# CURATED PAST EXAM ITEMS
# - Questions -

## CP 351– Asset Liability Management

**Important Information:**

- These curated past exam items are intended to allow candidates to focus on past SOA fellowship assessments. These items are organized by topic and learning objective with relevant learning outcomes, source materials, and candidate commentary identified. We have included items that are relevant in the new course structure, and where feasible we have made updates to questions to make them relevant.
- Where an item applies to multiple learning objectives, it has been placed under each applicable learning objective.
- Candidate solutions other than those presented in this material, if appropriate for the context, could receive full marks. For interpretation items, solutions presented in these documents are not necessarily the only valid solutions.
- Learning Outcome Statements and supporting syllabus materials may have changed since each exam was administered. New assessment items are developed from the current Learning Outcome Statements and syllabus materials. The inclusion in these curated past exam questions of material that is no longer current does not bring such material into scope for current assessments.
- Thus, while we have made our best effort and conducted multiple reviews, alignment with the current system or choice of classification may not be perfect. Candidates with questions or ideas for improvement may reach out to education@soa.org. We expect to make updates annually.
    - **September 2026**: Spring 2025 exam questions have been added and mapped to the 2026-2027 curriculum. The questions and solutions for the Spring 2025 questions can be found at: Past Exam Questions and Solutions.


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# CP 351
# LEARNING OBJECTIVE 1

**CATEGORIZED PAST EXAM QUESTIONS**

**Learning Objectives:** The candidate will understand the objectives of Asset Liability Management (ALM).

| Exam | Question Part | Exam Points | Source Material | Learning Outcomes |
|---|---|---|---|---|
| QFIIRM Fall 20 | 5a | 1 | Quantitative Enterprise Risk Management, Ch. 2: Risk Taxonomy | 1c |
| QFIIRM Spring 21 | 1c | 1.5 | Quantitative Enterprise Risk Management, Ch. 2: Risk Taxonomy | 1c |
| QFIIRM Fall 21 | 2b | 1 | Quantitative Enterprise Risk Management, Ch. 2: Risk Taxonomy | 1c |
| QFIIRM Spring 22 | 2a | 1 | Quantitative Enterprise Risk Management, Ch. 2: Risk Taxonomy | 1c |
| QFIIRM Spring 22 | 3a | 2 | Quantitative Enterprise Risk Management, Ch. 2: Risk Taxonomy | 1c |
| QFIIRM Spring 22 | 4a | 3 | Financial Enterprise Risk Management, Ch. 20: Case Studies | 1b |
| QFIIRM Spring 22 | 4b | 3 | Financial Enterprise Risk Management, Ch. 8: Risk Identification | 1c |
| QFIIRM Spring 22 | 4c | 2 | Financial Enterprise Risk Management, Ch. 8: Risk Identification | 1c |
| QFIIRM Fall 23 | 1a | 1 | Financial Enterprise Risk Management, Ch. 8: Risk Identification | 1c |
| QFIIRM Fall 23 | 7a | 0.5 | Quantitative Enterprise Risk Management, Ch. 2: Risk Taxonomy | 1c |
| QFIIRM Spring 24 | 1a | 3 | Quantitative Enterprise Risk Management, Ch. 2: Risk Taxonomy | 1c |
| QFIIRM Spring 24 | 2a | 1 | Quantitative Enterprise Risk Management, Ch. 2: Risk Taxonomy | 1c |
| QFIIRM Spring 24 | 2b | 1 | Quantitative Enterprise Risk Management, Ch. 2: Risk Taxonomy | 1c |
| QFIIRM Spring 24 | 9a | 1.5 | Quantitative Enterprise Risk Management, Ch. 2: Risk Taxonomy | 1c |

| | | | | |
|---|---|---|---|---|
| QFIIRM Fall 24 | 2c | 1.5 | Financial Enterprise Risk Management, Ch. 8: Risk Identification | 1c |
| QFIIRM Fall 24 | 9c | 1 | Quantitative Enterprise Risk Management, Ch. 20 Case Studies | 1b |
| QFIPM Fall 20 | 6a | 1 | IAA Risk Book | 1a |
| QFIPM Fall 20 | 6b | 1 | IAA Risk Book | 1a |
| QFIPM Fall 20 | 6c | 1 | IAA Risk Book | 1a |
| QFIPM Fall 20 | 6d | 2 | IAA Risk Book | 1a |
| QFIPM Spring 22 | 1a | 1 | IAA Risk Book | 1a |
| QFIPM Spring 22 | 1b | 2 | IAA Risk Book | 1a |
| QFIPM Spring 22 | 1c | 1.5 | IAA Risk Book | 1a |
| QFIPM Spring 22 | 1d | 1.5 | IAA Risk Book | 1a |
| ILA LAM Fall 23 | 3c | 6 | CP351-101-25: ALM for Life, Annuities, and Pensions (section 3)<br>CP351-105-25: Chapter 16 of Asset/Liability Management of Financial Institutions, Tilman 2003 | 1d |
| ILA LAM Spring 24 | 3b | 2 | CP351-101-25: ALM for Life, Annuities, and Pensions (section 3)<br>CP351-105-25: Chapter 16 of Asset/Liability Management of Financial Institutions, Tilman 2003 | 1d |

**QFI IRM Fall 2020 Question 5**

Source Material: Quantitative Enterprise Risk Management, Ch. 2: Risk Taxonomy

Learning Outcome: 1c) Demonstrate an understanding of various ALM risks

You have been hired by a group of shareholders of Flying High, which provides jets to airline companies. Flying High, under the recommendation of the head engineer, is rushing to develop a new jetliner as it seeks an edge in the competitive jet production market.

Flying High has one major competitor, Soaring Air, which recently launched an updated jetliner. Flying High produces all of its jets in Country X but is headquartered in Country Y. Country X features low labor and capital costs but has recently seen some political unrest.

(*1 point*) Identify and describe four risks faced by Flying High.

| ANSWER: |
| --- |

**QFI IRM Spring 2021 Question 1**

Source Material: Quantitative Enterprise Risk Management, Ch. 2: Risk Taxonomy

Learning Outcome: 1c) Demonstrate an understanding of various ALM risks

Your team conducts a risk prompt list analysis and recommends that the portfolio expand its asset classes to include more international investments, particularly in company XYZ. You know the following about XYZ:

- XYZ is a mining company that has operations in a few different countries: Countries A, B, and C.
- Leaders of Country A recently underwent intense scrutiny by local media due to evidence that there might have been favoritism shown in awarding lucrative mining rights to some of XYZ's competitors.
- Country B's legislature has been focusing on enacting laws aimed at improving workplace safety and otherwise improving workers' rights.
- The coastal region of Country C in which XYZ operates to extract certain minerals that can be toxic to marine animals has been experiencing increasing rates of flooding in recent years.
- XYZ sponsors employee pension plans in each country it operates in. XYZ's home country's pension plan member mortality table is used in calculating the liabilities under these plans.

(*1.5 points*)

(i) Describe four key non-financial risks involved in investing in XYZ.

| ANSWER: |
| --- |

(ii) Assess XYZ's choice of mortality table for modeling its pension plans.

| ANSWER: |
| --- |

**QFI IRM Fall 2021 Question 2**

Source Material: Quantitative Enterprise Risk Management, Ch. 2: Risk Taxonomy

Learning Outcome: 1c) Demonstrate an understanding of various ALM risks

ZYX is a U.S.-based asset management company that has two portfolios, a domestic bond portfolio and a foreign bond portfolio. The Board of Directors of ZYX has expressed concern regarding the decentralized risk governance structure of ZYX.

To address the concerns of the Board, ZYX establishes a central risk management team and appoints you as the head of the team. You have identified the following risks as the top priorities:

1. Interest rate risk
2. Exchange rate risk
3. Credit risk
4. Model risk

You learn the following:

- USD is expected to appreciate against most foreign currencies.
- Interest rates are projected to increase by 150 bps over the next 6 months.
- There is no expert on the risk-neutral equilibrium model used by the company.
- Corporate bonds issued by two companies make up over 25% of ZYX's portfolio.

(*1 point*) Explain how each of the risks above apply to ZYX.

| ANSWER: |
| --- |

**QFI IRM Spring 2022 Question 2**

Source Material: Quantitative Enterprise Risk Management, Ch. 2: Risk Taxonomy

Learning Outcome: 1c) Demonstrate an understanding of various ALM risks

You serve as a risk management consultant for a large casualty insurance company seeking to evaluate its risk culture. The managers identify the following risks facing the insurer.

1. The company has a large block of business in one region of the country.
2. The company invests its assets in bonds, both domestic and international.
3. The insurance market is supervised at the state and federal level.
4. Recent changes allow more individuals in the target insurance market to opt out of coverage.

(*1 point*)

(i) Classify each of the risks using a risk taxonomy.

| ANSWER: |
|---|

(ii) Explain how the risk arises from the situation presented.

| ANSWER: |
|---|

**QFI IRM Spring 2022 Question 3**

Source Material: Quantitative Enterprise Risk Management, Ch. 2: Risk Taxonomy

Learning Outcome: 1c) Demonstrate an understanding of various ALM risks

You work for a leading annuity provider in Country XYZ. Cryptocurrency holdings recently became prohibited in Country XYZ and there are no cryptocurrency derivatives markets. Your company's product managers see an immense market opportunity from the surging consumer interest in a specific cryptocurrency, CrypTik (CT). The product managers propose a new annuity with a crediting rate linked to CT's performance, which would make your company the only provider of (synthetic) exposure to CT in Country XYZ.

(*2 points*)

(i) Identify two categories of external risk and one category of internal risk (other than operational risk) applicable to the company's decision to sell a CT-linked annuity.

| ANSWER: |
| --- |

(ii) Describe one specific risk within each category in (i).

| ANSWER: |
| --- |

**QFI IRM Spring 2022 Question 4**

Source Material: Financial Enterprise Risk Management, Ch. 20: Case Studies;

Financial Enterprise Risk Management, Ch. 8: Risk Identification

Learning Outcome:

1b) Understand the lessons learned from ALM failures

1c) Demonstrate an understanding of various ALM risks

You are an actuarial consultant working at an ERM consulting firm. The firm is organizing a risk identification workshop for each of three different organizations:

Organization A:
The company is a small hedge fund. The company has a hierarchical risk culture, and senior management has an aggressive, dominating leadership style. Due to the size of the firm, there is little internal oversight to review the work of others.

Organization B:
The company is a startup investment firm. The firm's portfolio managers (PMs) base their investment decisions heavily on outputs of models built by analysts, yet they appear to be unclear on the limitations of the models. The head PM also oversees back-office analysis. In order to incentivize growth, the bonus structure for PMs is based on the monthly increase in portfolio size.

Organization C:
The company is a medium-sized insurance firm. The CEO has over 15 years of experience in the life insurance industry, so he is reluctant to adopt new practices and technologies used by competitors. When the concept of Enterprise Risk Management was introduced, the CEO took on the role of CRO as well. Given his limited time, the CEO delegates responsibility for ERM to a lower-level manager. The CEO explains to this manager that he is comfortable with the current risk concentration in a few best-selling products.

Case studies can be useful for risk identification, so you plan to provide some information on relevant case studies for each organization.

(a) (*3 points*)

(i) Identify two case studies most relevant for each organization.

| ANSWER: |
| --- |
| |

(ii) Explain how the identified case studies apply to each organization.

| ANSWER: |
|---|

You collect the following information about the participants in each organization's workshop and the goals for the session.

Organization A (started in 2012):
The participants include one trading associate, one junior accountant, one junior research analyst, and the Chief Operating Officer (one of the founding members of the company). The goal of the workshop is to have a holistic and strategic view of positive and negative aspects of the firm's risk exposure, considering internal and external contexts, while utilizing expertise from the COO and documentation of the company's processes.

