ILA LRM Model Solutions
Fall 2014

1. **Learning Objectives:**

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

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:

(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.

(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-115-14: Chapter 22 of Life Insurance Accounting, Asset/Liability Management

LRM-114-14: ALM for Insurers

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

Commentary on Question:

Commentary listed underneath question component.

1. Continued

Solution:

(a) Define each of the following ALM methods:

(i) Exact cash flow matching

(ii) Cash flow testing

(iii) Duration matching (immunization)

(iv) Convexity matching

(v) Dynamic financial analysis

Commentary on Question:
Most candidates were able to answer parts (i)-(iv), but many struggled fully explaining dynamic financial analysis (DFA). To receive full credit for part (v), the candidate needed to either provide a description of DFA and list the components or list and provide a description of each of the components.

(i) Exact cash flow matching

Eliminate interest rate risk by buying assets with cash flows that exactly offset liability cash flows.

(ii) Cash flow testing

Assess the potential cash flow impact of projecting cash flows under various interest rate scenarios.

(iii) Duration matching (immunization)

Matching the first derivative of the present value of liability and asset cash flows with respect to interest rates (duration) so that their values move in tandem for small change in interest rates.

(iv) Convexity matching

In addition to duration matching, also matching the second derivative of the present value of liability and asset cash flows with respect to interest rates (convexity) so that their values move in tandem for larger changes in interest rates.

1. Continued

(v) Dynamic financial analysis (DFA)

Allows the insurer to evaluate the company's position under a range of scenarios and to assess the impact of different strategic moves. DFA consists of the following components:

1.) Summarize the initial condition
2.) Create a scenario generator
3.) Build a financial calculator to translate scenarios into financial results
4.) Develop an optimizer to evaluate different strategic alternatives
5.) Analyze the results

(b) Define the following risks and state how they would impact each product sold by JSW:

(i) Disintermediation risk

(ii) Reinvestment risk

Commentary on Question:
Most candidates were able to successfully define each risk but many failed or omitted to explain how each risk impacted the specific products.

(i) Disintermediation risk

Risk of having to sell assets at depressed values to cover cash outflows when interest rates rise.

10-year Term

Minimal risk since term has little to no cash surrender value.

Permanent Life

Since permanent life policies can have significant cash surrender values, if interest rates rise policyowners would be inclined to surrender their policies in order to seek higher returns elsewhere.

(ii) Reinvestment risk

The risk of reinvesting at lower-than-expected rates when liability cash flows extend further in the future than asset cash flows.

1. Continued

10-year Term

Minimal risk since there are many assets available that cover the 10 year duration of the liability.

Permanent Life

The duration of the liability for permanent life insurance often exceeds the duration of any assets available in the marketplace (generally 30 years), which allows for the potential for reinvestment risk.

(c) Explain how JSW could revise its cash flow matching methodology to reduce interest rate risk.

Commentary on Question:
This question was intended to have the candidate suggest that the company adopt a more centralized/holistic ALM function. However, almost all candidates just suggested an alternative ALM technique instead of exact cash flow matching which we also excepted. To receive full credit for a "centralized/holistic" answer one would need to both identify the opportunity and explain in details the benefits of a centralized ALM function. In contrast, to receive full credit for an "alternative strategy", one needed to identify the disadvantages of exact cash flow matching, propose an alternative method, describe why the alternative method would be better, and then mention the opportunity to combine both products into a centralized ALM function.

"Centralized/holistic" Answer

Currently, JSW has separate ALM groups and separate assets backing each product. JSW could utilize a holistic approach to help reduce their interest rate risk. By consolidating their ALM groups and combining the assets backing each product, JSW would be no worse off with respect to cash flow mismatch. However, this would increase their flexibility in matching liability cash flows as well as reduce the possibility of mismatch and increase their ability to invest in higher yielding assets.

