Exam QFIPM

MORNING SESSION

Date: Thursday, October 31, 2019
Time: 8:30 a.m. – 11:45 a.m.

INSTRUCTIONS TO CANDIDATES

General Instructions

1. This examination has a total of 100 points. It consists of a morning session (worth 60 points) and an afternoon session (worth 40 points).
   a) The morning session consists of 9 questions numbered 1 through 9.
   b) The afternoon session consists of 7 questions numbered 10 through 16.

   The points for each question are indicated at the beginning of the question.

2. Failure to stop writing after time is called will result in the disqualification of your answers or further disciplinary action.

3. While every attempt is made to avoid defective questions, sometimes they do occur. If you believe a question is defective, the supervisor or proctor cannot give you any guidance beyond the instructions on the exam booklet.

Written-Answer Instructions

1. Write your candidate number at the top of each sheet. Your name must not appear.

2. Write on only one side of a sheet. Start each question on a fresh sheet. On each sheet, write the number of the question that you are answering. Do not answer more than one question on a single sheet.

3. The answer should be confined to the question as set.

4. When you are asked to calculate, show all your work including any applicable formulas. When you are asked to recommend, provide proper justification supporting your recommendation.

5. When you finish, insert all your written-answer sheets into the Essay Answer Envelope. Be sure to hand in all your answer sheets because they cannot be accepted later. Seal the envelope and write your candidate number in the space provided on the outside of the envelope. Check the appropriate box to indicate morning or afternoon session for Exam QFIPM.

6. Be sure your written-answer envelope is signed because if it is not, your examination will not be graded.

Recognized by the Canadian Institute of Actuaries.

Tournez le cahier d’examen pour la version française.
1. (7 points) You work for an asset manager that provides liability driven investing services. Your U.S. based client has a liability related to a one-time benefit payment with the following liability profile:

<table>
<thead>
<tr>
<th>Discount Rate</th>
<th>PV of Cashflow</th>
<th>Increase in PV due to a 1% decrease in discount rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liability 3.5% per annum</td>
<td>$100 million USD</td>
<td>10%</td>
</tr>
</tbody>
</table>

Your client’s benefit payment is currently backed using the following portfolio:

<table>
<thead>
<tr>
<th>Bond</th>
<th>Market Value of Holdings</th>
<th>Yield</th>
<th>Modified Duration (years)</th>
<th>Coupon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bond A</td>
<td>$75 million USD</td>
<td>4.5% per annum</td>
<td>11 years</td>
<td>0%</td>
</tr>
</tbody>
</table>

Your manager would like you to consider adding more of bond A to immunize the portfolio.

(a) (1 point)

(i) Calculate the dollar duration of both the portfolio and the liability.

(ii) Calculate the additional market value of Bond A required to immunize the portfolio.

The plan sponsor does not wish to contribute cash towards the purchase of additional bonds. Your manager suggests that repurchase agreements or interest rate futures could be used to hedge the plan’s interest rate risk instead.

(b) (1 point) Describe each of the two instruments your manager has suggested.
1. Continued

Your manager proposes entering a one year repurchase agreement for $50 million of Bond A and then using the proceeds to buy $50 million USD of zero-coupon Bond B, which has a modified duration of 7 years and a yield of 3.0% per annum. The current repo rate is 2.0% per annum and the duration of the repurchase agreement is one year. After incorporating your manager’s suggestion, you make several calculations for the resulting portfolio.

(c) (2 points)

(i) (0.5 points) Calculate the rate of return of the portfolio.

(ii) (1 point) Calculate the dollar duration of the portfolio.

(iii) (0.5 points) Calculate the size of the same repurchase agreement that would instead result in a dollar-duration-immunized portfolio.