Organization B (started in 2021):
The participants include six portfolio managers from the investment department, one lawyer, two accountants, and two back-office junior analysts. The goal of the workshop is to start at a very high level by identifying risks that should be considered and then progress to a more detailed categorization of risks that may or may not apply to the company.

Organization C (started in 2009):
The participants include two underwriters, one marketing associate, two claims managers, three valuation actuaries, and two financial reporting analysts. All are experienced employees, and they were involved with responding to several incidents in the past year.

You are given a list of risk identification tools:

- SWOT analysis
- Risk prompt lists
- Risk check lists
- Risk trigger questions
- Risk-focused process analysis
- Risk taxonomy

(b) (*3 points*)

(i) Recommend the two risk identification tools best suited to each organization from the list provided. (Note that each tool from the list must be used exactly once in your recommendations.)

| ANSWER: |
|---|

(ii) Justify your recommendations.

| ANSWER: |
|---|

The risk identification workshop will be one hour long and will be led by a facilitator. Your co-worker recommended the following risk identification technique for each organization:

- Organization A: Delphi technique
- Organization B: Independent group analysis
- Organization C: Brainstorming

(c) (*2 points*)

(i) Critique your co-worker's choice of technique for each organization.

| ANSWER: |
|---|

(ii) Recommend an alternative technique for Organization A, other than those listed prior to part (b).

| ANSWER: |
|---|

**QFI IRM Fall 2023 Question 1**

Source Material: Financial Enterprise Risk Management, Ch. 8: Risk Identification

Learning Outcome: 1c) Demonstrate an understanding of various ALM risks

You are working as an actuary in a market risk team for a large insurance company. The chief risk officer (CRO) has asked you to conduct a survey to identify equity risk exposure of the company. You have designed a standardized, one-time questionnaire and distributed it to the following participants:

(i) Junior staff within the market risk team

(ii) Senior investment and risk officers of the company

(iii) Independent consultants that are experts in risk management

(*1 point*)

(i) (*0.5 points*) Identify two risk identification techniques that would be the most suitable to use with the above participants.

| ANSWER: |
|---|

(ii) (*0.5 points*) Assess the approach of using a standardized, one-time questionnaire with the above participants.

| ANSWER: |
|---|

**QFI IRM Fall 2023 Question 7**

Source Material: Quantitative Enterprise Risk Management, Ch. 2: Risk Taxonomy

Learning Outcome: 1c) Demonstrate an understanding of various ALM risks

You work as a financial analyst for a car dealer, Company XYZ. On October 1, 2007, your company lost a lawsuit and must pay $100 million in 9 months. To pay the lawsuit, the company decided to sell one of its warehouses to raise cash.

Company ABC offers to buy the warehouse for $95 million and deliver the payment in cash in 6 months.

(*0.5 point*) Identify the risks that Company XYZ is facing after losing the lawsuit.

| ANSWER: |
| --- |

**QFI IRM Spring 2024 Question 1**

Source Material: Quantitative Enterprise Risk Management, Ch. 2: Risk Taxonomy

Learning Outcome: 1c) Demonstrate an understanding of various ALM risks

DEF, a life insurance company, has hired you to help the company understand Environment Social Governance (ESG) risks and advise on its investment decisions.

DEF has identified the following key risks:

- Regulatory Risk
- Reputational Risk
- Market Risk
- Environmental Risk

You learn the following:

- DEF's regulator is considering a new regulation that would fine financial service companies lacking proof of responsible investing.
- Life insurance consumers now consider the investment practices of companies in their purchase decisions.
- A recent pandemic has disrupted various industries and has also increased mortality rates.
- Decreased earnings from higher death benefit expenses are pressuring DEF to increase its investment margins. Management is considering purchasing more corporate debt.

(*3 points*)

(i) (*1.5 points*) Explain how each key risk applies to DEF.

| ANSWER: |
| --- |
| |

(ii) (*1.5 points*) Explain how incorporating ESG factors into the investment decision making can mitigate each key risk.

| ANSWER: |
| --- |
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**QFI IRM Spring 2024 Question 2**

Source Material: Quantitative Enterprise Risk Management, Ch. 2: Risk Taxonomy

Learning Outcome: 1c) Demonstrate an understanding of various ALM risks

XYZ is an insurance company that sells equity-linked universal life products. XYZ invests in long-term bonds and mortgage-backed securities to fund future claims and has a reinsurance agreement with UVW company to reduce the risk of large claims. You have been hired as a consultant to help with investment risk management at XYZ.

You have identified the following risks for XYZ:

- Stock Market Risk
- Interest Rate Risk
- Default Risk
- Liquidity Risk

(a) (*1 point*) Explain how each risk applies to XYZ.

| ANSWER: |
| --- |

(b) (*1 point*) Recommend one mitigating action for each of the risks identified in part (a).

| ANSWER: |
| --- |

**QFI IRM Spring 2024 Question 9**

Source Material: Quantitative Enterprise Risk Management, Ch. 2: Risk Taxonomy

Learning Outcome: 1c) Demonstrate an understanding of various ALM risks

You work as an ALM actuary for a mid-size insurance company with core businesses of life insurance and annuities. As interest rates rose in the last few years, the experience studies team reported significantly higher than expected surrenders for the fixed deferred annuities, especially those issued with a lower minimum crediting rate guarantee, when interest rates were low.

(*1.5 points*) Explain potential risks associated with the above situation.

| ANSWER: |
| --- |

**QFI IRM Fall 2024 Question 2**

Source Material: Financial Enterprise Risk Management, Ch. 8: Risk Identification

Learning Outcome: 1c) Demonstrate an understanding of various ALM risks

MNO's asset managers have a good track record when investing in financial services, energy, and consumer goods sectors. The Chief Investment Officer (CIO) would like to diversify the company's holdings by investing in the transportation sector. As the first step, the CIO enlists a panel of research analysts within the company to create a risk checklist to assess some potential investments.

(*1.5 points*)

(i) (*0.5 points*) Explain why the CIO's approach to create a risk checklist is inadequate.

| ANSWER: |
|---|

(ii) (*1 point*) Recommend two changes to the CIO's approach that could help ensure the risk checklist is adequate.

| ANSWER: |
|---|

**QFI IRM Fall 2024 Question 9**

Source Material: Quantitative Enterprise Risk Management, Ch. 20 Case Studies

Learning Outcome: 1b) Understand the lessons learned from ALM failures

Ron is a portfolio manager of a pension fund with total assets of $100 million.

Ron wants to change his team's bonus structure, which currently is 80% weighted towards individual performance and 20% weighted towards the team's performance. He is thinking of swapping the two weights.

(*1 point*) Explain the pros and cons of increasing the weight towards the team's performance in the bonus structure.

| ANSWER: |
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**QFI PM Fall 2020 Question 6**

Source Material: CP351-100-25: IAA Risk Book - Asset Liability Management: Techniques and Practices for Insurance Companies (2016)

Learning Outcome: 1a) Explain the principles of Asset Liability Management

(*5 points*) You are evaluating XYZ ALM process during which you observe the following:

- XYZ's assets include treasuries, corporate bonds, commercial mortgages and MBS, and a small portion of equities.

- XYZ calculates and reports the effective durations of liabilities and assets quarterly. For the most recent quarter, the asset duration is 15 years and the liability duration is 33 years.

- XYZ liabilities consist of products that have policy holder options and guarantees.

- Below are sensitivity results from XYZ's ALM model:

| Interest Rate Move | Asset | Liability |
|---|---|---|
| Shock Up 50 bps | 180M | 160M |
| No Shocks | 200M | 180M |
| Shock Down 50 bps | 210M | 220M |

(a) (*1 point*) Define in words:

(i) Macaulay duration

(ii) Effective duration

(iii) Dollar duration

(iv) Partial duration

| ANSWER: |
|---|
| |

(b) (*1 point*) Explain four reasons that the value of the assets could move differently from the effective duration predicted value.

| ANSWER: |
|---|

(c) (*1 point*) Identify two risks that XYZ faces in a falling interest rate environment.

| ANSWER: |
|---|

Your assistant reviewed XYZ's ALM policy along with current economic conditions and made the following suggestions:

- In the current low interest rate environment, the company should lower the allocation in bonds and increase allocation to equities to boost investment earnings.
- With a nearly flat yield curve, the company should reduce the duration of the assets to stay liquid in case interest rates spike up.
- The company should invest in emerging market debt because it achieved a high rate of return last year.

(d) (*2 points*) Critique your assistant's suggestions.

| ANSWER: |
|---|

**QFI PM Spring 2022 Question 1**

Source Material: CP351-100-25: IAA Risk Book - Asset Liability Management: Techniques and Practices for Insurance Companies (2016)

Learning Outcome: 1a) Explain the principles of Asset Liability Management

(*6 points*) XYZ Insurance has recently created an ALM team to help manage economic risks for its traditional life insurance block of business. Your manager informs you that the block is comprised entirely of whole life insurance policies issued to young lives and is currently backed by a portfolio consisting of a mix of corporate and government bonds.

Senior management is concerned with the level of risk exposure for this block of business.

(a) (*1 point*) Describe two ALM-related risks that this block of business is exposed to.

| ANSWER: |
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| |

Your team is investigating different asset strategies for managing this block of business. Senior management has mentioned that, since the liabilities have a long duration, they are concerned about interest rate exposure, particularly at the long-term end of the yield curve. The team is currently investigating two strategies:

X. Immunization
Y. Interest Rate Swap Overlay

(b) (*2 points*) Assess the appropriateness of each strategy with regards to addressing senior management's concerns.

| ANSWER: |
|---|
| |

Due to the low interest rate environment, senior management is concerned about asset yields and is investigating ways to improve the performance of the block. Your team is investigating the addition of equities to the portfolio, implemented using a carve out strategy.

(c) (*1.5 points*) Propose a carve out strategy for this block of business.

| ANSWER: |
|---|
| |

(d) (*1.5 points*) Critique the decision to add equity to the portfolio.

| ANSWER: |
| --- |

**ILA LAM Fall 2023 Question 3c**

Source Material:

- CP351-101-25: ALM for Life, Annuities, and Pensions (section 3)
- CP351-105-25: Chapter 16 of Asset/Liability Management of Financial Institutions, Tilman 2003

Learning Outcomes:
1d) Describe how different pension and insurance contracts generate embedded options

(c) (*6 points*) Insurance products are often sold with embedded options for both the policyholder and the insurance company.

For the following products:

- Deferred annuity with a minimum guaranteed crediting rate
- Participating traditional whole life insurance that provides cash value and dividends
- Long-term care product with guaranteed premium

(i) Identify two embedded options offered to the policyholder that are shared by more than one product.

| ANSWER: |
| --- |

(ii) Explain which product features are triggered for the embedded option(s) in part (i).

| ANSWER: |
| --- |

(iii) Identify two embedded options available to the insurance company that are shared by more than one product.

| ANSWER: |
| --- |

(iv) Explain which product features are triggered for the embedded option(s) in part (iii).

| ANSWER: |
| --- |

**ILA LAM Spring 2024 Question 3**

Source Material:

- CP351-101-25: ALM for Life, Annuities, and Pensions (section 3)
- CP351-105-25: Chapter 16 of Asset/Liability Management of Financial Institutions, Tilman 2003

Learning Outcomes:

1d) Describe how different pension and insurance contracts generate embedded options

RXZ Life sells a fixed deferred annuity with the following features:

- Accumulation period is 10 years.
- Fund value is credited a fixed interest rate.
- The fixed interest rate is set equal to the market rate when the policy is sold.
- Additional premiums can be paid during the accumulation period.
- Policyholders can make partial withdrawals during the accumulation period.
- Withdrawals are subject to a surrender charge that decreases by duration.