"Alternative Strategy" Answer

Even though exact cash flow matching eliminates interest rate risk, it is not a practical ALM technique due to the uncertainty of liability cash flows and the reduced investment flexibility the technique offers. An alternative approach would be to match the duration and convexities of the assets and liabilities. This technique would allow JSW more flexibility with their investment options then with exact cash flow matching.

1. Continued

In addition, JSW could also combine their ALM groups into a centralized group in order to take advantage of any efficiencies this might offer.

(d)

(i) Identify the risks associated with your colleague's strategy.

(ii) Identify another hedging strategy and explain the risks it introduces.

Commentary on Question:
Many candidates failed to identify that the market risk in question related to a guaranteed minimum death benefit (GMDB) on a variable life insurance policy and that the colleague was suggesting a static hedge. In particular, many candidates overlooked the fact that in a variable life insurance contract the assets are invested in the underlying funds so there is no upside risk. Note that even though static hedges are explicitly tested in the Life Pricing exams, they are generally considered common knowledge.

Part (ii) was looking for a description of dynamic hedging and then to compare the pros and cons versus dynamic and static hedging. Reinsurance was also an accepted an alternative hedging strategy.

(i) Identify the risks associated with your colleague's strategy.

My colleague is proposing a static hedge to help reduce the market risk related to the guaranteed minimum death benefit (GMDB). The following are some risks with this proposal:

- Lack of availability of options with expiry dates matching long-term death benefits.
- Longer term options, in general, have greater credit risk.
- Uncertainty of projected death benefits relating to potential difference in actual to expected mortality and lapse experience.

(ii) Identify another hedging strategy and explain the risks it introduces.

I propose implementing a dynamic hedge by constructing a hedge portfolio with equity market sensitivities (greeks: delta, theta, etc.) that match those of the liabilities. In theory, changes in the hedge portfolio will offset changes of the guaranteed liability.

1. Continued

The following are some risks that dynamic hedging introduces:

- Credit Risk: The hedge portfolio will still be exposed to counterparty credit risk but should be lower than the longer term options needed for the static hedge.
- Basis Risk: Basis risk, the risk of imperfect hedging, is present with both strategies; however, dynamic hedging allows the opportunity to rebalance whereas static hedging is locked in.
- Operational Risk: Since dynamic hedge may require frequent rebalancing, the additional transaction costs may outweigh the benefits compared to a static hedge.
- Catastrophic Risk: Dynamic hedging, in extreme circumstances, may prove ineffective and could result in sizeable losses.

2. 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.)

(3b) Apply and analyze scenario and stress testing in managing risk including the calibration and setting of assumptions

Sources:

C-25-07, An Introduction to Risk Measures for Actuarial Applications, Hardy

Chapter 14: Stress Testing, Jorion
Getting to Know CTE , Ingram

ERM - 102 - 12 Value-At-Risk: Evolution, Deficirencies and Alternatives - Vozian 2010 (also FE-C181-11)

Commentary on Question:

Commentary listed underneath question component.

Solution:

(a) Compare and contrast the following tail risk calculations:

(i) 95% VaR

(ii) 95% CTE

Commentary on Question:

Most of the candidate did well on this question

(i) α-VaR represents the loss that, with probability α will not be exceeded

(ii) the CTE is the expected loss given that the loss falls in the worst $(1 - \alpha)$ part of the loss distribution

(b) Calculate the 95% VaR and 95% CTE for X+Y, assuming X and Y are independent. Show all work.

Commentary on Question:

Most candidates did poorly on the calculation because they failed to develop the distribution of X+Y. Some even confused VAR with variance.

