

Exam QFIPM

MORNING SESSION

Date: Wednesday, April 29, 2020

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.

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Tournez le cahier d'examen pour la version française.

****BEGINNING OF EXAMINATION****
Morning Session

- 1.** (7 points) You are an investment consultant to a company that specializes in real estate investments.
- (a) (1.5 points) Describe three key behavioral biases in real estate investing.
 - (b) (3.5 points) For each of the behavioral bias you described in (a) above:
 - (i) (1.5 points) Describe an experiment confirming the bias.
 - (ii) (2 points) Recommend workarounds that would improve the investment decision process.
 - (c) (2 points) Explain why behavioral finance could be an important tool in shaping investment decision-making, particularly in the real estate investment area.

2. (6 points) You are an investment actuary reviewing a commercial mortgage backed security (CMBS) that is part of the investment portfolio for ZZZ Life Insurance Company. The CMBS has three tranches:

- senior tranche A with par value of 150 million and an annual coupon rate of 4%,
- junior tranche B with par value of 50 million and an annual coupon rate of 5%, and
- tranche X which is an interest-only tranche that is subordinate only to tranche A.

Interest and principal are paid in separate waterfall sequences.

The collateral underlying the CMBS consists of eight commercial mortgage loans with four loans maturing in one year and the other four loans maturing in two years. All mortgages are interest-only balloon loans, with prepayment lockout until maturity. Each loan has an outstanding loan balance of 25 million and pays an annual interest rate of 5%. The combined loan to value ratio (LTV) of the eight loans is 80%.

(a) (1 point) Describe four reasons the value of the underlying mortgages prior to tranching and securitization could be worth less than the total value of all the issued tranches.

A junior actuary says the A tranche should have a lower credit rating than the overall pool due to the high LTV ratio of the underlying pool of commercial mortgages.

- (b) (1 point) Explain why the A tranche deserves a higher credit rating, including a supporting calculation.
- (c) (2 points) Calculate the market value of the X tranche at issue if the yield to maturity at issue is 4%.

Three loans default at the end of year 2. The recovery value of each defaulted loan is 5 million.

(d) (2 points) Show the cash flows received by each tranche at the end of year 2.

3. (6 points) You are a portfolio manager for XYZ Insurance Company. Your portfolio is associated with long-dated and illiquid liabilities. The company believes the asset portfolio can earn additional spread by purchasing illiquid assets but has limited appetite for credit risk. Investment policy dictates that for each bond in the portfolio, no more than 50% of the option adjusted spread (OAS) should be attributable to credit risk.

Option adjusted spreads on several bonds have widened over the past year. The CFO believes that the credit worthiness of the issuers has deteriorated and asks you to reassess your portfolio.

- (a) (1 point) Provide two alternative explanations for the widened option adjusted spreads.

You perform a regression over investment grade bonds to decompose bond OASs. The model assumes the following relationship between OAS and credit default swap (CDS) spreads and liquidity cost scores (LCS):

$$OAS_i = a + \beta \times CDS_i + \gamma \times LCS_i + \eta_i$$

where:

All variables are expressed in basis points

OAS_i is the OAS for bond i

CDS_i is the CDS spread for issuer of bond i

LCS_i is the LCS for bond i

η_i is a random error term

The estimated regression coefficients are given below:

$$\hat{a} = 80$$

$$\hat{\beta} = 1.3$$

$$\hat{\gamma} = 0.9$$

3. Continued

You are given the following for the three bonds in your portfolio:

Bond	Market Value (\$M)	Option Adjusted Spread (bps)	CDS Spread (bps)	Option Adjusted Spread Duration	Indicative Bid-Ask Spread (bps)	Benchmark
A	200	450	150	7	20	Yes
B	400	700	250	5	60	No
C	400	400	200	3	30	Yes

The non-benchmark adjustment factor is 1.1.

(b) (3 points)

- (i) Attribute bond B's OAS to the following sources: market-level risk premium, credit risk, liquidity risk, and unexplained.
- (ii) Identify which bonds (if any) should be liquidated so that the portfolio is compliant with the investment policy.
- (iii) Estimate the transaction cost (in dollars) associated with liquidating bond B.