The assets backing this product are 10-year bonds whose yield provides a target spread relative to the fixed crediting rate.

(b) (*2 points*)

(i) Identify the option(s) granted to policyholders in this annuity product. Justify your answer.

| ANSWER: |
| --- |

(ii) Assess how changes in the interest rate environment can trigger policyholders to exercise the options described in (i).

| ANSWER: |
| --- |

# CP 351
# LEARNING OBJECTIVE 2

**CATEGORIZED PAST EXAM QUESTIONS**

**Learning Objectives:** The candidate will understand how to measure risks from assets and liabilities

| Exam | Question Part | Exam Points | Source Material | Learning Outcomes |
|---|---|---|---|---|
| QFIIRM Spring 22 | 3c | 1 | Quantitative Enterprise Risk Management, Ch. 8: Market Risk Models | 2b |
| QFIIRM Fall 23 | 1b | 2 | Quantitative Enterprise Risk Management, Ch. 8: Market Risk Models | 2b |
| QFIIRM Fall 23 | 1c | 3 | Quantitative Enterprise Risk Management, Ch. 8: Market Risk Models<br><br>Understanding the Connection Between RW and RN Generators, Strommen, 2022, sections 1-5<br>• Companion Excel-based Tool | 2a, 2b |
| QFIIRM Fall 23 | 1d | 0.5 | Quantitative Enterprise Risk Management, Ch. 8: Market Risk Models | 2b |
| QFIIRM Fall 23 | 1e | 1.5 | Quantitative Enterprise Risk Management, Ch. 8: Market Risk Models | 2b |
| QFIIRM Fall 23 | 1f | 1 | Quantitative Enterprise Risk Management, Ch. 8: Market Risk Models | 2b |
| QFIIRM Spring 24 | 3a | 2.5 | Quantitative Enterprise Risk Management, Ch. 8: Market Risk Models | 2b |
| QFIIRM Spring 24 | 3b | 2.5 | Quantitative Enterprise Risk Management, Ch. 8: Market Risk Models | 2b |
| QFIIRM Spring 24 | 6a | 1.5 | IAIS Application Paper on Liquidity Risk Management | 2b |
| QFIIRM Spring 24 | 6b | 1.5 | IAIS Application Paper on Liquidity Risk Management | 2b |
| QFIIRM Spring 24 | 6c | 1 | IAIS Application Paper on Liquidity Risk Management | 2b |
| QFIIRM Spring 24 | 6d | 1 | IAIS Application Paper on Liquidity Risk Management | 2b |

| | | | | |
|---|---|---|---|---|
| QFIIRM Spring 24 | 6e | 1 | IAIS Application Paper on Liquidity Risk Management | 2b |
| QFIIRM Fall 24 | 5a | 2 | Quantitative Enterprise Risk Management, Ch. 8: Market Risk Models | 2b |
| QFIIRM Fall 24 | 5b | 2 | Quantitative Enterprise Risk Management, Ch. 8: Market Risk Models | 2b |
| QFIIRM Fall 24 | 5c | 2 | Quantitative Enterprise Risk Management, Ch. 8: Market Risk Models | 2b |
| ILA LAM Fall 20 | 2d, 2e | 6 | Key Rate Durations: Measures of Interest Rate Risk | 2a |
| ILA LAM Spring 21 | 2b, 2c | 6 | Key Rate Durations: Measures of Interest Rate Risk | 2a |
| ILA LAM Fall 21 | 3b | 3 | Key Rate Durations: Measures of Interest Rate Risk | 2a |
| ILA LAM Spring 23 | 3b | 6 | Key Rate Durations: Measures of Interest Rate Risk<br>IAIS Application Paper on Liquidity Risk Mgmt | 2a, 2b |
| ILA LAM Fall 23 | 6a,6c,6d | 2 | ALM for Life, Annuities, and Pensions (section 4) | 2a |
| ILA LAM Fall 24 | 4a,4b,4c | 11 | Key Rate Durations: Measures of Interest Rate Risk<br>ALM for Life, Annuities, and Pensions (section 4) | 2a |
| ILA LAM Fall 24 | 6b | 4 | ALM for Life, Annuities, and Pensions (section 4)<br>Ch 4 of Fixed Income Securities: Tools for Today's Markets, Tuckman, Bruce and Serrat, Angel, 4th Edition, 2022 | 2a |

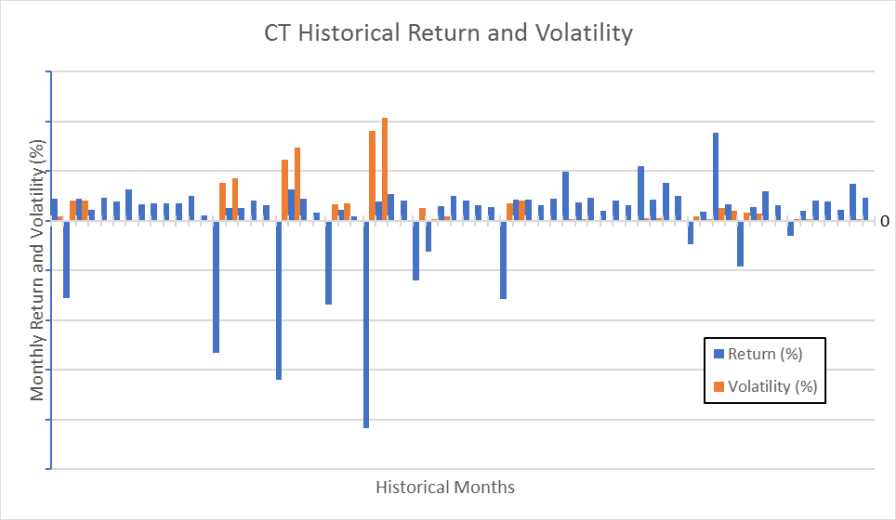
**QFI IRM Spring 2022 Question 3**

Source Material: Quantitative Enterprise Risk Management, Ch. 8: Market Risk Models

Learning Outcome:

2b) Evaluate a company's or a portfolio's exposures to various risks

You are provided the following historical data for CT:




The company is capable of creating three types of models:

- Lognormal
- GARCH
- Regime-Switching

(*1 point*) Recommend which model above would best capture the features of CT's price.

| ANSWER: |
| --- |

**QFI IRM Fall 2023 Question 1**

Source Material: Quantitative Enterprise Risk Management, Ch. 8: Market Risk Models

Learning Outcome:

2b) Evaluate a company's or a portfolio's exposures to various risks

You are working as an actuary in a market risk team for a large insurance company. The chief risk officer (CRO) has asked you to conduct a survey to identify equity risk exposure of the company. You have designed a standardized, one-time questionnaire and distributed it to the following participants:

(i) Junior staff within the market risk team

(ii) Senior investment and risk officers of the company

(iii) Independent consultants that are experts in risk management

In the survey, the independent consultant points out the need to strengthen the company's modeling capability and is proposing to use either an independent lognormal process (ILN) or GARCH (1,1) to model the monthly returns of the Equity Index (EI).

(b) (*2 points*)

(i) (*1 point*) List four important stylized facts about equity price movements.

| ANSWER: |
|---|

(ii) (*0.5 points*) Evaluate how well ILN addresses these four facts.

| ANSWER: |
|---|

(iii) (*0.5 points*) Evaluate how well GARCH addresses these four facts.

| ANSWER: |
|---|

Because of recent inflation, the equity market is experiencing high volatility. You are interested in quantitatively assessing the probability that EI will experience a significant decline in the next month.

After reviewing the comments in the survey, you decide to implement a GARCH (1,1) model for the EI monthly log-returns. The junior staff provides you with the following parameters calibrated based on the historical data.

$\mu = 0.003,$
$a_0 = 6.5 \times 10^{-4}, a_1 = 0.1, b = 0.6$
$\sigma_0^2 = 0.0036$

The EI value at time t = 0 is 400, and the EI value at time t = -1 was 450.

(c) (*3 points*)

(i) (*0.5 points*) Explain whether you should use the risk-neutral or real-world measure for this calculation.

| ANSWER: |
|---|

(ii) (*1 point*) Calculate the probability that the EI will drop by more than 20% in a month.

| *The response for this part is to be provided in the Excel spreadsheet.* |
|---|

(iii) (*1 point*) Calculate the number of months after which the expected variance will equal the long-term variance (within 6 decimals).

| *The response for this part is to be provided in the Excel spreadsheet.* |
|---|

After reviewing, you realize that the junior staff made a mistake in his calibration, and the correct parameters should be $a_1 = 0.15$ , $b = 0.75$.

(iv) (*0.5 points*) Describe qualitatively how these new parameters will impact the results of the model.

| ANSWER: |
|---|

In addition to the monthly log returns, you would like to model the quarterly, semi-annual and the annual log returns as well. The junior staff responds that this can be done by simply scaling up the parameters of your model based on the time factors.

(d) (*0.5 points*) Critique the junior staff's suggestion.

| ANSWER: |
|---|

The CRO is interested in evaluating market-consistent prices of future cash flows while retaining the same variance process as your model.

(e) (*1.5 points*) Propose an equivalent process that addresses the CRO's needs and describe its distribution in terms of your model's parameters.

(Equation is not required. A detailed explanation of the process would suffice.)

| ANSWER: |
| --- |

The CRO is concerned that your model does not adequately address the leverage effect, where higher volatility clusters are observed in market crashes or failures.

(f) (*1 point*) Revise the GARCH model to address the CRO's concern and justify your response.

| ANSWER: |
| --- |

**QFI IRM Spring 2024 Question 3**

Source Material: Quantitative Enterprise Risk Management, Ch. 8: Market Risk Models

Learning Outcome:

2b) Evaluate a company's or a portfolio's exposures to various risks

You are a quantitative analyst at MNO Market Makers, a firm specializing in providing liquidity in the equity markets. Your firm is considering becoming a market maker for company IJK's stocks. You are tasked with assessing the profitability and risk of this deal.

The past year's monthly IJK share prices, $S_{IJK,}$ and volume, $V_{IJK,}$ are given below.

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_{IJK}$ ($) | 50 | 39 | 32 | 38 | 47 | 46 | 50 | 43 | 36 | 43 | 39 | 40 |
| $V_{IJK}$ (millions) | 8 | 7 | 4 | 6 | 5 | 8 | 6 | 5 | 5 | 10 | 5 | 4 |

You decide to use the independent lognormal model (ILN) to model the stock prices.

(a) (*2.5 points*)

(i) (*1 point*) Estimate the monthly mean log-return, $\hat{\mu}$, and monthly volatility, $\hat{\sigma}$, from the provided data.

*The response for this part is to be provided in the Excel spreadsheet.*

IJK's current share price is $35.

(ii) (*1.5 points*) Calculate the probability that IJK's share price is above $40 in 6 months.

*The response for this part is to be provided in the Excel spreadsheet.*

(b) (*2.5 points*)

(i) (*1.5 points*) Describe the shortcomings of the ILN model.

ANSWER:

(ii) (*1 point*) Recommend an alternative model to address the ILN model's shortcomings.

ANSWER:

**QFI IRM Spring 2024 Question 6**

Source Material: CP351-109-25: IAIS Application Paper on Liquidity Risk Management

Learning Outcome:

2b) Evaluate a company's or a portfolio's exposures to various risks

(*6 points*) You are an actuarial analyst on the risk management team for PQR Life Insurance supporting the assessment and management of PQR's liquidity risk.

