SOCIETY OF ACTUARIES
Quantitative Finance and Investments Core

Exam QFI CORE

AFTERNOON SESSION

Date: Wednesday, October 30, 2013
Time: 1:30 p.m. – 3:45 p.m.

INSTRUCTIONS TO CANDIDATES

General Instructions

1. This afternoon session consists of 6 questions <u>numbered 12 through 17</u> for a total of 40 points. 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 since 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 QFI Core.

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

Tournez le cahier d'examen pour la version française.

12. (*7 points*)

(a) (*2.5 points*) Define and describe the payment structure of the following derivative instruments:

   (i) Cap & Floor
   (ii) Receiver Swaption & Payer Swaption
   (iii) Index amortization swap

Company ABC sells traditional 5-year fixed annuity products with no market value adjustment. The initial crediting rate is fixed for 5 years and reset every 5 years based on the new money rate. The products carry a guaranteed minimum credited interest rate. The annuity products are subject to disintermediation when interest rates increase.

ABC's CFO has recently heard about the use of interest rate derivatives and wants to understand how they may be used to hedge the annuity risk.

(b) (*3 points*) Evaluate and recommend trades for ABC using interest rate derivatives listed above if:

   (i) ABC portfolio consists of 10-year floating rate bond
   (ii) ABC portfolio consists of 10-year fixed rate bond
   (iii) ABC portfolio consists of 10-year residential mortgage pass-throughs

ABC's CRO decides to add market-value-adjustment to mitigate interest rate risk. Due to regulatory and marketing requirements, initial principal is guaranteed.

(c) (*1.5 points*) Evaluate and recommend trades for ABC using interest rate derivatives listed above if:

   (i) ABC portfolio consists of 10-year floating rate bond
   (ii) ABC portfolio consists of 10-year fixed rate bond

13. (7 *points*) Lawrence Park manages the portfolio of US equity managers for a pension fund. The portfolio is comprised of four managers. Their assets under management (AUM) and historical performance statistics (as measured by the pension fund) over the past year are shown below:

	AUM	Alpha	Tracking Risk
Manager A	$300	0.00%	0.00%
Manager B	$75	0.50%	1.00%
Manager C	$75	1.50%	5.00%
Manager D	$50	4.00%	9.00%

- The pension fund measures the managers' performance against the S&P 500 Index.
- All four managers' alphas are uncorrelated.
- The pension fund trustees have stated the following objectives:
  o Achieve an information ratio of 0.6 or greater,
  o Keep the tracking risk no more than 2% per year,
  o Keep broad sector weightings in line with that of the benchmark.
- Manager C's fund universe is well represented by S&P 500 Growth index, which is this manager's normal benchmark.
  o Return of S&P 500 index and S&P 500 Growth index is 7% and 5% respectively.
  o The manager's "misfit" risk is 4 percent annually.
- Lawrence Park plans to minimize the "misfit" risk of each manager.

(a) (*0.5 point*) Identify and describe the structure of the portfolio of investment managers used by this pension fund.

(b) (*1.5 points*) Evaluate whether this portfolio of managers is expected to meet the trustees' investment objectives.

(c) (*3 points*)
   (i) Describe the concepts of "true" and "misfit" active return and risk for a manager and the circumstances when these concepts are useful.
   (ii) Evaluate Manager C's performance based on his "true" information ratio.
   (iii) Assess Lawrence's plan to minimize "misfit" risk of each manager.

(d) (*1 point*) Recommend an approach that would allow Park to keep broad sector weightings in line with the benchmark while retaining the alpha from active management.

(e) (*1 point*) Propose a fee structure so that the managers' interests are aligned with those of the pension fund while their incentive to take a high level of risk is limited.

14. (*8 points*) The investment objective of an endowment fund EDF is to maintain the real purchasing power after distributions with the annual spending rate of 3%.

- The fund trustees estimate expected inflation of 3% per annum and the annual cost of earning investment returns is 0.4%.
- The trustees use the T-bill yield of 2% for the risk-free rate.
- The trustees prefer to keep the portfolio standard deviation below 9% per annum.
- The trustees' objective is to preserve capital and to minimize the probability that the portfolio return will fall below the threshold level of 4.5% based on Roy safety-first criterion.
- The trustees wish to consider four asset classes with the following capital market expectations:

Asset Classes	Expected Annual Return	Annual Standard Deviation	Correlations			
			1.	2.	3.	4.
1. Bonds	4%	6%	1			
2. Mortgages	6%	9%	0.7	1		
3. Large Cap Equities	10%	15%	0.2	0.3	1	
4. Small Cap Equities	12%	24%	--	--	0.7	1

Signed-constrained mean-variance optimization based on the above inputs generates the following corner portfolios:

Corner Portfolio	Asset Class Portfolio Weight				Expected Annual Return	Annual Standard Deviation
	Bonds	Mortgages	Large Cap Equities	Small Cap Equities		
1	82%	5%	7%	6%	5.0%	5.9%
2	0%	58%	27%	15%		9.5%
3	0%	0%	75%	25%	10.5%	

(a) (*1 point*)

(i) State the return and risk objectives of EDF endowment fund.