2. Continued

Values for X+Y:					
	X	5	80	500	0
Y		0.8	0.17	0.03	0
10	0.85	15	90	510	10
120	0.145	125	200	620	120
2000	0.005	2005	2080	2500	2000
0	0	5	80	500	0
Probabilities for X+Y:					
	X	5	80	500	0
Y		0.8	0.17	0.03	0
10	0.85	0.68000	0.14450	0.02550	0
120	0.145	0.11600	0.02465	0.00435	0
2000	0.005	0.00400	0.00085	0.00015	0
0	0	0	0	0	0

Rank	Value	Probability
1	2500	0.00015
2	2080	0.00085
3	2005	0.00400
4	620	0.00435
5	510	0.02550
6	200	0.02465
7	125	0.11600
8	90	0.14450
9	15	0.68000

The VaR is set at 200 which is the smallest number that gives the property that the loss will be smaller with at least 95% probability.

CTE95 = E[X+Y|X+Y>=200] = =(2500*0.00015 + 2080*0.00085 + 2005*0.004 + 620*0.00435 + 510*0.0255 + 200*0.01515)/0.05 = 577.9

(c) Explain the shortcomings of VaR and how stress testing can complement standard VaR models.

Commentary on Question:
Most candidates were able to identify and provide a brief explanation on one or more of the shortcomings of VAR. Some candidates just identified shortcomings without an explanation. As the questions asked to 'explain' shortcomings, no credit was awarded if no explanation was provided.

2. Continued

Shortcoming of VAR
1. VAR is not coherant – it fails the sub-additivity property and doesn't consider tail risk
2. VAR assumed normal distribution - the real distribution return is not normally distributed, no skew in tail
3. VAR calculation method is not prescribed - different companies use different methodologies to calculate VAR
4. Parametric risk - VAR Historical data and observation period, can be distorted by outliers and dependent on data used in parameter calibration
5. Agency problem – VAR can be manipulated by manager to hide risks
6. Regulatory disclosure - No standard VAR reporting template are enforced by the regulator which gives rise to risk of misrepresentation

How can stress testing be complement to VAR
VaR are based on recent historical data which fails to identify extreme unusual situations and stress testing can help manage situations that could cause extraordinary losses through the utilization of i) scenario analysis; ii) stressing models and iii) policy responses. It helps the managers paint a more realistic picture of tail risks.

3. Learning Objectives:

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

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:

(2a) Identify, categorize and evaluate potential sources of risk in products including but not limited to mortality, morbidity, and lapse.

(2c) Describe and evaluate the other risks an insurance company faces including operational, marketplace and expense risks.

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

Sources:

Sweeting Chapter 14: Quantifying Particular Risks; 14.6 Liquidity Risk; 14.8 Demographic Risk & 14.9 Non-Life Insurance Risk

A New Approach for Managing Operational Risk - SoA Research 2008.]

Commentary on Question:

Commentary listed underneath question component.

Solution:

(a) Describe primary sources of Demographic Risk and explain how they can be modeled.

Commentary on Question:

To get full marks, candidates needed to list and describe the 4 ***primary*** *sources of demographic risk (from the list of 5 below), and give an explanation on how the risk can be modeled. Few candidates were able to describe the risks, and even fewer candidates explained how the risk can be modeled.*

Level Risk: Risk that the underlying mortality of a particular population differs from that assumed.

- Risk can be modeled through Experience Rating and Risk Rating

Volatility Risk: Risk that the mortality experience will differ from that assumed due to there being a finite number of lives in the population considered.

- Risk is best modeled stochastically (i.e. Binomial is optimal but Poisson is acceptable)

3. Continued

Catastrophe Risk: Risk of large losses due to some significant event increasing mortality rates beyond simple random volatility.

- Risk can be modeled using scenario analysis or copulas

Trend Risk: Risk that mortality rates will improve over time at a rate different to be assumed.

- Risk can be modeled through parametric or non-parametric (i.e. P-spline) methods

Lapse risk: Risk that unexpected persistency could lead to financial losses.

- Risk can be modeled by combining company's experience with industry experience based on credibility.

(b) Calculate the 95% VaR for the Net Amount at Risk (NAR) for a 1-year horizon.