To support your analysis, you are provided PQR's most recent balance sheet:

| **Assets** | **Total** |
|---|---|
| Sovereigns Bonds backing same-jurisdiction liabilities | 10,000 |
| Non-Financial Corporate Bonds AA-/Aa3 and better | 55,000 |
| Financial Corporate Bonds AA-/Aa3 and better | 20,000 |
| Non-Financial Corporate Bonds at least BBB-/Baa3 but below AA-/Aa3 | 2,500 |
| Common Equity, Publicly Traded | 25,000 |
| Private Equity | 10,000 |
| Diversified Demand Deposits | 10,000 |
| Governance Money Market Funds | 2,500 |
| **Total Assets** | **135,000** |

| **Liabilities** | **Total** |
|---|---|
| Liabilities for Insurance and Investment Contracts | 100,000 |
| Universal Life without Secondary Guarantees | 80,000 |
| Term | 20,000 |
| Other Liabilities | 20,000 |
| **Total Liabilities** | **120,000** |
| **Surplus** | **15,000** |

Your colleague notes that PQR is well capitalized and is expected to maintain target capital ratios even under stress conditions. Therefore, there should be no concerns around liquidity risk.

(a) (*1.5 points*) Critique your colleague's conclusion about liquidity risk.

| ANSWER: |
|---|
| |

You are asked to develop a liquidity stress scenario.

(b) (*1.5 points*) List six liquidity risk drivers to be considered when developing a liquidity stress scenario.

| ANSWER: |
|---|

Management is concerned with the ability of the asset portfolio to support unexpected liquidity outflow events. You note that only highly liquid assets should be used to support liquidity shortfalls as they arise.

(c) (*1 point*) Summarize four key characteristics of highly liquid assets.

| ANSWER: |
|---|

You are told that in projecting liquidity stress scenarios, PQR assumes that:

- Primary assets are sold before Secondary assets.
- Primary asset sales incur no haircuts.
- Secondary asset sales incur a 5% haircut.
- No regular asset inflows, such as from coupons or maturities, are assumed over a short-term horizon

(d) (*1 point*) Calculate the amount of Secondary asset sales needed to meet a short-term liquidity need of 30,000, based on assumptions described above and the current balance sheet.

| ANSWER: |
|---|

After performing your liquidity stress analysis, you are asked to draft a report for the Financial Risk Committee summarizing key aspects of PQR's liquidity position and risks.

(e) (*1 point*) List six key features of a liquidity risk management report.

| ANSWER: |
|---|

**QFI IRM Fall 2024 Question 5**

Source Material: Quantitative Enterprise Risk Management, Ch. 8: Market Risk Models

Learning Outcome:

2b) Evaluate a company's or a portfolio's exposures to various risks

Your manager asked you to recommend the best model to evaluate equity risk using the expected shortfall measure. She provided you with the following information on the maximum log-likelihoods for three models, after fitting the model using 500 data points for both monthly and daily data.

| Model | Maximum Log-likelihood (Monthly) | Maximum Log-likelihood (Daily) | Number of Parameters |
|---|---|---|---|
| ILN | 595 | 1335 | 2 |
| GARCH | 611 | 1609 | 4 |
| RSLN | 619 | 1579 | 6 |

(a) (*2 points*) Explain which models above are appropriate for short-term risk assessment and which are appropriate for long-term risk assessment.

ANSWER:

(b) (*2 points*) Describe practical considerations in deciding which model to use.

ANSWER:

(c) (*2 points*) Recommend one of these models using both of Akaike Information Criterion and Bayes Information Criterion, based on:

(i) (*1 point*) daily data

*The response for portion of this part is to be provided in the Excel spreadsheet.*

(ii) (*1 point*) monthly data

*The response for portion of this part is to be provided in the Excel spreadsheet.*

**ILA LAM Fall 2020 Question 2**

Source Material: CP351-107-25: Key Rate Durations: Measures of Interest Rate Risk

Learning Outcome:

2a) Demonstrate an understanding of various risk identification tools

CW Life is attempting to acquire a block of insurance. You have been asked to recommend a discount curve and assess the interest rate exposure of the block. You are given:

- 100 years of monthly liability cashflows
- The investment strategy is to match asset and liability cash flows
- Detailed information about assets in the portfolio

Your model has produced the following results:

| **Key Rate Duration by Term** | **1 Year** | **5 Years** | **10 Years** | **20 Years** | **30 Years** | **Total** |
|---|---|---|---|---|---|---|
| Asset | 0.1 | 0.5 | 0.9 | 2 | 9.9 | *X* |
| Liability | 0.05 | *Y* | 0.4 | 1 | 12 | *Z* |
| Portfolio Size | 100,000 | 200,000 | 100,000 | 300,000 | 300,000 | 1,000,000 |

- Income impact of a minus 10 basis point parallel shift = -200

(d) (*4 points*)

(i) Calculate the values for X, Y, and Z in the chart.

*The response for this part is to be provided in the Excel document*

(ii) Calculate the income impact from the following movement in interest rates:

| **In basis points** | **1 Year** | **5 Year** | **10 Year** | **20 Year** | **30 Year** |
|---|---|---|---|---|---|
| Interest Rate Change | 20 | 15 | -30 | -20 | -5 |

Show all work, including writing out relevant formulas used in any calculations

| |
|---|
| *The response for this part is to be provided in the Excel document* |

(iii) Recommend changes to the asset portfolio to reduce interest rate exposure.

| |
|---|
| ANSWER: |

After conducting your work an error in the asset information is found. What was reported as a 30-year bond is in fact a 30-year bond which can immediately be called at par.

(e) (*2 points*) Explain how the key rate duration profile will change if:

(i) The coupon rate of the callable bond is the same as the non-callable bond.

| |
|---|
| ANSWER: |

(ii) The coupon rate of the callable bond is higher than the non-callable bond.

| |
|---|
| ANSWER: |

**ILA LAM Spring 2021 Question 2**

Source Material: CP351-107-25: Key Rate Durations: Measures of Interest Rate Risk

Learning Outcome:

2a) Demonstrate an understanding of various risk identification tools

MRK Life is a company writing long duration interest-sensitive insurance policies.

(b) (*4 points*)

(i) (*1 point*) Explain why MRK might want to minimize surplus volatility instead of minimizing asset-only volatility in their ALM practice.

| ANSWER: |
|---|

(ii) (*1 point*) You are given the following information on MRK Life's balance sheet:

| | **Market Value** | **Effective Duration** |
|---|---|---|
| **Assets** | 1,000 | 10 |
| **Liability** | 800 | 15 |

Assume a -0.5% parallel shift in the interest rate curve. Calculate the change to MRK's surplus. Show all work.

| *The response for this part is to be provided in the Excel document* |
|---|

(iii) (*2 points*) You are given the following information on two types of interest rate hedging instruments available in the market:

| **Hedging Instrument** | **Notional** | **Effective Duration** |
|---|---|---|
| **Swap 1** | 100 | 15 |
| **Swap 2** | 100 | -10 |

Recommend a suitable hedging portfolio using the above swaps to minimize the surplus volatility solved for in part (ii). Show all work.

| *The response for this part is to be provided in the Excel document* |
|---|

(c) (*2 points*) MRK is considering the following two bond portfolios:

| | **Market Value of Zero-Coupon Bonds** | | | **Effective Duration** |
|---|---|---|---|---|
| | **10-year** | **20-year** | **30-year** | |
| **Portfolio 1** | 100 | 100 | 400 | 25 |
| **Portfolio 2** | 0 | 300 | 300 | 25 |

Interest rates experience the following change:

| **Rate** | **Change** |
|---|---|
| **10-year** | +0.05 |
| **20-year** | +0.1 |
| **30-year** | -0.05 |

Calculate the change in return for each portfolio. Show all work.

*The response for this part is to be provided in the Excel document*

**ILA LAM Fall 2021 Question 3**

Source Material: CP351-107-25: Key Rate Durations: Measures of Interest Rate Risk

Learning Outcome:

2a) Demonstrate an understanding of various risk identification tools

(b) (*3 points*) PBJ Life is a life insurance company with several lines of business.

You are given the following information on one of PBJ Life's asset segments supporting a single liability payment in Year 19:

| | | **MV ($million)** |
|---|---|---|
| **Liability** | Single payout in Yr 19 | 100 |
| **Assets (Zero Coupon Bonds (ZCB))** | 5yr ZCB<br>10yr ZCB<br>30yr ZCB<br>Total | 20<br>30<br>50<br>100 |

You are given the following interest rate shock scenarios:

| **Interest Rate Shock** | **5yr** | **10yr** | **30yr** |
|---|---|---|---|
| Scenario 1 (parallel shock) | -50bp | -50bp | -50bp |
| Scenario 2 (Steepening shock)* | -50bp | -25bp | +150bp |

*Linearly interpolate shock at different terms, if necessary.

(i) (*2 points*) For each of the given interest rate shock scenarios, calculate the impact on surplus. Show all work.

*The response for this part is to be provided in the Excel spreadsheet.*

(ii) (*1 point*) Critique the following statement:

*"The asset portfolio has the same effective duration as the liability, therefore exposure to interest rate risk is perfectly immunized."*

ANSWER:

**ILA LAM Spring 23 Question 3**

Source Material:

- CP351-107-25: Key Rate Durations: Measures of Interest Rate Risk
- CP351-109-25: IAIS Application Paper on Liquidity Risk Management

Learning Outcomes:

2a) Demonstrate an understanding of various risk identification tools

2b) Evaluate a company's or a portfolio's exposures to various risks

Your company is reviewing an annuity product which provides policyholders level annual annuity payments for the next 10 years. The company plans to invest evenly between 5-year and 10-year zero coupon bonds to back this liability.

You are provided with three yield curve shocks and liability portfolio key rate durations (KRD).

Yield Curve Shocks (in basis points):

| | **1 yr** | **2 yr** | **3 yr** | **4 yr** | **5 yr** | **6 yr** | **7 yr** | **8 yr** | **9 yr** | **10 yr** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Shock 1** | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| **Shock 2** | 70 | 66 | 55 | 33 | 0 | 25 | 35 | 45 | 55 | 65 |
| **Shock 3** | -75 | -55 | -35 | -15 | -10 | -1 | 10 | 25 | 45 | 55 |

Liability Portfolio KRD:

| | **1 yr** | **2 yr** | **3 yr** | **4 yr** | **5 yr** | **6 yr** | **7 yr** | **8 yr** | **9 yr** | **10 yr** |
|---|---|---|---|---|---|---|---|---|---|---|
| **KRD** | 0.1 | 0.3 | 0.7 | 0.9 | 1.2 | 1.4 | 1.5 | 1.1 | 0.3 | 0.2 |

Assume the asset and liability values are 100 million at time zero.