(ii) Identify the relevant considerations and constraints for EDF endowment fund.

(b) (*4.5 points*) Using the results of the mean-variance analysis summarized above:

(i) Determine the composition of the efficient portfolio with the expected return equal to the EDF objective, assuming that only the four asset classes considered by the trustees are permissible.

(ii) Determine and justify the overall most appropriate strategic asset allocation for EDF, assuming that T-bills are also a permissible asset class.

14. Continued

(c)   (*1 point*) Critique the mean-variance optimization approach in setting asset allocation.

(d)   (*1.5 points*) Describe briefly the process of the following alternative approaches to setting optimal asset allocation:

   (i)   Black-Litterman

   (ii)   Monte Carlo Simulation

   (iii)   Experience Based

15. (*6 points*) Your manager, Bill, has asked you to review the following Guaranteed Investment Contract (GIC) and the asset portfolio supporting it. The current asset portfolio consists of a single Inflation Linked Bond (ILB).

GIC Details
Issue date:	Jan 15, 20X3
Remaining term:	3 years
Amount deposited:	$100 million
Promised return:	2.5% payable per annum
Principal withdrawals:	Not permitted

ILB Details
Purchase date:	Jan. 15, 20X3
Issue date:	Jan 15, 20X1
Coupon:	2% of inflation adjusted principal, payable annually
Inflation basis:	Consumer Price Index (CPI) at Jan. 1
Real yield at purchase:	1%
Remaining term:	8 years
Deflation protection:	Maturity principal payment only

Consumer Price Index (CPI) (base = 220)

Date	1/1/20X1	1/1/20X2	1/1/20X3	1/1/20X4	1/1/20X5	1/1/20X6
Actual	220	228	230			
Predicted by Bill				225	232	239

Bill plans to sell the ILB on Jan. 15, 20X6 and justifies his decision to invest entirely in this ILB to back the GIC by his prediction that in 3 years the real yield on the ILB will fall down to 0%.

(a)   (*3 points*) Derive the following cash flows assuming that Bill's predictions will materialize. Show all calculations:

(i)   Liability cash flows
(ii)   Expected asset portfolio cash flows

(b)   (*1.5 point*) Explain the reasons why pension plans, endowments and individuals, respectively, use Inflation-Linked Bonds (ILBs).

(c)   (*1 point*) Critique Bill's decision to invest entirely in ILBs to back the GIC.

(d)   (*0.5 points*) Calculate the break-even inflation rate implied by the ILB for the 8-year period beginning on Jan. 15, 20X3, if the nominal yield of the conventional 8-year bond with the same credit rating as the ILB was 2.8% at that date.

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16. (*7 points*) Buddy Inc. is a construction company with stable earnings that are expected to remain stable or increasing. It sponsors a defined benefit (DB) plan with the following characteristics:

- The projected benefit obligation is $40 million.

- The current value of the fund is $45 million.

- Normal retirement at age 65 with no early retirement permitted.

- No lump sum settlements permitted.

- The average age of the employees is 55 years.

(a) (*2 points*) Explain how the following factors affect the risk tolerance for a DB pension plan.

    (i)   Plan status

    (ii)   Plan features

    (iii)   Sponsor financial status

    (iv)   Sponsor profitability

(b) (*2 points*) Assess the risk tolerance of Buddy Inc.'s DB plan.

The plan assets are invested in equities and bonds. You make the following assumptions:

- Equities track closely to XYZ Equity Index.
- Bonds track closely to XYZ Bond Index.
- Liabilities track closely to the benchmark Liability Index.

Asset Classes	Expected Annual Return	Annual Standard Deviation	Duration	Correlations		
				1.	2.	3.
1. XYZ Equity Index	7.5%	15%	--	1		
2. XYZ Bond Index	5.0%	6%	5	0.50	1	
3. Liability Index	4.5%	19%	15	0.30	0.99	1

16. Continued

(c)   (*2 points*) Calculate the maximum portion of the plan assets to be invested in bonds in order to minimize the surplus risk.

(d)   (*1 point*) Assess the impact on the plan's risk tolerance for each of the following new provisions that Buddy Inc. considers to introduce:

   (i)   Early retirement at age 55

   (ii)   Lump sum settlements

17. (*5 points*) You are given the following information:

- $S = 90$
- A European Call option with strike K has a price of 7.227
- A European Put option with strike K has a price of 12.350
- Risk free rate is 5%
- Maturity of the options is 1 year
- There are 250 days in a year
- S pays no dividend
- $d_1 / d_2 = 0.2418$
- $\Gamma = 0.017$

(a) (*2 points*) Calculate the volatility implied by the market.

(b) (*2 points*) You decide to sell the European Call option and to delta hedge it using implied volatility. On the first day, the actual volatility is 37%.

Estimate your mark-to-market profit for that day.

(c) (*1 point*) Explain the advantages of hedging with implied volatility.

END OF EXAMINATION
Afternoon Session

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