You liquidate a bond from your existing portfolio and the proceeds must be reinvested into a new bond. You wish to screen for bonds that are likely to have high liquidity premiums.

- (c) (1 point) Describe three bond attributes other than OAS and Benchmark that can be used to identify bonds with high liquidity cost scores.

You are considering purchasing an unquoted Bond Z. You have access to a database of quoted bond attributes, including trading volume, age, bid-ask prices, and others.

- (d) (1 point) Explain how you can estimate the LCS for bond Z using the database of quoted bond attributes.

4. (6 points) ATL Company is considering adding infrastructure assets to its investment portfolios. You are an investment consultant who specializes in infrastructure investments. You are hired by ATL to provide your expertise on infrastructure as an asset class.

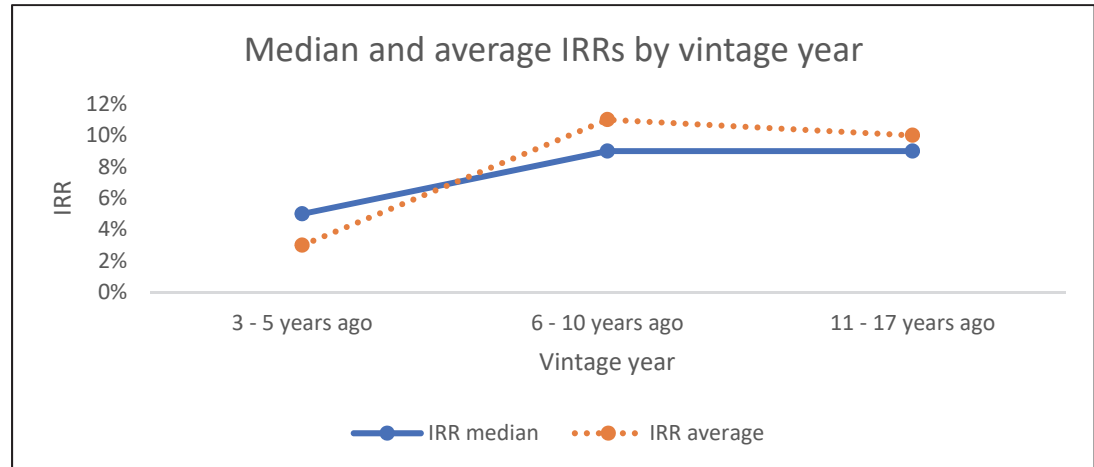
- (a) (1 point) List four benefits of infrastructure as an asset class.
- (b) (0.5 points) Describe two types of infrastructure investment vehicles.
- (c) (1.5 points) Evaluate the appropriateness of using primarily infrastructure investments supporting the following liabilities:
 - (i) 3-year Guaranteed Investment Contract (GIC)
 - (ii) Whole life insurance contracts with high surrender charge
 - (iii) Defined benefit pension liabilities with a portability option

A recent study suggests that global pension funds have allocated about 0.5% of their overall assets to infrastructure investments.

- (d) (1 point) Describe four potential issues associated with infrastructure asset allocation data in this study.
- (e) (0.5 points) Explain why the total exposure to infrastructure could be significantly higher than the data suggests.

4. Continued

Another recent study of over 40 unlisted infrastructure funds shows the following trends of internal rate of return (IRR) against the funds' vintage year.



- (f) (1.5 points) Identify the trend in the above graph and explain why such a trend exists.

5. (6 points) EcL issued a zero-coupon bond to fund its corporate project in the past. Except for this zero-coupon bond, EcL has no other debt or liabilities.

You are given the following:

- The remaining time-to-maturity of EcL's zero-coupon bond = 16 years
- The face value of the zero-coupon bond = \$100 million
- The market value of the zero-coupon bond = \$63.89 million
- The continuously compounded risk-free interest rate = 2% for all maturities

- (a) (1 point) Calculate the continuously compounded credit spread of the zero-coupon bond

The assumed loss-given-default of this zero coupon bond is 24.01% of the face value.

- (b) (1 point) Show that the risk-neutral probability of default of this zero-coupon bond is 50%.

You are using Merton's model to estimate the total asset value. You decide to calibrate the model using the risk-neutral probability of default of 50%, and you assume an asset volatility of 10%.