(b) (*6 points*)

(i) Calculate the change in surplus under each shock. Show all work.

| |
|---|
| *The response for this part is to be provided in the Excel document* |

(ii) Assess if the investment strategy immunizes the company's surplus.

| |
|---|
| *The response for this part is to be provided in the Excel document* |

(iii) Identify key considerations if implementing a liquidity risk policy for this product.

| |
|---|
| ANSWER: |

**ILA LAM Fall 2023 Question 6**

Source Material:

- CP351-101-25: ALM for Life, Annuities, and Pensions (section 4)

Learning Outcomes:

2a) Demonstrate an understanding of various risk identification tools

You are given the following information about a bond:

| | |
|---|---|
| Face value | 250,000 |
| Time to maturity | 10 years |
| Annualized yield to maturity | 3.0% |
| Semi-annual coupon payment | 4.5% |

(a) (*1 point*) Calculate the Macaulay Duration of the bond.

| |
|---|
| *The response for this part is to be provided in the Excel spreadsheet.* |

You want to exchange one bond issue for another that you believe is undervalued.

| | **Existing Bond** | **New Bond** |
|---|---|---|
| Market Value | 350,000 | n/a |
| Price | 90 | 115 |
| Duration | 5 | 7 |

(c) (*1 point*) Determine the par value of the new bond needed to keep the duration of the portfolio constant.

| |
|---|
| *The response for this part is to be provided in the Excel spreadsheet.* |

**ILA LAM Fall 2024 Question 4**

Source Material: CP351-107-25: Key Rate Durations: Measures of Interest Rate Risk

Learning Outcome:

2a) Demonstrate an understanding of various risk identification tools

(*11 points*) You are evaluating two potential securities to include in a broader asset portfolio:

- Security A: 7-year zero-coupon bond (ZCB)
- Security B: An alternative asset that pays 100 at the end of years 3, 7, and 15

You are given the following prices of ZCBs maturing for 100 in (t) years.

| **t** | **3** | **7** | **15** |
|---|---|---|---|
| Price | 95.88 | 74.09 | 47.94 |

For Security B, a student has calculated the key rate durations (KRDs) for each cash flow.

| **t** | **3** | **7** | **15** |
|---|---|---|---|
| KRD | 1.32 | 2.19 | 3.30 |

(a) (*2 points*)

(i) Determine whether the student calculated the correct key rate durations. Show all work.

(ii) Demonstrate that the two securities have the same effective duration. Show all work.

*The response for this part is to be provided in the Excel spreadsheet.*

You are given the following three yield-curve shocks:

| Scenario | 3 | 7 | 15 |
|---|---|---|---|
| X | 0.2% | 0.0% | -0.2% |
| Y | -0.2% | -0.2% | -0.2% |
| Z | -0.2% | 0.0% | 0.2% |

(b) (*5 points*)

(i) Calculate the change in the value of Security A and B under each scenario. Show all work.

(ii) Explain why effective duration is often inadequate in measuring a security's interest rate risk exposure. Justify your answer using part (i).

(iii) Identify two other advantages of key rate duration over effective duration.

*The response for this part is to be provided in the Excel spreadsheet.*

You are considering investing in the following asset classes:

- Callable Corporate Bonds
- Callable Bonds with a Sinking Fund
- European Call Options
- European Put Options

(c) (*4 points*) Contrast the interest rate risk profile of these assets, including the sensitivity to rate changes at different points in the yield curve.

ANSWER:

**ILA LAM Fall 2024 Question 6**

Source Material:

- CP351-101-25: ALM for Life, Annuities, and Pensions (section 4)
- Fixed Income Securities: Tools for Today's Markets, Tuckman, Bruce and Serrat, Angel, 4th Edition, 2022

Learning Outcomes:

2a) Demonstrate an understanding of various risk identification tools

You are given the following information about a bond:

| | |
|---|---|
| Time to Maturity | 15 years |
| Annual Coupon Rate | 6.5% |
| Par Value | 1,000,000 |
| Market Value | 1,000,000 |

(b) (*4 points*)

(i) Calculate the modified duration of the bond.

(ii) Calculate the convexity of the bond.

(iii) Estimate the change in market value of a 1% increase in interest rates using the information calculated in (i) and (ii).

Show all work.

*The response for this part is to be provided in the Excel spreadsheet.*

# CP 351
# LEARNING OBJECTIVE 3

**CATEGORIZED PAST EXAM QUESTIONS**

**Learning Objectives:** The candidate will understand tools and strategies to manage ALM risks.

| Exam | Question Part | Exam Points | Source Material | Learning Outcome |
|---|---|---|---|---|
| QFIIRM Fall 20 | 4a | 2 | The Devil is in the Tails<br>Quantitative Enterprise Risk Management, Ch. 6: Copulas | 3b |
| QFIIRM Fall 20 | 4b | 1 | The Devil is in the Tails | 3b |
| QFIIRM Fall 20 | 4c | 1.5 | The Devil is in the Tails<br>Quantitative Enterprise Risk Management, Ch. 6: Copulas | 3b |
| QFIIRM Fall 20 | 4e | 1.5 | The Devil is in the Tails | 3b |
| QFIIRM Fall 20 | 4f | 0.5 | The Devil is in the Tails | 3b |
| QFIIRM Spring 21 | 2a | 1.5 | The Devil is in the Tails | 3b |
| QFIIRM Spring 21 | 2b | 3 | Quantitative Enterprise Risk Management, Ch. 6: Copulas | 3b |
| QFIIRM Spring 21 | 2c | 2.5 | Quantitative Enterprise Risk Management, Ch. 6: Copulas<br>Quantitative Enterprise Risk Management, Ch. 7: Stress Testing | 3b<br>3c |
| QFIIRM Fall 21 | 4a | 2 | Quantitative Enterprise Risk Management, Ch. 6: Copulas | 3b |
| QFIIRM Fall 21 | 4b | 2.5 | Quantitative Enterprise Risk Management, Ch. 6: Copulas | 3b |
| QFIIRM Fall 21 | 4c | 1.5 | Quantitative Enterprise Risk Management, Ch. 6: Copulas | 3b |
| QFIIRM Fall 21 | 4d | 1 | Quantitative Enterprise Risk Management, Ch. 6: Copulas | 3b |
| QFIIRM Fall 22 | 1a | 0.5 | Quantitative Enterprise Risk Management, Ch. 6: Copulas | 3b |
| QFIIRM Fall 22 | 1b | 1.5 | Quantitative Enterprise Risk Management, Ch. 6: Copulas | 3b |
| QFIIRM Fall 22 | 1c | 2 | Quantitative Enterprise Risk Management, Ch. 7: Stress Testing | 3c |
| QFIIRM Spring 23 | 3a | 1 | Quantitative Enterprise Risk Management, Ch. 7: Stress Testing | 3c |
| QFIIRM Spring 23 | 3b | 2 | Quantitative Enterprise Risk Management, Ch. 7: Stress Testing | 3c |

| | | | | |
|---|---|---|---|---|
| QFIIRM Spring 23 | 3c | 2 | Quantitative Enterprise Risk Management, Ch. 7: Stress Testing | 3c |
| QFIIRM Spring 23 | 9a | 0.5 | Fixed Income Securities: Valuation, Risk, and Risk Management, Pietro Veronesi, Ch. 5 and 6 | 3f |
| QFIIRM Spring 23 | 9b | 1 | Fixed Income Securities: Valuation, Risk, and Risk Management, Pietro Veronesi, Ch. 5 and 6 | 3f |
| QFIIRM Spring 23 | 9c | 2 | Fixed Income Securities: Valuation, Risk, and Risk Management, Pietro Veronesi, Ch. 5 and 6 | 3f |
| QFIIRM Spring 23 | 9d | 1.5 | Fixed Income Securities: Valuation, Risk, and Risk Management, Pietro Veronesi, Ch. 5 and 6 | 3f |
| QFIIRM Fall 23 | 2b | 1 | Quantitative Enterprise Risk Management, Ch. 6: Copulas | 3b |
| QFIIRM Fall 23 | 2c | 3 | Quantitative Enterprise Risk Management, Ch. 6: Copulas | 3b |
| QFIIRM Fall 23 | 2e | 1 | Quantitative Enterprise Risk Management, Ch. 6: Copulas | 3b |
| QFIIRM Fall 23 | 4a | 1 | Quantitative Enterprise Risk Management, Ch. 14: Model Risk and Governance | 3d |
| QFIIRM Fall 23 | 4b | 1.5 | Quantitative Enterprise Risk Management, Ch. 14: Model Risk and Governance | 3d |
| QFIIRM Fall 23 | 4c | 3 | Quantitative Enterprise Risk Management, Ch. 14: Model Risk and Governance | 3d |
| QFIIRM Fall 23 | 4d | 1 | Quantitative Enterprise Risk Management, Ch. 14: Model Risk and Governance | 3d |
| QFIIRM Fall 23 | 7c | 1 | Fixed Income Securities: Valuation, Risk, and Risk Management, Pietro Veronesi, Ch. 6 | 3f |
| QFIIRM Fall 23 | 7d | 1.5 | Fixed Income Securities: Valuation, Risk, and Risk Management, Pietro Veronesi, Ch. 6 | 3f |
| QFIIRM Fall 23 | 7e | 1 | Fixed Income Securities: Valuation, Risk, and Risk Management, Pietro Veronesi, Ch. 6 | 3f |
| QFIIRM Spring 24 | 4f | 1 | Quantitative Enterprise Risk Management, Ch. 6: Copulas | 3b |
| QFIIRM Spring 24 | 7a | 3 | Quantitative Enterprise Risk Management, Ch. 15: Risk Mitigation using Options and Derivatives<br>Fixed Income Securities: Valuation, Risk, and Risk Management, Pietro Veronesi, Ch. 5 and 6 | 3e, 3f |
| QFIIRM Spring 24 | 7b | 1.5 | Quantitative Enterprise Risk Management, Ch. 15: Risk Mitigation using Options and Derivatives<br>Fixed Income Securities: Valuation, Risk, and Risk Management, Pietro Veronesi, Ch. 5 and 6 | 3e, 3f |
| QFIIRM Spring 24 | 7c | 1 | Quantitative Enterprise Risk Management, Ch. 15: Risk Mitigation using Options and Derivatives<br>Fixed Income Securities: Valuation, Risk, and Risk Management, Pietro Veronesi, Ch. 5 and 6 | 3e, 3f |
| QFIIRM Spring 24 | 7d | 2 | Quantitative Enterprise Risk Management, Ch. 15: Risk Mitigation using Options and Derivatives<br>Fixed Income Securities: Valuation, Risk, and Risk Management, Pietro Veronesi, Ch. 5 and 6 | 3e, 3f |
| QFIIRM Spring 24 | 7e | 1.5 | Quantitative Enterprise Risk Management, Ch. 15: Risk Mitigation using Options and Derivatives<br>Fixed Income Securities: Valuation, Risk, and Risk Management, Pietro Veronesi, Ch. 5 and 6 | 3e, 3f |
| QFIIRM Fall 24 | 4a | 1 | Quantitative Enterprise Risk Management, Ch. 6: Copulas | 3b |
| QFIIRM Fall 24 | 4c | 0.5 | Quantitative Enterprise Risk Management, Ch. 6: Copulas | 3b |
| QFIIRM Fall 24 | 4d | 1.5 | Quantitative Enterprise Risk Management, Ch. 6: Copulas | 3b |
| QFIIRM Fall 24 | 4e | 1 | Quantitative Enterprise Risk Management, Ch. 6: Copulas | 3b |

| | | | | |
|---|---|---|---|---|
| QFIIRM Fall 24 | 8a | 2 | Quantitative Enterprise Risk Management, Ch. 15: Risk Mitigation using Options and Derivatives | 3e |
| QFIIRM Fall 24 | 8b | 1 | Quantitative Enterprise Risk Management, Ch. 15: Risk Mitigation using Options and Derivatives | 3e |
| QFIIRM Fall 24 | 8c | 2 | Quantitative Enterprise Risk Management, Ch. 15: Risk Mitigation using Options and Derivatives | 3e |
| QFIIRM Fall 24 | 8d | 2 | Quantitative Enterprise Risk Management, Ch. 15: Risk Mitigation using Options and Derivatives | 3e |
| QFIPM Fall 21 | 6a | 1 | LDI Explained | 3a |
| QFIPM Fall 21 | 6b | 1 | LDI Explained | 3a |
| QFIPM Spring 22 | 12a | 1 | LDI Explained | 3a |
| QFIPM Spring 22 | 12b | 1 | LDI Explained | 3a |
| QFIPM Spring 22 | 12c | 0.5 | LDI Explained | 3a |
| QFIPM Spring 22 | 12d | 1 | LDI Explained | 3a |
| QFIPM Spring 22 | 12e | 1 | LDI Explained | 3a |
| QFIPM Spring 22 | 12f | 1.5 | LDI Explained | 3a |

**QFI IRM Fall 2020 Question 4**

Source Material:

CP351-112-25: The Devil is in the Tails

Quantitative Enterprise Risk Management, Hardy, Mary and Saunders, David, 2022, Ch 6: Copulas

Learning Outcome:

3b) Demonstrate an understanding of and apply tools and techniques for measuring and managing interest rate risk in an ALM context

You are an analyst in the investment department of a large insurance company. You wish to simulate a collateralized debt obligation (CDO) after calibrating your copula to fit market prices.

