Learning Objectives:

1. The candidate will demonstrate an understanding of the principles of Risk Management.
2. The candidate will demonstrate an understanding of the various sources of risks faced by an insurer.

Learning Outcomes:

- (1b) Evaluate the role of risk management within an insurance company
- (1d) Describe how risk management techniques may be used to manage capital deployed by insurers and how they impact strategic decision making.
- (2a) Identify, categorize and evaluate potential sources of risk in products including but not limited to mortality, morbidity, and lapse.
- (2b) Identify, categorize and evaluate potential sources of risk in investments including but not limited to credit risk, liquidity, equity-based exposure and asset-liability matching.
- (2c) Describe and evaluate the other risks an insurance company faces including operational, marketplace and expense risks.

Sources:

LRM-105-14: Mapping of Life Insurance Risks, AAA Report to NAIC
Risk Appetite: Linkage with Strategic Planning

Commentary on Question:

This question assesses candidates on the understanding of various sources of credit risk, the use of risk measurement techniques (such as Expected Loss Score, Strategic Asset Allocation (SAA) vs Target Asset Allocation (TAA)), and applying them in a risk management framework to manage credit risk.

Solution:

- (a) Define the four elements of credit risk as related to insurance companies, according to the Federal Reserve.

Commentary on Question:

Candidates received full credit for identifying all four elements and providing a brief definition/explanation on each.

3. Continued

- 1) Counterparty credit risk – the risk that counterparty will fail to perform an obligation or default on amounts due.
- 2) Invested asset credit risk – the risk of non-performance of contractual obligations on invested assets.
- 3) Political risk – the investment risk associated with changes in domestic or foreign government policies.
- 4) Concentration risk – the risk due to increased exposure to major asset defaults (of a single security issuer or class of security issuers), or economic conditions (if business is concentrated in a certain industry sector).

(b)

- (i) Determine if XYZ Life is compliant based on its credit risk management framework. Justify your answer.
- (ii) Assume there is a future cash flow of 500 million expected this year due to new business.

Assess how much in additional BBB-rated bonds XYZ Life can purchase while remaining compliant with its desired credit quality exposure.

- (iii) Assume the Expected Loss Score is currently 0.80%.

Evaluate how acquiring the SPIA block from Simple Life will impact the expected loss score.

Commentary on Question:

To earn full credit in Part (i), candidates need to compare the current Expected Loss Score against its limit, and discuss compliance under the SAA/TAA requirements.

Candidates generally did well on Part (i) in calculating the expected loss and comparing to the Expected Loss Score Limit of 1.35%.

Some candidates stopped at comparing to the Expected Loss Score limit and did not discuss the Strategic Asset Allocation and Tactical Asset Allocation. When calculating the expected loss, some candidates used the total asset mix per term instead of allocating for each term uniformly.

Part (ii) asks for BBB-rated bonds under the S&P rating system, whereas information in the question was provided under the Moody's system. BBB rating is equivalent to Baa. Many candidates were unable to make this translation; it was not intended to test whether candidates could make this translation so therefore candidates received full credit for performing the calculation correctly using either the Baa or <Baa rating.

3. Continued

Part (ii) requires the candidate to demonstrate their understanding of the actual asset mix and the tactical allocation. A common mistake was to calculate the impact on the Expected Loss Score instead of using the Tactical Asset Allocation.

Candidates struggled with part (iii). Most candidates failed to gather all the information from the case study. Partial credits were given for candidates that demonstrated understanding of the quality of the SPIA portfolio compared to the given expected loss of 0.8%. Many candidates did not use duration greater than 5 years for the expected probability of default.

(i)

Expected Loss Score = market value weighted expected probability of default

As the term of bonds is uniformly distributed across 1-5 years, for each rating, the expected probability of default is the average of probabilities from all five terms:

Aaa: $(0.01\% + 0.03\%) / 5 = 0.01\%$
Aa: $(0.01\% + 0.03\% + 0.05\% + 0.10\% + 0.12\%) / 5 = 0.06\%$
A: $(0.03\% + 0.10\% + 0.17\% + 0.25\% + 0.35\%) / 5 = 0.18\%$
Baa: $(0.10\% + 0.30\% + 0.50\% + 0.75\% + 1.00\%) / 5 = 0.53\%$
<Baa: $(0.65\% + 1.75\% + 3.00\% + 4.20\% + 5.30\%) / 5 = 2.98\%$

Expected Loss Score = $0.01\% * 2.1\% + 0.06\% * 13.1\% + 0.18\% * 64.2\% + 0.53\% * 20.2\% + 2.98\% * 0.4\%$
= 0.2428%
< 1.35% Expected Loss Score limit, no violation in this category.