The plan sponsor indicates that he is concerned about the risks associated with repurchase agreements. Given that concern, your manager again recommends the use of interest rate futures to hedge the plan’s remaining interest rate risk. After researching, you find that you cannot use cash settlement but either of the following two bonds C and D may be delivered to settle the futures contract:

<table>
<thead>
<tr>
<th>Bond</th>
<th>Market Value of Bond</th>
<th>Modified Duration (years)</th>
<th>Conversion factor</th>
<th>Coupon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bond C</td>
<td>$1.0 million USD</td>
<td>10</td>
<td>1.1</td>
<td>0%</td>
</tr>
<tr>
<td>Bond D</td>
<td>$1.1 million USD</td>
<td>11</td>
<td>1.2</td>
<td>0%</td>
</tr>
</tbody>
</table>

(d) (1 point) Calculate the number of whole futures contracts required to immunize the client’s existing portfolio from interest rate risk relative to the liabilities.

The plan sponsor has heard about the use of international bonds to hedge interest rate risk while providing an enhanced yield. He asks you to consider the following Canadian bond portfolio to hedge his liabilities:

<table>
<thead>
<tr>
<th>Bond</th>
<th>Market Value of Bond</th>
<th>Modified Duration</th>
<th>Coupon</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bond E</td>
<td>$65 million CAD</td>
<td>20 years</td>
<td>0%</td>
<td>BBB-</td>
</tr>
</tbody>
</table>

CAD to USD FX Rate: $1.00 USD = $1.30 CAD

(e) (2 points) Describe four significant risks associated with the use of this bond portfolio to hedge the plan sponsor’s liability.
2. (7 points) As an investment officer of ABC Life Insurance Company, you have been asked by the Chief Financial Officer (CFO) for advice on a new bond issuance by ABC. The CFO has first asked for your opinion on issuing a Medium Term Note.

(a) (1 point) Describe four advantageous features of issuing a Medium Term Note.

The CFO explains that, in case of deterioration of its debt ratio, ABC would like to be able to retire the issue early using provisions which can be included in the bond’s indenture.

(b) (2 points) Compare and contrast three types of provisions that would provide this flexibility.

Suddenly, ABC was downgraded to below-investment-grade, so the CFO is now also concerned about the potentially heavy burden of interest payments from the new issue and would like to avoid using cash to make interest payments for a period of three years.

(c) (1 point) Describe three types of deferred-coupon structures that meet this requirement.

The CFO is also concerned about a mismatch in the average lives between the new issue and the investment portfolio, which has a large allocation to mortgage-backed securities.

(d) (2 points) Explain the impacts of prepayment risk on cash flow patterns of mortgages.

After ABC issues the debt, the CFO asks for a recommendation on how to invest the proceeds. He states that the current exposure of ABC to commercial mortgages is too low and he would like to increase it.

(e) (1 point) Recommend a type of commercial mortgage ABC should pursue.
3. (6 points) You are an investment actuary in a Canadian life insurance company named TWA, and your manager had asked you to review the following excerpt from an internal analyst’s report on commercial real estate investment strategy.

*We continue to favour commercial real estate in local regional markets in Canada due to our familiarity of such markets, where we have readily available information from our research team and word-of-mouth advice. Also, we believe that commercial properties in developed markets behave in a broadly similar fashion over time. As in the past 3 years, we expect to continue to focus in core and core+ office buildings.*

*We focus on the factors that drive lease income returns over capital returns. To forecast the lease income and capital gains from such real estate, we value the opinions from professional appraisers, property transaction prices from the past 5 years, as well as historical and forecast economic growth rates from economists.*

You are planning to write a memo for your manager limited to the context of real estate.

(a) (1.5 points) Discuss the consequences of three behavioral biases in the excerpt.

(b) (1.5 points) Propose an approach to address each of the behavioral biases you have identified in (a).

You are considering the market value (MV) and investment value (IV) of a given commercial property noted in the internal analyst’s report.

(c) (1 point) Explain why the IV of a property may differ for different investors at the same point in time.

The noted commercial property is currently rented to a well-established fast food chain, allowing TWA to earn a very stable net lease income of 200,000 per year on a post-tax basis. If the commercial property is put up for sale, there is a 40% chance it will sell for 1,000,000, a 30% chance for 1,200,000 and 30% chance for 1,600,000.