(a) (*2 points*)

(i) Describe the steps necessary to simulate a loss distribution given random variables $X_1, X_2, \ldots, X_n$ with distributions $F_1, F_2, \ldots, F_n$, and a copula $C(u_1, \ldots, u_n)$.

| ANSWER: |
|---|
| |

(ii) Compare and contrast the use of rank correlation and linear correlation for copula calibration.

| ANSWER: |
|---|
| |

The company is considering purchasing two CDOs – CDO A and CDO B. You have been asked to assess their risks.

CDO A contains 100 equally-weighted, investment-grade issuers. You are given the market prices for the three tranches. Using the one-factor Gaussian copula model, you calculate the correlation needed to replicate the market prices for each tranche, as shown:

| **Seniority** | **Correlation** |
|---|---|
| Equity | 20% |

| | |
|---|---|
| Mezzanine | 18% |
| Senior | 25% |

Your coworker reviews your results and states:

1. The underlying default dependence structure is not a function of tranche seniority.
2. The correlations should be identical for all tranches.

(b) (*1 point*) Critique your coworker's statements.

| ANSWER: |
|---|

CDO B contains 20 equally-weighted issuers. Historical data indicates that this CDO has the following properties:

- Asymmetric default risk, as the issuers are clustered around certain locales/industries
- High tail dependence between the bond issuers

To model defaults on a tranche from this CDO, you are considering the following copulas:

1. Gaussian Copula
2. Student-*t* Copula
3. Gumbel Copula

(c) (*1.5 points*) Assess the appropriateness of each copula to quantify the risks of this CDO.

| ANSWER: |
|---|

The company has set the following objectives should a similar financial crisis occur:

- Limit the exposure to loss from credit defaults
- Maintain sufficient liquidity to be able to act on potential acquisition opportunities during a crisis

You are developing actions that can be taken to meet the above objectives. In doing so, you take note that your firm has a substantial long position in mezzanine tranches.

You are considering the following potential actions:

1. Sell protection on super-senior tranches instead of mezzanine tranches
2. Reduce the allocation in CDOs and purchase treasuries
3. Purchase credit default swaps (CDS) for hedging

(e) (*1.5 points*) Assess the effectiveness of each action in meeting the company's objectives.

| ANSWER: |
| --- |

(f) (*0.5 points*) Recommend the most appropriate action.

| ANSWER: |
| --- |

**QFI IRM Spring 2021 Question 2**

Source Material: CP351-112-25: The Devil is in the Tails;

Quantitative Enterprise Risk Management, Ch. 6: Copulas;

Quantitative Enterprise Risk Management, Ch. 7: Stress Testing

Learning Outcome:

3b) Demonstrate an understanding of and apply tools and techniques for measuring and managing interest rate risk in an ALM context

3c) Apply stress testing and scenario analysis to assess extreme ALM events

You are a client risk manager at an asset management firm, where you are responsible for assisting clients in using risk metrics and other methods to uncover the market risks of their portfolios. One client is concerned about risks present in their CDO portfolio, which they currently model using a Gaussian copula.

(a) (*1.5 points*)

(i) Explain two limitations of using the Gaussian copula for risk management of CDOs.

| ANSWER: |
|---|

(ii) Describe an alternative approach to quantify the risk of a CDO portfolio using stress testing.

| ANSWER: |
|---|

This client also invests in two corporate bond portfolios, X and Y. They are concerned that large losses in one portfolio may frequently occur simultaneously with large losses in the other.

To assist the client, you gather a 9 month sample of loss data for each portfolio and calculate the Pearson correlation coefficient and Kendall's $\tau$, shown in the table below.

| $Month_i$ | $Loss_X$ | $Loss_Y$ |
|---|---|---|
| 1 | 30 | 390 |
| 2 | 9 | 230 |
| 3 | 400 | 400 |

| | | |
|---|---|---|
| 4 | 28 | 280 |
| 5 | 3 | 301 |
| 6 | 10 | 308 |
| 7 | 22 | 302 |
| 8 | 0 | 0 |
| 9 | 35 | 398 |

| **Risk Measure** | **Value** |
|---|---|
| Pearson correlation coefficient | 0.398 |
| Kendall's $\tau$ | 0.722 |
| Spearman correlation coefficient | |

(b) (*3 points*)

(i) Calculate the sample Spearman correlation coefficient.

*The response for this part is to be provided in the Excel spreadsheet.*

(ii) Calculate the concordance for the first pair $(x_1, y_1)$.

*The response for this part is to be provided in the Excel spreadsheet.*

(iii) Assess your client's concern using the risk measures above. Justify your response.

*The response for this part is to be provided in the Excel spreadsheet.*

The client manages their combined portfolio risks with a 95% CTE loss limit of \$200M. The client wishes to perform a reverse stress test. The joint dependency structure of the annual change in portfolio value $(N, M)$ is assumed to follow a Gumbel copula. You are also provided the following information:

- $C_{Gumbel}(u,v) = \exp\left\{-\left[(-lnu)^a + (-lnv)^a\right]^{\frac{1}{a}}\right\}$
- $p^n_{loss} = \Pr[N < 0] = p^m_{loss} = \Pr[M < 0] = 1/e^2$
- $Loss_n = Loss_m = \$100\ Million$ ; losses are constant and independent
- For the Gumbel copula, $a = \dfrac{1}{1-\tau}$

(c) (*2.5 points*)

(i) Explain two reasons why a firm would use a reverse stress test.

*The response for this part is to be provided in the Excel spreadsheet.*

(ii) Calculate the 95% CTE if an independence copula is used.

*The response for this part is to be provided in the Excel spreadsheet.*

(iii) Determine the smallest value of Kendall's $\tau$ such that the limit is breached.

*The response for this part is to be provided in the Excel spreadsheet.*

**QFI IRM Fall 2021 Question 4**

Source Material: Quantitative Enterprise Risk Management, Ch. 6: Copulas

Learning Outcome:

3b) Demonstrate an understanding of and apply tools and techniques for measuring and managing interest rate risk in an ALM context

You are a market risk analyst for an institutional asset management firm and are assigned the task of assessing tail risks for a large client's portfolio.

The portfolio's asset allocation includes only two asset classes, public equities and venture capital. To assess the joint return distribution of the portfolio, you consider three types of copulas:

1. Fundamental copula
2. Implicit copula
3. Explicit copula

(a) (*2 points*)

(i) Describe each type of copula listed above.

| ANSWER: |
| --- |

(ii) Recommend the best copula to model returns for this portfolio. Justify your response.

| ANSWER: |
| --- |

As a first step to building your model, you consider two basic functional forms the copula could take:

$$Form\ A: C_1(u,v) = \max(u,v)$$
$$Form\ B: C_2(u,v) = uv$$

(b) (*2.5 points*)

(i) List three requirements a function $C:[0,1]^2 \to [0,1]$ must meet for $C$ to be a copula.

| ANSWER: |
|---|

(ii) Assess whether each of Form A and Form B is a copula. Justify your response.

| ANSWER: |
|---|

(iii) Identify the functional form of each of the upper and lower bounds of all bivariate copulas.

| ANSWER: |
|---|

Your manager reviews your initial results and recommends that you consider a copula that can incorporate tail-dependency. Your colleague suggests using the following form:

$$C_C(u,v) = \max\left(\left[u^{-\frac{1}{2}} + v^{-\frac{1}{2}} - 1\right]^{-2}, 0\right)$$

(c) (*1.5 points*)

(i) Define upper and lower tail dependence.

| ANSWER: |
|---|

(ii) Explain the interpretation and importance of lower tail dependence in the context of portfolio risk management.

| ANSWER: |
|---|

(iii) Assess whether the copula $C_C(u,v)$ above exhibits lower tail dependence. Justify your response.

| ANSWER: |
|---|

You conclude that a Gumbel copula is most appropriate for the client's portfolio and need to determine the copula's single parameter. You obtain a selection of paired return data for the portfolio's two asset classes.

(d) (*1 point*) Describe two methods of calibrating the copula parameter.

| ANSWER: |
|---|

**QFI IRM Fall 2022 Question 1**

Source Material: Quantitative Enterprise Risk Management, Ch. 6: Copulas;

Quantitative Enterprise Risk Management, Ch. 7: Stress Testing

Learning Outcome:

3b) Demonstrate an understanding of and apply tools and techniques for measuring and managing interest rate risk in an ALM context,

3c) Apply stress testing and scenario analysis to assess extreme ALM events

You work at XYZ insurance company, and they have recently launched an indexed annuity product. Policyholders can choose between one of two indices to link to their product: Index A or Index B. You have been assigned with evaluating the tail risks associated with this product.

In order to measure the concordance between the two indices, you look at the average index price each year over the past 15 years. The sum of the signs over each possible distinct value of i and j > i is 75.

$$\sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sign((A_i - A_j)(B_i - B_j)) = 75$$

(a) (*0.5 point*) Calculate the sample estimate of Tau for the dataset.

| *The response for this part is to be provided in the Excel spreadsheet.* |
|---|

The Vice President (VP) of Investments uses 20 years of historical data and calculates Tau to be 0.50.

(b) (*1.5 points*)

(i) Interpret the difference between your estimate for tau and the VP's estimate after their addition of 5 years to the data set.

| *The response for this part is to be provided in the Excel spreadsheet.* |
|---|

(ii) Calculate Theta using the Gumbel copula and the VP's recommended Tau.

| *The response for this part is to be provided in the Excel spreadsheet.* |
|---|

XYZ's management is concerned about the tail risk of this product line. They have asked you to evaluate the CTE(80) of the Indexed Annuity product using the historical return/loss statistics provided in the table below.

| | **Index A** | **Index B** |
|---|---|---|
| Expected Return | 7.5% | 9.5% |
| Standard Deviation | 15% | 20% |
| Index Loss | 500 | 375 |
| Joint Loss | 1035 | |

Gumbel Copula, where $\theta = 2$:

$$C(u, v) = e^{-((-\log(u))^{\theta} + (-\log(v))^{\theta})^{(\frac{1}{\theta})}}$$

(c) (*2 points*)

(i) Calculate the probability that both Index A and B are negative using the Gumbel copula.

*The response for this part is to be provided in the Excel spreadsheet.*

(ii) Calculate CTE(80) for Index A and B.

*The response for this part is to be provided in the Excel spreadsheet.*

**QFI IRM Spring 2023 Question 3**

Source Material: Quantitative Enterprise Risk Management, Ch. 7: Stress Testing

Learning Outcome:

3c) Apply stress testing and scenario analysis to assess extreme ALM events

You are a consultant specialized in stress testing for insurance companies.

(a) (*1 point*) Identify four uses of stress testing on investment portfolio.

| ANSWER: |
|---|

You begin stress testing for company XYZ and ask for input from employees who design insurance products.