The actual asset mix deviates from the strategic asset mix (SAA), but is still within the tactical asset allocation (TAA), no violations.

Based on the above, XYZ Life is compliant under its credit risk management framework.

(ii)

Based on the TAA, XYZ Life's upper limit for Baa bond allocation is
 $25\% * 1.5 \text{ billion} = \$375\text{m}.$

The upper limit for Baa bond allocation after a year of new business sales is
 $25\% * (1.5 \text{ billion} + 500 \text{ million}) = \$500\text{m}.$

XYZ Life's current Baa holdings is
 $20.2\% * 1.5 \text{ billion} = \$303\text{m}.$

Therefore, its current additional capacity for Baa bonds is
 $\$62\text{m} (= 375\text{m} - 303\text{m}).$

3. Continued

After one year of new business sales, the additional capacity for Baa will be \$197m (= 500m – 303m).

(iii)

Based on the data from the case study, SPIA from Simple Life has \$1.81 billion (page 23) assets, duration 5+ years (page 25), rating of 2.5 (page 25) (in between Aa and A).

Expected Loss Score = market value weighted expected probability of default

Expected Loss before acquiring SPIA business = 0.8% (given in question)

Expected Loss after acquiring the SPIA business:

SPIA Expected Loss Score is = average of (0.12%, 0.35%) = 0.235%, expected probability of default with term greater than 5 years

Expected Loss Score = $(0.80\% * 1.5 \text{ billion} + 0.235\% * 1.81 \text{ billion}) / (1.5 \text{ billion} + 1.81 \text{ billion})$
= 0.49%

Therefore, the Expected Loss Score decreases from 0.80% to 0.49%.

4. Learning Objectives:

3. The candidate will demonstrate an understanding of important risk measurement techniques along with their uses and limitations, and be able to perform risk measurement calculations.

Learning Outcomes:

- (3a) Analyze and evaluate risk measures & estimators (e.g., Value-At-Risk, Conditional Tail Expectations, etc.)
- (3c) Analyze and evaluate parameter risk

Sources:

Diversification: Consideration on Modelling Aspects & Related Fungibility and Transferability, CRO, Oct 2013, pp. 4 – 14, 19 - 30

LRM-121-14: Value at Risk - Uses and Abuses

LRM-111-14: Value-At-Risk: Evolution, Deficiencies and Alternatives

Commentary on Question:

Commentary listed underneath question component.

Solution:

- (a) Explain the advantages and disadvantages of the following methodologies for risk aggregation:
 1. Simple Summation
 2. Variance-covariance matrix
 3. Copulas
 4. Integrated models

Commentary on Question:

Most candidates received full credit for this part of the question.

Candidates did not need to include all the advantages and disadvantages listed below to receive full credit.

1. Simple Summation:
 - a. Advantages:
 - i. Simple to calculate.
 - ii. Provides an upper bound on the level of risk.
 - iii. Easy to explain

4. Continued

- b. Disadvantages:
 - i. Does not reflect any correlations between risks
 - ii. If any correlations exist, not a realistic picture of risk aggregation
- 2. Variance-Covariance matrix
 - a. Advantages:
 - i. Captures interactions/correlations between risks
 - ii. Relatively easy to implement, calculate and communicate
 - b. Disadvantages:
 - i. Assumes linear and constant interactions between risks
 - ii. Implies underlying risk distributions are elliptically distributed
- 3. Copulas
 - a. Advantages:
 - i. Captures interactions/correlations between risks
 - ii. Can capture the skewness, non-linearity and heavy tails in the underlying distributions
 - b. Disadvantages:
 - i. Requires estimation of the distributions for all underlying risk categories
 - ii. Can be very computationally demanding
 - iii. There is heavy parameter risk
 - iv. Communication of results can be difficult
 - v. Requires expertise to build and use.
- 4. Integrated Models:
 - a. Advantages:
 - i. Complete picture of the risks being aggregated
 - ii. All material interactions/correlations can be considered
 - b. Disadvantages:
 - i. Very complex to implement and operate
 - ii. Can be very computationally demanding
 - iii. There is heavy parameter risk
 - iv. Requires expertise to build and use.

4. Continued

- (b)
 - (i) Critique the implied assumptions for risk aggregation and risk diversification in Opinion 1.
 - (ii) Critique the implied assumptions for capital fungibility and transferability in Opinion 2.
 - (iii) Describe diversifying strategies NYC Financial can use to manage the type and amount of risk in their portfolio.