- (c) (2 points) Calculate the implied total asset value of EcL.
- (d) (2 points) Calculate the instantaneous volatility of EcL's equity value (σ_E).

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- 6.** (7 points) ABC is an insurance company that issues Single Premium Deferred Annuities (SPDA) and funding agreements (FA). ABC's balance sheet contains the following:

Liabilities:

- SPDA – annuities with a fixed crediting rate for 7 years. The surrender charge starts at 7% in year 1 and grades down 1% each year until reaching 0% in year 8 and later.
- FA – 10-year term with a fixed crediting rate. The contract holder has the right to demand repayment of principal within 7 days at any time.

Assets:

- BBB-rated Corporate Bonds – 5-year fixed rate callable bonds
- BBB-rated MBS Bonds – mortgage backed securities made up of 30-year fixed rate loans

The Chief Risk Officer (CRO) has been asked to give a presentation to the Board of Directors on the company's liquidity risk and has included the following statements in the presentation:

- "A sharp increase in interest rates is a stress liquidity risk to ABC."
- "A sharp decrease in interest rates is not a stress liquidity risk to ABC."
- "There will be no impact to ABC's liquidity position if one of our major competitors becomes insolvent."

- (a) (2 points) Critique the CRO's statements.
- (b) (1 point) Recommend changes to the asset and/or liability profile to reduce ABC's stress liquidity risk.

6. Continued

ABC's senior management has adopted a policy to address its liquidity risk. The policy mandates the company maintain a cash flow cushion of at least 105% under a stressed 3-month period. The table below contains the projected cash flows for the best estimate scenario.

Projected Cash Flows (millions)	Month 1	Month 2	Month 3
Corporate Bonds	400	400	400
MBS Bonds	50	75	50
SPDA	-300	-400	-500
FA	-100	-125	-150

Concerned about a potential interest rate increase, the CRO asks you to perform a scenario analysis. You have been provided with the following information on the liquidity stress scenario:

- Interest rates increase
- Only 80% of the MBS coupons are received
- Withdrawal from the SPDA increases by 20%
- Withdrawals from the FA increases by 100%

(c) (2.5 points) Calculate the minimum liquidity reserve that needs to be established in order to comply with the liquidity risk policy.

ABC chooses a non-benchmark, A rated corporate bond as the asset to support liquidity reserve. The bond has a bid-ask spread of 40 bps, with an option adjusted spread duration of 5, and a non-benchmark adjustment factor of 1.15.

(d) (1.5 points) Calculate the amount (in millions) of the bond that would need to be sold to provide the 3-month cash flows in the liquidity stress scenario.

7. (7 points) You are an investment actuary at ABC Life Insurance Company in its ALM department. ABC's management is concerned about the dollar duration mismatch in the traditional line of business. It has been suggested that the company increase its exposure to fixed income. You are asked to study various investment strategies.

First, you are asked to consider investing in a Treasury Inflation-Protected Securities (TIPS) bond with real yield of 0.5%. You are provided the following information:

- Issuance date 1 year ago
- 10-year maturity at issuance
- 1% real coupon paid annually
- forecasted annualized inflation rate is 2%
- 1000 original face amount per unit

- (a) (1.5 points) Calculate the real duration and an estimate of the effective duration of this TIPS bond.

The current yield of a Treasury note with the same maturity date is 2.5%.

- (b) (1.5 points) Assess whether you should invest in this TIPS bond instead of the conventional bond taking into consideration the break-even inflation rate.

Second, you are asked to consider increasing the company's exposure to asset-backed securities (ABS) as a means of closing the duration gap while attempting to earn high yields. One type of ABS that has been suggested is the Nonagency Residential Mortgage-Backed Securities (Nonagency RMBS) class. You intend to write a memo to Management about Nonagency RMBS and the two major credit enhancement structures for the class: Senior/Subordination Shifting Interest (Senior/Sub) structure (also called six-pack structure) and Overcollateralization and Excess Spread (OC/XS) structure.

- (c) (1 point) Describe Nonagency RMBS.
- (d) (1 point) Describe the key measurements of collateral performance for Nonagency RMBS.
- (e) (2 points) Compare the two credit enhancement strategies for Nonagency RMBS.