- Employee A recommends stressing the interest rate in isolation by 1-2 basis points, which is a typical movement in the interest rate.
- Employee B recommends stressing the interest rate by 1000-2000 basis points while also stressing the tax rate on bonds.
- Employee C recommends stress testing based on the market conditions during the 2020 pandemic.

(b) (*2 points*) Critique each of the employees' recommendations.

| ANSWER: |
|---|

Now you assess company QRS, which uses stress testing to evaluate risks in their models. You collect the following information on the firm's use of stress testing:

- The objectives of the stress tests were determined by the Chief Risk Officer (CRO) and shared with the Board.
- The stress tests were used to ensure compliance with regulatory frameworks.
- The CRO reviews the results of the stress test and examines the model framework annually.
- Employees seem dismissive of the results, with one commenting "such events would never occur and modeling their impact is a waste of time."

(c) (*2 points*)

(i) Critique the firm's current use of stress testing.

| ANSWER: |
| --- |

(ii) Recommend three changes the firm can implement to more effectively utilize stress testing.

| ANSWER: |
| --- |

**QFI IRM Spring 2023 Question 9**

Source Material: Fixed Income Securities: Valuation, Risk, and Risk Management, Pietro Veronesi, Ch. 5 and 6

Learning Outcome:

3f) Understand interest rate derivatives and use them to mitigate interest rate risk

On January 1, 2000, your company sold a line of business for $100M and will receive the full payment in six months at $t_1$. Your company does not need the money at $t_1$ but will need it in twelve months at $t_2$ to fund a capital investment. Your company would like to lock in the interest rate to be applicable on the $100 million receivable for the six-month period from $t_1$ to $t_2$.

Assume that interest rates are positively correlated with futures prices.

(a) (*0.5 point*) Explain whether the price of a futures contract may be different from the price of an otherwise equivalent forward contract.

| ANSWER: |
|---|

Your firm enters into a 6-month forward rate agreement (FRA) expiring on July 1, 2000 with a bank on January 1, 2000 for the period of July 1, 2000 to January 1, 2001. The current price of the 6-month zero coupon bond is $96.79 and the price of the 1-year zero coupon bond is $93.51.

(b) (*1 point*)

(i) Determine the semi-annually compounded forward rate of the contract.

| *The response for this part is to be provided in the Excel spreadsheet.* |
|---|

(ii) Calculate the value of the FRA at inception.

| *The response for this part is to be provided in the Excel spreadsheet.* |
|---|

Consider that it's now July 1, 2000. You receive the discount factors Z(0,T) in the following table.

| | July 1, 2000 |
|---|---|
| Maturity | Z(0,T) |
| 0.25 | 0.9848 |
| 0.5 | 0.9692 |

| | |
|---|---|
| 0.75 | 0.9545 |
| 1 | 0.9402 |

(c) (*2 points*)

(i) Calculate the value of the FRA on $t_1$, July 1, 2000.

*The response for this part is to be provided in the Excel spreadsheet.*

(ii) Calculate the current semi-annually compounded spot interest rate.

*The response for this part is to be provided in the Excel spreadsheet.*

(iii) Determine the net amount to be paid at the settlement of the FRA on $t_2$, January 1, 2001and which party will be responsible for it.

*The response for this part is to be provided in the Excel spreadsheet.*

You are also given that on July 1, 2000, the European Call option and Put option on the 13-week Treasury bill with maturity in 6 months and strike price of $99.12 is priced at $0.2934 and $0.1044, respectively.

(d) (*1.5 points*)

(i) (*0.5 points*) Demonstrate that the securities are priced incorrectly.

*The response for this part is to be provided in the Excel spreadsheet.*

(ii) (*0.5 points*) Recommend a strategy to take advantage of the arbitrage opportunity.

ANSWER:

(iii) (*0.5 points*) Determine the net cashflow of d (ii).

*The response for this part is to be provided in the Excel spreadsheet.*

**QFI IRM Fall 2023 Question 2**

Source Material: Quantitative Enterprise Risk Management, Ch. 6: Copulas

Learning Outcome:

3b) Demonstrate an understanding of and apply tools and techniques for measuring and managing interest rate risk in an ALM context

You are a risk manager at an insurance company. The Chief Risk Officer (CRO) is particularly interested in modeling market risk (risk factor $X_1$) and credit default risk (risk factor $X_2$). The CRO suggests rank correlation because he believes that correlation is not an appropriate dependency measure.

(b) (*1 point*) Describe these two types of relationships.

(i) (*0.5 points*) Concordant

| ANSWER: |
|---|

(ii) (*0.5 points*) Discordant

| ANSWER: |
|---|

You have gathered historical data for ten periods.

| **Time** | $X_1$ | $X_2$ |
|---|---|---|
| 1 | 2.1% | -0.5% |
| 2 | 10.2% | 2.0% |
| 3 | 20.1% | 7.8% |
| 4 | -4.4% | -1.8% |
| 5 | 19.7% | 3.8% |
| 6 | 5.5% | 1.0% |
| 7 | -7.5% | 2.4% |
| 8 | 10.6% | 0.0% |
| 9 | 30.4% | -1.9% |
| 10 | -1.7% | 0.5% |

(c) (*3 points*) Calculate three types of correlation of $X_1$ and $X_2$

(i) (*1 point*) Pearson's

| |
|---|
| *The response for this part is to be provided in the Excel spreadsheet.* |

(ii) (*1 point*) Spearman's rank

| |
|---|
| *The response for this part is to be provided in the Excel spreadsheet.* |

(iii) (*1 point*) Kendall's rank

| |
|---|
| *The response for this part is to be provided in the Excel spreadsheet.* |

The CRO wants to know more about the effect of the recessionary cycle to the correlation of two factors. A risk analyst suggests using a copula approach.

(e) (*1 point*) Explain the advantages of the copula approach to model the tail risk.

| |
|---|
| ANSWER: |

**QFI IRM Fall 2023 Question 4**

Source Material: Quantitative Enterprise Risk Management, Ch. 14: Model Risk and Governance

Learning Outcome:

3d) Understand and evaluate model and parameter risks

You have applied for a model governance position at an actuarial software and consulting firm. Interviewers are in discussions with you on various topics related to model risk and model governance.

The first interviewer asks about model risk and model governance.

(a) (*1 point*)

(i) (*0.5 points*) Identify the two main sources of model risk.

| ANSWER: |
|---|

(ii) (*0.5 points*) List the main purposes of model governance.

| ANSWER: |
|---|

The second interviewer states: "Some of the companies we work with are small with limited resources; we work with these companies to develop proxy models that can deliver the needed results with the resources available."

(b) (*1.5 points*)

(i) (*1 point*) List four methods for constructing proxy models.

| ANSWER: |
|---|

(ii) (*0.5 points*) Identify two risks of using proxy models.

| ANSWER: |
|---|

The interviewer notes that client companies are very concerned about estimating parameters, in particular, understanding the parameter risk of their models.

(c) (*3 points*)

(i) (*1 point*) Explain the conditions when standard errors can be used to estimate parameter uncertainty.

| ANSWER: |
|---|

(ii) (*0.5 points*) Describe the key advantage of Bayesian methods over MLE for assessing parameter uncertainty.

| ANSWER: |
|---|

(iii) (*1.5 points*) Describe the steps to simulate values from the predictive distribution using the Markov Chain Monte-Carlo (MCMC) algorithm given a prior $p$ and likelihood function $L$.

| ANSWER: |
|---|

Another interviewer describes a new model being developed of real-world exchange rates between US Dollars (USD) and an emerging-market nation Buranda outside of North America with currency BUR. The model is to be used to decide investment returns of held-to-maturity pension plan assets.

- The model uses a weekly projection time-step.
- Model USD/BUR performance is benchmarked to long-established FX models for USD/Canadian dollars and USD/Mexican pesos.
- The model parameters require at least 10 years of data to fully calibrate. Buranda was part of a larger neighboring nation until 8 years ago; due to their shared history, that nation's historical exchange rate with USD is used when USD/BUR is unavailable.

(d) (*1 point*) Critique the appropriateness of the model characteristics above.

| ANSWER: |
|---|

**QFI IRM Fall 2023 Question 7**

Source Material: Fixed Income Securities: Valuation, Risk, and Risk Management, Pietro Veronesi, Ch. 6

Learning Outcome:

3f) Understand interest rate derivatives and use them to mitigate interest rate risk

You work as a financial analyst for a car dealer, Company XYZ. On October 1, 2007, your company lost a lawsuit and must pay $100 million in 9 months. To pay the lawsuit, the company decided to sell one of its warehouses to raise cash.

Company ABC offers to buy the warehouse for $95 million and deliver the payment in cash in 6 months.

Your company decided to enter into a Eurodollar futures contract with expiration on April 1, 2008 to hedge interest rate risk. The underlying instrument is 3-month LIBOR. The company will buy 100 contracts, each with notional value of $1 million.

The price of a 90-day Eurodollar futures contract expiring on April 1, 2008 is $95.39.

(c) (*1 point*) Determine the minimum bid price your company should accept from Company ABC that will allow the company to pay the lawsuit, ignoring interest earned between April 1 and July 1, 2008.

*The response for this part is to be provided in the Excel spreadsheet.*

It is now April 1, 2008. Your firm has sold the warehouse at the minimum bid price 6 months ago while hedging the interest rate risk. The firm has now received the proceeds from Company ABC and the 100 futures contracts. The 90-day LIBOR rate is now 3.7088%. The price of the futures contract is currently $97.2912.

(d) (*1.5 point*)

(i) (*0.5 points*) Calculate the profit or loss of the futures contract.

*The response for this part is to be provided in the Excel spreadsheet.*

(ii) (*1 point*) Assess whether your firm will be able to pay the lawsuit on July 1, 2008.

*The response for this part is to be provided in the Excel spreadsheet.*

Your coworker notices that the amount available to pay the lawsuit is not exactly $100 million, even though interest rate risk had been hedged using futures.

(e) (*1 point*)

(i) (*0.5 points*) Identify the shortcoming of hedging with futures that is referred to by your coworker.

| ANSWER: |
| --- |

(ii) (*0.5 points*) Explain one method to overcome this shortcoming.

| ANSWER: |
| --- |

**QFI IRM Spring 2024 Question 4**

Source Material: Quantitative Enterprise Risk Management, Ch. 6: Copulas

Learning Outcome:

3b) Demonstrate an understanding of and apply tools and techniques for measuring and managing interest rate risk in an ALM context

You are also given that the market values of the two companies are linked by a Frank copula:

$$C(F(x), G(y)) = -\frac{1}{\alpha}\ln\left[1 + \frac{(e^{-\alpha F(x)}-1)(e^{-\alpha G(y)}-1)}{e^{-\alpha}-1}\right],$$

with $\alpha = 2.5$.

(*1 point*) Calculate the probability that both companies will default in one year.

| *The response for this part is to be provided in the Excel spreadsheet.* |
|---|

**QFI IRM Spring 2024 Question 7**

Source Material: Quantitative Enterprise Risk Management, Ch. 15: Risk Mitigation using Options and Derivatives;

Fixed Income Securities: Valuation, Risk, and Risk Management, Pietro Veronesi, Ch. 5 and 6

Learning Outcome:

3e) Explain and implement techniques used to mitigate market risks

3f) Understand interest rate derivatives and use them to mitigate interest rate risk

You are the Chief Financial Officer (CFO) of a small startup in the US which just received a seed fund invested in the money market. It is expected the seeding fund will be sufficient to fund operations for the next three years without additional capital raises. The company is relying on your expertise to ensure this commitment despite marketplace volatility. You are actively exploring possible actions.

The business must purchase significant amounts of agricultural commodity A to process into its final commercial product. The commercial product is in a highly competitive market and price elastic. Clearly, large increases in the price of commodity A pose a material risk.