Commentary on Question:

Candidates were expected to either critique assumptions or describe diversifying strategies. Full credit was not given if a critique of the assumptions was not given.

- (i) *Most candidates performed well on this part of the question as they were able to discern that the opinion appeared to assume risks were aggregated without considering diversification. That said, very few candidates pointed out that there was not enough information to determine whether the low/no correlation assumed in the opinion was justified or not.*
 - (ii) *While many candidates were able to define capital fungibility and transferability, few actually critiqued the implied assumptions of these characteristics and thus did not receive full credit.*
 - (iii) *Most candidates were able to outline several strategies NYC Financial could use to manage the type and amount of risk. The majority of candidates received full credit on this part.*
- (i) The implied assumption in Opinion 1 is that the risk aggregation was done using a simple summation or assumed very little diversification benefit (< 10m). This would result in total capital of 100m and risk of 110m. This supports the assertion of capital insufficiency.

If there is any correlation between the legal entities then using simple summation would not be appropriate as it would not reflect any diversification benefit that may exist.

We do not have enough information to determine whether the assumption of no correlation is reasonable or whether another risk aggregation method was used and in fact the diversification benefit was less than 10 million.

4. Continued

- (ii) Fungibility of capital refers to the ability to use funds in one of the entities in a group to absorb losses elsewhere within the group. Transferability refers to the actual ability to transfer own funds from one entity in a group to another within a certain timeframe.

The implied assumption is that capital at NYC is fungible as JFK has more risk than available capital on a standalone basis. Opinion 2 is assuming that losses in JFK can be absorbed by capital elsewhere in NYC. This is a reasonable assumption as there are many methods to move capital within a group (eg: intra-group loans, reinsurance) and this assumption is often used as the basis for economic capital modelling.

The Opinion also assumes that NYC's capital has high transferability such that capital is movable within a reasonable timeframe between entities both legally and operationally. This is a reasonable opinion if NYC has good liquidity management practices.

- (iii) Pooling similar and sufficiently independent risks will reduce the volatility of claims and allow for more predictable results.

Pooling dissimilar risks (eg: different geographies or markets) allows for enterprise wide diversification.

Combining risks with offsetting outcomes can provide internal hedges. Eg: Life insurance and payout annuities.

Limiting risk concentrations with management actions (eg: reinsurance, underwriting for particular risks) can reduce the magnitude of risks and allow more certainty in the risk.

- (c) Recommend which risk to assume from each pair. Justify your answer.

- (i) Risk 1 and risk 2.

- (ii) Risk 2 and risk 3.

- (iii) Risk 1 and risk 3.

Commentary on Question:

Candidates were asked to recommend one risk for NYC Financial to assume out of a pair of risks. Credit was only given for using the criteria that was of the most concern to NYC (downside risk at the 75th percentile). To justify the risk selection both the 75th percentile and the amount of downside risk should be considered.

4. Continued

Some candidates misinterpreted the question and instead added the risks, re-ordered them or recommended assuming the risk with the largest loss. That said, many candidates achieved full credit on this question.

NYC financial is mostly concerned with downside risk and focuses on the 75th percentile. Metrics such as VaR (which indicate the severity of downside risk at the 75th percentile) and CTE (which also gives an indication of the thickness of the tail of the downside risk at the 7th percentile) can be used to choose the appropriate risk.

VaR(75) is the outcome for which the probability is at least 75%. For each risk, since five scenarios are given, this would be the 4th worst result. CTE(75) would then be the average of the 4th and 5th worst result.

Risk	VaR(75)	CTE(75)
Risk 1	-1	$(-1 + -2)/2 = -1.5$
Risk 2	-1	$(-1 + -5)/2 = -3.0$
Risk 3	-1	$(-1 + -5)/2 = -3.0$

Will assume negative outcomes are undesirable.

- (i) Risk 1 has the same VaR(75) as Risk 2 but has a more desirable CTE(75). This implies that the outcomes beyond the 75th have less downside risk for Risk 1 than Risk 2. Risk 1 should be assumed.
- (ii) Risk 2 and Risk 3 have the same VaR(75) and CTE(75). We will need to recommend a risk based on different criteria than what is laid out in the question.

The expected returns of both risks are also the same but 3rd worst value for Risk 2 is better than Risk 3. Therefore, since NYC is concerned with downside risk, should recommend Risk 2.

- (iii) For the exact same reasons as part i) Risk 1 should be selected.