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8. (7 points) ABC Company is a publicly traded life insurance company selling two products:

- 1) Universal life (UL) insurance products with investment features and limited market value adjustment at surrender
- 2) Immediate annuities

(a) (1 point) Explain why segmentation of the asset portfolios is important for ABC.

Two important aspects of interest rate risk are valuation concern and reinvestment risk.

(b) (1 point) Describe valuation concern with an example of how rising interest rates could adversely affect ABC's UL products.

(c) (1 point) Describe reinvestment risk with an example of how declining interest rates could adversely affect ABC's annuity business.

Insurance companies are sensitive to the risk of any significant chance of principal loss or any interruption of investment income. ABC's Chief Risk Officer has noted that insurance regulators require certain formulaic additional asset requirements that are not based on market valuations of assets to mitigate these risks.

(d) (1 point) Discuss any potential adverse impacts of these regulatory requirements to ABC.

XYZ is a manufacturing company which offers a defined benefit pension plan to its employees. XYZ manages all assets on behalf of the pension plan members and bears all related pension risks.

(e) (1.5 points) Explain how the following factors may impact the risk tolerance of a traditional defined benefit pension plan:

- (i) Plan funded status
- (ii) Sponsor financial status
- (iii) Sponsor profitability
- (iv) Workforce characteristics

8. Continued

XYZ is considering entering into a pension de-risking transaction with ABC. The transaction allows XYZ to transfer the insurance risks associated with all retirees to ABC by paying a risk premium to ABC. XYZ maintains all pension assets and makes all pension payments to members.

- (f) (1.5 points) Discuss how the transaction will impact the following elements of the IPS for XYZ:
- (i) Risk and return objectives
 - (ii) Liquidity
 - (iii) Time horizon
 - (iv) Legal and regulatory factors

9. (8 points) You are reviewing the annual credit risk report at *ABC Life Insurance*.

(a) (1.5 points) Critique the following statements included in the report:

- A. Empirical studies show that the ratio of corporate bond durations to synthetic Treasury bond durations is constant as a function of synthetic Treasury duration.
- B. Effective durations should not be calculated based on changes in a single reference yield for all bonds in a portfolio; these should instead be linked to changes in yields for bonds with similar characteristics.
- C. Real-world default probabilities are often lower than risk-neutral default probabilities as they reflect the efficiency of the market.
- D. The spread DV01 of a long protection position is calculated to be \$3,042, meaning that a 100bp increase in the LIBOR curve while keeping the spread curve fixed would cause the value of the CDS position to increase by this amount.

You are given the following transition matrix included in the report, where “D” corresponds to the default state.

	AAA	AA	A	BAA	BA	B	D
AAA	89%	10%	1%	0%	0%	0%	0%
AA	1%	89%	9%	1%	0%	0%	0%
A	0%	3%	90%	2%	3%	2%	0%
BAA	0%	0%	7%	83%	6%	1%	1%
BA	0%	0%	1%	6%	83%	6%	4%
B	0%	0%	0%	1%	6%	90%	3%
D	0%	0%	0%	0%	0%	1%	99%

(b) (1.5 points) Describe four (4) problems in the above transition matrix.

9. Continued

The following was included in the report:

“We are switching our approach to spread sensitivity analysis from spread duration to DTS. This change has a number of advantages and disadvantages, including the following.”

- (c) (2 points) Describe four (4) advantages or disadvantages of the DTS approach for analyzing spread sensitivity.
- (d) (1 point) Assess the relative merits of switching the approach from spread duration to DTS.

The following formulas for the valuation of CDS contracts were included in the report:

$$V_{premium} = \frac{C(T)}{2} \sum_{i=1}^N \Delta(t_{i-1}, t_i) Z(t_i) (Q(t_i) + Q(t_{i-1}))$$

$$V_{protection} = (1 - R) \sum_{n=1}^M Z(t_n) (Q(t_{n-1}) - Q(t_n))$$

$$U(0) = V_{protection} - V_{premium}$$

- (e) (2 points) Explain the key terms in the above formulas.

****END OF EXAMINATION****
Morning Session

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