Commentary on Question:
Candidates did not do well on this part. A lot of candidates did not realize that Pr(l(x+1) = n) represents the probability that n individuals are alive. As a result, very few candidates set up the distribution table correctly, and realized that P(X<=3) = 0.95. Candidates who set up the distribution table correctly but instead picked n = 4, got majority of the mark.

A binomial process is the most appropriate to calculate the 95% VaR for the NAR due to high mortality rate.

n	P(X=n)	P(X<=n)
0	0.1969	0.1969
1	0.3474	0.5443
2	0.2759	0.8202
3	**0.1298**	**0.9500**
4	0.0401	0.9901
5	0.0085	0.9986
6	0.0012	0.9999
7	0.0001	1.0000
8	0.00001	1.0000
9	0.0000	1.0000
10	0.0000	1.0000

P(X<=3) = 0.95
VaR(95) = 100,000*3 – 15,000*3 = 255,000

3. Continued

(c) Describe the risks XYZ may face from its claims paying process.

Commentary on Question:
This question was not well answered but most of the candidates received partial marks. Candidates lost points for not providing sufficient number of risks.

- This is an example of process risk.
- XYZ faces reputation risk as it has not kept its promise and this may be negatively portrayed in the media.
- The slow payment of claims could lead to legal/litigation risk.
- The slow payment of claims could also damage Mirage's competitiveness in the market; they could lose existing and potential customers.

(d) As part of your risk review of XYZ, you interview a few key employees of the company. Critique each of the following three statements:

(i) One of XYZ's top sales agents stated, "*Sometimes it is necessary to change the medical declaration or smoking status on an application for a life insurance product in order to get the customer a premium rate they can afford. There is really no downside risk in doing this; I get commission for selling the policy, the customer gets insurance, and the company gets new sales.*"

(ii) The Chief Financial Officer of XYZ said, "*Our operational risk management focus should be on risks that have a high likelihood and a high impact. Those are the risks that are most dangerous to the company.*"

(iii) The Manager of actuarial modeling stated, "*The best way to model operational risk is to use internal data. Since every company faces unique operational risks, external data would be irrelevant. When gathering internal data, we will exclude any outliers that could greatly distort the mean.*"

Commentary on Question:
Candidates performed well on this part compared to other parts of this question. Well prepared candidates were able to recognize that there were issues with all the statements above and were successfully able to critique them. On the other hand, very few candidates adequately explained the external data portion in Part (iii).

3. Continued

(i) This is an example of principal-agent. It is not a criminal risk because the agent doesn't intend to hurt anyone, and truly believes that it is beneficial for everyone.

The agent is wrong when he states there is no downside risk. Changing underwriting information to increase sales may nominally benefit him and the company, but in the long run it is not in the company's best interest.

In addition, changing the underwriting info on life products exposes the company to mortality risk. The company may think this business has lower expected mortality which will lead to inadequate reserves and possibly inadequate future pricing.

(ii) The high likelihood risks are not the most dangerous to a company because these risks are not unexpected and as a result, the company should have already prepared for them.

The statement is consistent with traditional operational risk management, which focuses on commonly observable threats but the largest risks go unrecognized.

Instead, company should focus on high severity and low frequency events because these events are the ones that can pose the biggest risks to a company.

(iii) External data can be very valuable when modeling operational risk. When using external data, you assume that operational risks are independent so, for example, 10 years of data from 20 companies represents 200 years of data. This is more valuable than internal data points from one company when assessing tail event.

The outliers should not be ignored in the modeling data. In operational risk, the outliers are usually the most relevant since they represent the large, rare events that could pose the biggest threat to the company.

4. Learning Objectives:

1. The candidate will demonstrate an understanding of the principles of Risk Management.

Learning Outcomes:

(1a) Define and evaluate risk.

(1d) Describe how risk management techniques may be used to manage capital deployed by insurers and how they impact strategic decision making.

Sources:

Risk Appetite: Linkage with Strategic Planning

ILA-C124-10: Insurance Criteria: Refining the Focus of Insurer ERM Criteria, June 2006 (exclude pp. 20-26 (property/Casualty -Nonlife Insurance Risk)

Commentary on Question:

Commentary listed underneath question component.