You are considering two financial instruments, forward agreements and futures contracts to mitigate this risk.

(a) (*3 points*)

(i) (*2 points*) Contrast the advantages and disadvantages of forward agreements and future contracts, regarding the following risks:

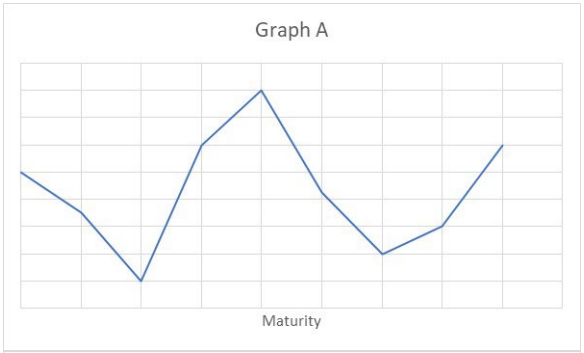
- Customization and Basis Risk
- Counterparty/Credit Risk
- Rollover Risk
- Liquidity Risk

| ANSWER: |
| --- |
| |

(ii) (*1 point*) Recommend the most appropriate financial instrument of the two for the business.

ANSWER:

A draft report from your team contained two graphs as of the same date: (1) the yield curve and (2) the futures prices of an agricultural commodity across maturities, but there were no associated labels or descriptions.



(b) (*1.5 points*) Explain which graph most likely represents the commodity futures and which one represents the yield curve.

ANSWER:

The CEO suggests entering into an interest rate swap agreement to avoid any financial impact implied by the yield curve identified in part (b).

(c) (*1 point*) Assess the CEO's suggestion.

ANSWER:

The company anticipates purchasing 11,200 units of commodity A in the coming year and would like to fully hedge, if possible. You are considering cross-hedging the risk. One possibility has a $\beta$ of 0.7 with each 1-year contract representing 250 units of the underlying, where $\beta$ is an estimate of the optimal hedge ratio.

(d) (*2 points*)

(i) (*0.5 points*) Calculate the number of contracts for this cross-hedge.

| ANSWER: |
|---|

(ii) (*1.5 points*) Describe three factors that would impact the effectiveness of the cross-hedge if using futures.

| ANSWER: |
|---|

Company Y is a foreign company operating in currency CY. It receives a 2% discount on commodity A from the US market rate (in USD) due to its relationship with the supplier. Your company incurs no foreign exchange transaction costs between USD and CY, while the foreign exchange transaction cost between USD and CY is 2% for company Y.

(e) (*1.5 points*) Recommend a mutually beneficial arrangement between your company and company Y.

| ANSWER: |
|---|

**QFI IRM Fall 2024 Question 4**

Source Material: Quantitative Enterprise Risk Management, Ch. 6: Copulas

Learning Outcome:

3b) Demonstrate an understanding of and apply tools and techniques for measuring and managing interest rate risk in an ALM context

You are studying risk modeling techniques, including copulas.

(a) (*1 point*) Describe two advantages of using copulas.

| ANSWER: |
|---|

A colleague is modeling joint risks and suggests using a multivariate normal distribution is appropriate when the marginal distributions are normally distributed.

(c) (*0.5 points*) Critique your colleague's suggestion.

| ANSWER: |
|---|

(d) (*1.5 points*) Describe two tests to determine if the multivariate normal distribution is appropriate.

| ANSWER: |
|---|

(e) (*1 point*) List three properties of the generating function $\phi(u)$ of an Archimedean copula.

| ANSWER: |
|---|

**QFI IRM Fall 2024 Question 8**

Source Material: Quantitative Enterprise Risk Management, Ch. 15: Risk Mitigation using Options and Derivatives

Learning Outcome:

3e) Explain and implement techniques used to mitigate market risks

In a recent risk committee meeting for NewTech, the committee members expressed their concerns on the market risks faced by NewTech. The risk committee also considers the following:

- Instead of eliminating risks, risk-return trade-off should be considered.
- The hedging portfolio should be efficiently managed by the current small investment team.

NewTech hires you as a financial analyst to review the company's market risk profile.

The risk committee is considering the following three hedging options to mitigate the company's equity exposure:

- Delta-neutral hedging
- Delta-gamma-neutral hedging
- Hedging with option combinations

(a) (*2 points*)

(i) (*1 point*) Describe each of the three hedging options above.

| ANSWER: |
|---|

(ii) (*1 point*) Assess the suitability of each option, in light of the risk committee's considerations.

| ANSWER: |
|---|

NewTech asks you to construct an example for delta-neutral hedging and compare it against the portfolio without hedging (assume fully invested in stock). You come up with the following portfolio as an example:

| | **Time = 0** |
|---|---|

| | |
|---|---|
| Investment | 5,000 |
| Unit of stock | 202.8 |
| Unit of put | 624.3 |
| Stock price | 20 |
| Strike price | 19 |
| Option term | 1.00 |
| Risk free rate | 0.04 |
| Volatility | 0.3 |
| N(-d1) | 0.3248 |
| N(-d2) | 0.4387 |
| Trading days per year | 250 |
| $z_{99\%}$ | 2.3263 |

(b) (*1 point*)

(i) (*0.5 points*) Verify that the portfolio value at time T=0 was $5,000.

*The response for this part is to be provided in the Excel spreadsheet.*

(ii) (*0.5 points*) Verify that the portfolio is delta-neutral at time T=0.

*The response for this part is to be provided in the Excel spreadsheet.*

At time T= 0.05, stock price increases to 22 per unit. Assume options are priced based on the Black–Scholes formula and that risk-free rate and volatility are constant. You compare this delta-neutral portfolio with the $5,000 investment portfolio consisting of only stocks with no hedging.

(c) (*2 points*) Calculate the return of the portfolio with and without delta-neutral hedging.

*The response for this part is to be provided in the Excel spreadsheet.*

(d) (*2 points*) Calculate the 1-day 99% VaR for the portfolio with and without delta-neutral hedging, as a percentage of the portfolio value, using the delta-normal method.

*The response for this part is to be provided in the Excel spreadsheet.*

**QFI PM Fall 2021 Question 6**

Source Material: CP351-106-25: Liability Driven Investment Explained

Learning Outcome:

3a) Develop and critique asset allocation strategies appropriate to underlying liability profiles such as pension plans and long-tail insurance liabilities

You are the manager of your company's pension plan, whose funding ratio has experienced volatility over the last year and is now at 70%. Currently, the portfolio backing the pension liabilities is invested 40% in equity and 60% in a mix of Treasury and corporate bonds.

Your assistant recommends that the plan reposition the portfolio to invest 50% in Treasury bonds and 50% in corporate bonds.

(a) (*1 point*) Explain the major benefits and limitations of this proposed allocation.

| ANSWER: |
| --- |

(b) (*1 point*) Describe derivative securities that will help achieve capital efficient liability hedging that address a plan's interest and inflation risks.

| ANSWER: |
| --- |

**QFI PM Spring 2022 Question 12**

Source Material: CP351-106-25: Liability Driven Investment Explained

Learning Outcome:

3a) Develop and critique asset allocation strategies appropriate to underlying liability profiles such as pension plans and long-tail insurance liabilities

(*6 points*) You are evaluating a lump sum pension payment currently worth $100, that will be made in 34 years. The payment is indexed to inflation, which is assumed to be 1% per year. Your portfolio consists of a zero-coupon bond with a fixed notional of $120 maturing in 30 years. The discount rate for pension and bond payments is 5%.

(a) (*1 point*) Calculate the funding ratio.

| ANSWER: |
|---|

(b) (*1 point*) Identify key risk factors that can adversely affect the funding ratio.

| ANSWER: |
|---|

You decide to sell the bond and invest 70% of the proceeds into equity, while the remaining 30% is held back as cash. You use this cash as collateral to enter into a 34-year interest rate swap, receiving 5% in exchange for a variable rate of interest.

(c) (*0.5 points*) Identify advantages of using swaps instead of bonds.

| ANSWER: |
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(d) (*1 point*) Calculate the Liability Driven Investment (LDI) leverage, defined as the value of liabilities as a percentage of LDI assets value.

| ANSWER: |
|---|

Assume that one year has passed. Equity dropped by 10% over the year, and the inflation expectation and discount rate are revised to 1.5% and 5.5%, respectively. The LDI leverage has now increased to 575%.

(e) (*1 point*) Calculate the new funding ratio.

| ANSWER: |
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(f) (*1.5 points*) Evaluate the situation (increase in leverage / decrease in funding ratio) and potential courses of action for the fund manager.

| ANSWER: |
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Spring 2025 Exam

| Exam | Q | LOs | Source | New Exam | New LO | New Source |
|---|---|---|---|---|---|---|
| QFI-PM | 8abc | 4d | Managing Investment Portfolios: A Dynamic Process, Maginn & Tuttle, 3rd Edition, 2007, Ch. 3: Managing Institutional Investor Portfolios | CP 351 | 2b | CP351-108-25: Life Insurance Risk, Capital, and ALM in the Age of Uncertainty - Paper 2 - Risk models and monitoring, and management implications |
| QFI-PM | 8d | 4d | Managing Investment Portfolios: A Dynamic Process, Maginn & Tuttle, 3rd Edition, 2007, Ch. 3: Managing Institutional Investor Portfolios | CP 351 | 2b | AAA Liquidity Risk paper |
| QFI-PM | 9 | 6ad | Managing Investment Portfolios: A Dynamic Process, Maginn & Tuttle, 3rd Edition, 2007, Ch. 6: Fixed-Income Portfolio Management | CP 351 | 3af | CP351-101-25: ALM for Life, Annuities, and Pensions (section 5) |
| QFI-PM | 11ab | 6ad | QFIP-158-23 A guide to Duration | CP 351 | 2a | CP351-107-25: Key Rate Durations: Measures of Interest Rate Risk |
| QFI-IRM | 1c | 1b | Financial Enterprise Risk Management, Sweeting, Ch.8 | CP 351 | 1c | |
| QFI-IRM | 2c | 1a | Quantitative Enterprise Risk Management, Hardy and Saunders, 2022 Ch. 2: Risk Taxonomy | CP 351 | 1c | |
| QFI-IRM | 3a | 2f | Investment Risk Management, Baker, Kent and Filbeck, Greg, 2015 | CP 351 | 2b | AAA Liquidity Risk paper |
| QFI-IRM | 3g | 2f | Investment Risk Management, Baker, Kent and Filbeck, Greg, 2015 | CP 351 | 3a | Liability Driven Investment Explained |
| QFI-IRM | 4 | 2cg | Quantitative Enterprise Risk Management, Hardy and Saunders, 2022 Ch. 6: Copulas & Ch. 7: Stress Testing | CP 351 | 3bc | |
| QFI-IRM | 5a | 2g | IAA Note on Stress Testing and Scenario Analysis | CP 351 | 3c | Quantitative Enterprise Risk Management, Hardy and Saunders, 2022 Ch. 7: Stress Testing |
| QFI-IRM | 5b-d | 2a | Quantitative Enterprise Risk Management, Hardy and Saunders, 2022 Ch. 8: Market Risk Models | CP 351 | 2b | |
| QFI-IRM | 7 | 4ab | Fixed Income Securities, Veronesi, Ch 5: Forwards and Swaps, Ch. 6: Futures and Options | CP 351 | 3f | |
| QFI-IRM | 8a-d | 4cd | Handbook of Fixed Income Securities, Fabozzi, 9th Edition, Ch. 69: Credit Derivative Valuation and Risk | CP 351 | 3f | Fixed Income Securities, Veronesi, 2010, Ch. 6: Futures and Options |