With a required post-tax return of 10% annually, the analyst report assumes a perpetual annuity calculation for IV.

(d) (1 point) With respect to the commercial property noted above:

(i) Calculate the IV.

(ii) Calculate the MV.
3. **Continued**

In the same analyst report, the following is written:

*TWA has extensive research in a somewhat sluggish real estate market that we have witnessed predictable cycles of short-run movement in prices. We can take advantage of this predictability to attempt to buy low and sell high. We believe that in that real estate market, we have a greater opportunity for making successful market timing decisions.*

(e) *(1 point)* Critique the above excerpt.
4. (8 points) You are a risk analyst for ABC Insurance Company. Investment policy mandates that all bonds must have a Liquidity Cost Score (LCS) of 6% or better. A portfolio of bonds was compliant when the bonds were purchased, but the LCS may have drifted over time. The Chief Risk Officer (CRO) has asked you to reassess the portfolio.

No bonds have been bought, sold, or matured in the past year; however, the following has changed:

- All bonds are one year older.
- One long-dated bond is approaching maturity within the next year.
- The issuer for one bond has been downgraded by rating agencies. This has triggered high trading volumes from forced selling.
- A ten-year bond was previously the most recent issue. The issuer has recently issued new ten-year bonds.

(a) (2 points) Assess how each of the above changes may have affected the portfolio’s LCS.

The CRO has identified 4 bonds that she believes may no longer be compliant with the investment policy. Dealers have provided indicative bid-ask spreads for bonds A, B, and C. Bond D is unquoted. The CRO has pulled together some characteristics that she believes can be used to approximate the LCS for bond D.

<table>
<thead>
<tr>
<th>Bond</th>
<th>Age (Years)</th>
<th>Issue Size ($M)</th>
<th>DTS (bps)</th>
<th>Benchmark/ Non-Benchmark</th>
<th>Bid Price</th>
<th>Ask Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8</td>
<td>1000</td>
<td>300</td>
<td>Yes</td>
<td>110</td>
<td>114</td>
</tr>
<tr>
<td>B</td>
<td>6</td>
<td>300</td>
<td>700</td>
<td>No</td>
<td>95</td>
<td>100</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>800</td>
<td>400</td>
<td>Yes</td>
<td>102</td>
<td>106</td>
</tr>
<tr>
<td>D</td>
<td>5</td>
<td>500</td>
<td>500</td>
<td>No</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

The maximum non-quoted adjustment factor is 1.35. The non-benchmark adjustment factor is 1.15.

(b) (2 points) Estimate a range for the Liquidity Cost Score (LCS) for bond D.

(c) (1 point) Identify which bonds (if any) should be liquidated so that the portfolio is compliant with the investment policy.
4. Continued

You have identified several bonds to be liquidated. The proceeds will be reinvested into bonds compliant with the investment policy. The Chief Investment Officer (CIO) believes that Option Adjusted Spread (OAS) decomposition can be used to identify attractively priced bonds. A junior analyst has performed a regression over investment grade bonds to determine the OAS regression coefficients. The model assumes the following relationship between OAS and credit default swap (CDS) spreads and liquidity cost scores:

\[
OAS_i = a + \beta \times CDS_i + \gamma \times LCS_i + \eta_i
\]

Where

All variables are expressed in basis points

- \( OAS_i \) is the OAS for bond \( i \)
- \( CDS_i \) is the CDS spread for bond \( i \)
- \( LCS_i \) is the LCS for bond \( i \)
- \( \eta_i \) is a random error term

The estimated regression coefficients are given below:

\[
\hat{a} = 100 \\
\hat{\beta} = 1.2 \\
\hat{\gamma} = 0.7
\]

The CIO has identified the following three bonds, which may or may not be compliant with investment policy:

<table>
<thead>
<tr>
<th>Bond</th>
<th>Option Adjusted Spread (bps)</th>
<th>CDS Spread (bps)</th>
<th>Option Adjusted Spread Duration</th>
<th>Indicative Bid-Ask Spread (bps)</th>
<th>Benchmark?</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>500</td>
<td>150</td>
<td>7</td>
<td>40</td>
<td>Yes</td>
</tr>
<tr>
<td>Y</td>
<td>650</td>
<td>50</td>
<td>6</td>
<td>90</td>
<td>No</td>
</tr>
<tr>
<td>Z</td>
<td>550</td>
<td>200</td>
<td>4</td>
<td>100</td>
<td>Yes</td>
</tr>
</tbody>
</table>

(d) (3 points) Recommend bonds (if any) to be added to the portfolio.
5. (6 points) You are an investment actuary working for XYZ Life Insurance Co. You are considering using credit default swaps (CDS) to hedge the credit risk of your company’s asset portfolio.

(a) (2 points)

(i) Describe two situations in which an investor would purchase CDS protection.

(ii) Describe two situations in which an investor would sell CDS protection.

You encounter the auction process in the CDS market.

(b) (1 point) Explain the “delivery option” for the protection buyer (long position) in the CDS market.

(c) (1.5 points) Describe the main objectives of the auction process.

Your manager is asking about the triggering of a CDS contract following a restructuring credit event.

(d) (1.5 points) Explain to your manager why each counterparty would prefer the other side to trigger a CDS in a restructuring event.
6. (5 points) You are an ALM manager of a small firm and are tasked with setting up a Liability Driven Investment (LDI) strategy for the pension plan. Your company specializes in equity investing as a core part of your normal business. The pension plan currently has an 80% funding ratio and owns a portfolio with a current split of 40% bonds and 60% equity backing the pension plan. The firm has a goal of achieving a 100% funding ratio.

(a) (1 point) Explain the two main unrewarded risks pension schemes face.

(b) (1 point) Identify instruments that can be used in an LDI strategy to address unrewarded risks.

You are considering three options to implement an LDI strategy.

Option A: Sell down growth assets.

Option B: Use Synthetic Assets reinvesting the 40% Bond portfolio in a leveraged LDI strategy

Option C: Invest 100% in Bonds and create the 60% equity portfolio using synthetic equity.

(c) (2 points) Rank the three options in their ability to efficiently achieve the firm’s goal. Justify your answer.

The board is considering the following approaches while setting up the LDI portfolio:

- Using no more than 2.5 times the leverage
- Using no more than 4 times the leverage

(d) (1 point) Compare and contrast the portfolio structure (Pooled funds, Segregated Portfolio, Bespoke fund) under the two approaches being considered by the board.
7. (7 points) You are a CEO of a pension fund with 2 managers. You are doing year end evaluation of the performance of the two managers. Here is the information you have collected so far:

<table>
<thead>
<tr>
<th></th>
<th>Manager A</th>
<th>Benchmarked weight</th>
<th>Portfolio Weight</th>
<th>Portfolio return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small cap</td>
<td>30%</td>
<td>8.0%</td>
<td>35%</td>
<td>7.8%</td>
</tr>
<tr>
<td>Large cap</td>
<td>30%</td>
<td>6.0%</td>
<td>25%</td>
<td>7.2%</td>
</tr>
<tr>
<td>REIT</td>
<td>25%</td>
<td>4.0%</td>
<td>20%</td>
<td>2.0%</td>
</tr>
<tr>
<td>International Equities</td>
<td>15%</td>
<td>12.0%</td>
<td>20%</td>
<td>11.2%</td>
</tr>
<tr>
<td></td>
<td>Manager B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small cap</td>
<td>30%</td>
<td>8.0%</td>
<td>35%</td>
<td>7.5%</td>
</tr>
<tr>
<td>Large cap</td>
<td>30%</td>
<td>6.0%</td>
<td>25%</td>
<td>7.0%</td>
</tr>
<tr>
<td>REIT</td>
<td>25%</td>
<td>4.0%</td>
<td>20%</td>
<td>3.0%</td>
</tr>
<tr>
<td>International Equities</td>
<td>15%</td>
<td>12.0%</td>
<td>20%</td>
<td>11.0%</td>
</tr>
</tbody>
</table>

(a) (1.5 points) Describe the simplified framework for return accountability (Brinson’s model).