Solution:

(a)

(i) Calculate the profit margin and risk-adjusted return on capital (RAROC) for each proposed product.

(ii) Recommend which UL product(s) ABC Life should add to its portfolio, if any. Justify your answer.

Commentary on Question:

The general concept of using RAROC to compare the options was fairly well understood

Common mistakes were missing the PV factors in the RAROC formula and not comparing the results against the hurdle rate.

Profit Margin $= \frac{Underwriting\ Profit}{Annual\ Premium}$

RAROC

$= \frac{[(PV\ of\ Underwriting\ Profit) + (PV\ of\ Investment\ Income\ on\ Capital)]}{PV\ of\ Required\ Capital} * (1 - tax)$

UL #1

Profit Margin $\frac{15}{110}$ =13.64%

RAROC $= \frac{2\times15+8.5}{2\times140} * (1 - .3) = 9.63\%$

UL #2

Profit Margin $\frac{12}{135}$ =8.89%

4. Continued

$$\text{RAROC} = \frac{2\times12+10.5}{2\times130} * (1-.3) = 9.29\%$$

UL #3
Profit Margin $\frac{9.5}{100}$ =9.50%

$$\text{RAROC} = \frac{2\times9.5+7.5}{2\times100} * (1-.3) = 9.28\%$$

UL Product #1 has a RAROC of 9.63% which is above the hurdle rate of 9.5%, however, ABC Life does not have enough available capital to support this product. UL #2 and UL #3 are below the hurdle rate and should not be selected as they would deplete shareholder value.

I would not recommend ABC Life add any of these products to its portfolio.

(b) Calculate the maximum duration mismatch allowed based on duration matching.

Commentary on Question:
This question overall was done poorly.
Most students understood that Assets – Liability = Surplus. Some attempted to use the duration to calculate what a change in interest rate would do to surplus.
Several students missed that a 1 in 200 year event meant a 1/200=.005 probability.
Few students factored in the diversification benefit and budgeted risk appetite for equity risk.

ABC's policy is not to lose more than 150 of surplus for a 1 in 200 year event.

Aggregated Risk Appetite = Budgeted Risk Appetite + Diversification Benefit = 150 +94

Risk Appetite for Interest Rate Risk = Aggregated Risk Appetite – Budgeted Risk Appetite for Equity Risk = 244 - 100

Change in surplus must not exceed 144 for interest shock.

Change in Liability after -3% shock
=900*20(-(-3%))=540

Change in Assets after -3% shock
=1200*D*(-(-3%))

36*D – 540 >= -144
D=11

Duration mismatch cannot exceed 20 – 11 = 9

5. Learning Objectives:

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

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:

(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.

(4a) For an ALM model
- (vi) Select appropriate assumptions and scenarios
- (vii) Model dynamic behavior of both assets and liabilities
- (viii) Model and explain various strategies, including hedging
- (ix) Analyze and evaluate results (including actual v. projected differences)
- (x) 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 –100-14 Chew Ch 31 – theory of risk capital in finance

Case Study

Commentary on Question:

In general, candidates performed poorly on this question. To earn significant points, candidates were expected not only to explain relevant concepts, but also to apply them to the Simple Life case study as well. Candidates received full marks if they have correctly explained the context of the statement and provided at least one example relevant to the case study.

Areas where candidates performed well:

- *Recognizing that standard accounting methods fail to adequately account for risk, which could produce either under- or over-statement of profit*
- *Defining risk capital as amount required to insure any loss in net assets relative to risk-free investment of net assets*
- *Diversification benefits arising from low correlations among existing lines of business*
- *Commenting on potential diversification benefits not only among lines of business, but also between companies in Lyon group and from considering new lines*
- *Some candidates made direct reference to economic capital and risk-based capital in Simple Life financial statements*

5. Continued

- *Stating profitability and IRR distorted by using allocation of risk capital using stand-alone basis*
- *Providing examples of information risks, e.g. underwriting concerns for term block*

Areas where candidates did not perform well:
- *Not making any reference to the case study*
- *Stating that risk depends on form of financing*
- *Stating "correct/incorrect" or "true/false" without any supporting reasoning*
- *Stating full allocation of capital among lines of business is feasible*

Solution:
Validate each of the following statements based on Chew's paper "Theory of Risk Capital in Financial Firms" and explain how each statement applies in the context of Simple Life or its holding company, Lyon Corporation:

(i) "*Standard methods of accounting can fail to measure risk capital and its associated costs correctly in the calculation of a company's profitability, resulting in an overstatement of profitability.*"

- Standard methods of accounting often fail to include gains or losses from insurance along with gains and losses from all other assets when calculating profitability
- Omission of risk capital expended overstates profits when underlying assets perform well and understates when assets perform poorly
- From case study:
  (a) Impact of risk capital is not clearly presented in current income statements
  (b) Value of parental guarantees by Lyon to Simple Life is not reflected

(ii) "*The amount of risk capital depends only on the riskiness of net assets and not at all on the form of financing of net assets.*"

- Gross assets can be risky, but if they match the liabilities, the net assets are riskless
- Risk capital is independent of form of financing
- Risk capital is value of guarantee that pays for any underperformance of assets relative to investing net assets at risk-free rate
- From case study:
  (a) Simple Life looks to achieve some level of asset/liability matching (including hedging) which would reduce amount of risk capital required
  (b) More explicit determination of risk capital required to determine net assets

5. Continued

(iii) "*The risk capital of a multi-business firm can be less than the aggregate risk capital of the businesses on a standalone basis.*"

- When businesses are not perfectly correlated with one another, there will be a diversification benefit
- Risk capital will mirror the diversification
- The businesses coinsure each other
- From case study:
  (a) Balance sheet from Simple Life shows both risk-based and economic capital at parent level
  (b) There is diversification from multiple companies and geographic locations

(iv) "*The full allocation of risk capital across individual businesses of a multi-business firm is not feasible.*"

- Full allocation of capital overstates the amount of marginal capital required
- Risk capital evaluated on standalone basis overstates marginal capital required
- Riskiness of net assets affected by correlations between business units
- From case study:
  (a) Risk calculated for each unit separately. Aggregate risk calculated using correlation matrix based on prior 10 years of market movements. Negative correlations floored at 0
  (b) Lyon overall credit rating is BBB+. Rating reflects weakened capital position from acquisition failure (A Health Company) offset by financial success and niche position of A P&C Company

(v) "*The true profitability of individual businesses can be significantly distorted by the attempt to fully allocate the risk capital of a multi-line business.*"

- With diversification, businesses that appear unprofitable due to high risk capital requirements on a standalone basis might appear profitable when combined with business having offsetting risks
- True profitability of businesses within multi-business firm will be distorted if using standalone risk capital
- Similar challenges occur even if using marginal risk capital
- From case study:
  (a) Current level of analysis does not support full allocation as diversification benefits not attributable to lines of business
  (b) Need better analysis of marginal risk capital
  (c) Profitability by line not clear without reflecting correct capital requirements

5. Continued

(vi) "*The economic costs of risk capital to the firm are the spreads on the price of asset insurance arising from information costs due to moral hazard or adverse selection and agency costs.*"

- Expected profit should reflect economic cost of capital
- Transacting is not costless: requires a spread over fair market value
- Spreads are "deadweight" and arise from cost of economic risk capital
- Spreads can be lowered by being more transparent in reporting, but can lead to loss of competitive advantage
- From case study:
  (a) Surplus (net assets) allocated by line of business within general account
  (b) Can only track spread costs at aggregate corporate level
  (c) Lyon and Simple Life may not be able to provide level of detail required to achieve greater transparency