You overheard Manager A mention to one of his colleagues – “I will be getting a massive payday this bonus season. I consider myself a superior stock picker to manager B. I have outperformed him in 3 out of the 4 asset classes we invest in.”

(b) (2 points) Critique the accuracy of the above statement by comparing Manager A and Manager B’s selection return.

(c) (2.5 points) Calculate the decomposition of each manager’s active return.

(d) (1 point) Compare their performance qualitatively using the results from part (c).
8. (7 points) Company ABC’s pension plan has pension liabilities of $100 million, funded at only 80% due to a recent market downturn. 40% of the fund is invested in a domestic equity fund, the rest is invested in a domestic bond fund. Surplus is defined as assets minus liabilities. The liability duration is 115% of the bond fund. The volatility associated with the payouts is zero. The payouts are negligible in the single period. The risk-free rate is 3%.

<table>
<thead>
<tr>
<th>Equity Fund</th>
<th>Bond Fund</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excess Return</td>
<td>3%</td>
</tr>
<tr>
<td>Volatility</td>
<td>15%</td>
</tr>
<tr>
<td>Correlation</td>
<td></td>
</tr>
</tbody>
</table>

ABC is concerned about the funding status of the plan under a further market downturn.

(a) (2 points) Calculate the volatility of surplus.

The fund manager is considering a new strategy: Replace the domestic equity fund with a global equity fund because the global fund has a higher Sharpe ratio.

(b) (1 point) Critique this strategy.

Many retirees from ABC are worried about the underfunded status of the pension plan. One retiree, Jack, relies heavily on the pension income to cover his living expenses. He sought help from his financial advisor. The advisor recommended to him to invest all of his savings in an Equity Indexed Annuity (EIA) to protect him from further market risks.

(c) (2 points) Evaluate the advisor’s recommendation.
8. Continued

Responding to the retirees’ concerns, ABC injected funding to the plan and now the plan’s funding ratio has risen to 200%. Management intends to change the equity allocation to minimize surplus risk for the given level of the funding ratio. Some simulations are generated to analyze the relationships among the funding status, the equity allocation and the surplus volatility relative to asset value.

![Volatility of Surplus Relative to Asset Value](image)

You observe that for an overfunded plan fully invested in bonds, moving a small amount of the fund to equities could lead to a decrease in the surplus volatility.

(d) \((0.5\text{ points})\) Explain your observation.

(e) \((1.5\text{ points})\) Calculate the optimal equity allocation that achieve management’s goal given the new funding status.
9. (7 points) ABC Insurance Company has large portfolio of over-the-counter derivatives.

(a) (1 point) Describe the fundamental components used in the measurement of counterparty credit risk.

You are given the following credit default swap (CDS) spread curve:

<table>
<thead>
<tr>
<th>Time</th>
<th>CDS Spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>1Y</td>
<td>200 bps</td>
</tr>
<tr>
<td>2Y</td>
<td>275 bps</td>
</tr>
<tr>
<td>3Y</td>
<td>400 bps</td>
</tr>
<tr>
<td>4Y</td>
<td>500 bps</td>
</tr>
<tr>
<td>5Y</td>
<td>700 bps</td>
</tr>
</tbody>
</table>

You assume an interest rate of 5% and a recovery rate of 30%.

(b) (1.5 points) Determine an estimate for the implied default probability for each of the first two years, based on the spread curve above.

(c) (1.5 points) Describe the use of credit value adjustment (CVA) and credit limits, in managing counterparty risk.

The company’s new Chief Risk Officer would like to determine CVA charges.

(d) (1.5 points) Compare and contrast the use of historical data versus market data for determining appropriate CVA charges.

(e) (1.5 points) Discuss ways the company can mitigate counterparty risk, noting benefits and drawbacks of each approach.

**END OF EXAMINATION**

Morning Session
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