SOCIETY OF ACTUARIES

Quantitative Finance and Investment Core

# Exam QFICORE

## AFTERNOON SESSION

**Date:** Wednesday, October 28, 2015
**Time:** 1:30 p.m. – 3:45 p.m.

### INSTRUCTIONS TO CANDIDATES

**General Instructions**

1. This afternoon session consists of 8 questions numbered 10 through 17 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 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 QFICORE.

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.


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****BEGINNING OF EXAMINATION****
**Afternoon Session**
***Beginning with Question 10***

**10.** (*4 points*) You are considering interest-only (IO) and principal-only (PO) tranches that are stripped out from collateralized mortgage obligations (CMO).

(a) (*2 points*) Analyze the impact of a falling interest rate environment on the IO tranches and PO tranches.

(b) (*1 point*) Explain how IO tranches can be used to hedge interest rate risk of a portfolio that contains ordinary fixed income securities.

(c) (*1 point*) Explain how PO tranches can be used to hedge interest rate risk of fixed income liabilities.

**11.** (*4 points*) The manager of a bond fund for XYZ Company's pension plan is tightly managing tracking risk of the fund portfolio against a bond benchmark.

(a) (*0.5 points*) Define tracking risk.

(b) (*2 points*) List and describe risk factors that should be managed to minimize tracking risk.

The manager likes the passive investing approach of this bond fund. Although he is comfortable with the returns of the benchmark index, he is concerned that because of the expenses and transaction costs, the actual returns on the bond fund could be substantially lower than the returns on the benchmark index.

(c) (*1.5 points*) Suggest three index enhancement strategies.

**12.** (*6 points*) In order to immunize surplus of a pension plan against small parallel interest rate shifts, the following three immunization conditions have to be met:

- Market Value of Assets ≥ Market Value of Liabilities
- Duration of Assets = Duration of Liabilities
- Convexity of Assets ≥ Convexity of Liabilities

(a) (*2 points*) Demonstrate that the surplus of the pension plan satisfying the above three conditions is immunized against small parallel interest rate changes.

ABC liabilities are represented by a single payment of $1,900 at year 6. ABC assets consist of two zero-coupon bonds with face values of $907 and $1,000 maturing at year 5 and 7, respectively. Spot rates and cash flows are given below:

| Term (year) | Spot rate | Cash Flows | |
|---|---|---|---|
| | | Assets | Liabilities |
| 5 | 5.0% | $907 | |
| 6 | 5.0% | | $1,900 |
| 7 | 5.0% | $1,000 | |

(b) (*2 points*) Show whether the immunization conditions hold for the ABC Pension portfolio.

The manager of ABC assets is considering hiring a consultant to advise them on portfolio immunization. One consultant made the following statements during his presentations:

1. A great thing about immunization is that it is a set-and-forget strategy. That is, once you have immunized your portfolio, there is no subsequent work to be done.
2. The immunization target rate of return is more than the yield-to-maturity.
3. If a portfolio is immunized against a change in the market yield at a given horizon by matching portfolio duration to the horizon, the portfolio faces no risk except for default risk.
4. The liquidity of securities used to construct an immunized portfolio is irrelevant.
5. In general, the entire portfolio does not have to be turned over to rebalance an immunized portfolio. Furthermore, rebalancing need not to be done on a daily basis.
6. There are no reinvestment and pricing risks.

(c) (*2 points*) Critique the above statements.

**13.** (*4 points*) You have recently joined the investment team in a life insurance company. The company has traditionally worked with a single equity portfolio manager who has managed the company's indexed portfolio since its inception. The company's benchmark has been the Russell 3000 index, a value-weighted index that represents the 3,000 largest domestic stocks.

(a) (*1 point*) Describe the advantages of equity indexing, and list alternative passive investment vehicles available.

Your equity portfolio manager had implemented a fully replicated index portfolio. After analyzing past performance reports, you noticed that the indexed portfolio returns had consistently lagged the benchmark's returns. Your equity manager has justified this underperformance to be due to transaction costs driven by high trading frequency, as the business-as-usual aspect of implementing a fully replicated indexed portfolio.

(b) (*1.5 points*) Critique your equity manager's justification.

(c) (*1.5 points*) Describe one alternative approach to full replication for constructing an indexed portfolio.

**14.** (*6 points*) You are a consultant researching the investment style of a portfolio manager. This is the information you have gathered about the portfolio one year ago and the portfolio today:

| | Portfolio 1 year ago | Portfolio Today | Market Benchmark |
|---|---|---|---|
| Number of stocks | 50 | 28 | 700 |
| Weighted Avg Market Cap | \$25 Billion | \$45 Billion | \$37 Billion |
| Dividend Yield | 2.10% | 2.80% | 2.40% |
| P/E | 23 | 14 | 18 |
| P/B | 2.4 | 1.3 | 2 |
| EPS Growth (5 year projected) | 15% | 10% | 13% |

(a) (*1.5 points*) Identify and describe the portfolio manager's investment styles today and one year ago.

(b) (*1 point*) Identify the issues relating to this manager's investment practices and recommend whether or not to use this portfolio manager to manage your clients' funds.

(c) (*2 points*)

(i) Describe the purpose of the investment policy statement (IPS).

(ii) List the elements of the IPS.

(iii) Identify and describe those elements that could be specified to avoid the issues of this portfolio manager.

(d) (*1.5 points*) Identify four criteria that characterize a benchmark style and explain why the liquidity should be considered as a benchmark style.

**15.** (*5 points*) ABC Life Insurance company, a stock company in the U.S., has three equally profitable major lines.

- Universal Life (UL) insurance with low cash value and low guaranteed premium
  - Duration matched with target spread of 1% with minimum crediting rate of 3%
- Single Premium Fixed Deferred Annuity (SPDA) with no market value adjustment
  - Duration matched with target spread of 0.5% with minimum crediting rate of 1%
- Variable Annuity with return of premium guaranteed minimum death benefit (GMDB) and 10 year return of premium guaranteed minimum accumulation benefit (GMAB)
  - Currently no hedging for these minimum guarantees

You are asked to draft the investment policy statements (IPS) for ABC Life's three liability lines.

(a) (*0.5 points*) State the advantage of the segmentation of portfolios.

(b) (*1 point*) Draft the risk objective section of the IPS for the UL line.

(c) (*1 point*) Explain why effective duration is more appropriate for the UL line instead of modified duration.

(d) (*1 point*) Comment on the liquidity requirement in the IPS for the SPDA line.

ABC Life sponsors a defined benefit pension plan for its employees. Currently, the plan is under-funded. The Chief Investment Officer (CIO) suggested that the plan should under-weigh equities compared to ABC's peers because the company is not hedging VA minimum guarantees.

(e) (*1.5 points*) Critique the CIO's statement.

**16.** (*7 points*) VNT pension plan has \$94 million in assets and \$100 million in liabilities. The current investment management firm uses an asset-only approach to strategic asset allocation.

(a) (*0.5 points*) Describe the asset-only approach currently employed.

(b) (*0.5 points*) Identify and describe one alternative approach to strategic asset allocation.

(c) (*1 point*) Assess whether the current approach is appropriate for VNT.

VNT fiduciary Board just approved the following investment objectives and constraints:

- Return objective: To earn an average 6% annual portfolio risk-adjusted return.
- Risk objective: Accept a portfolio standard deviation of returns of 14% or less.
- Regulatory constraints: No short-selling allowed.
- Have a maximum Roy's safety-first ratio.

VNT's measured risk aversion, $R_A$, is equal to 4.

Your team has generated the following corner portfolios based on your firm's capital market expectations:

| | Portfolio Allocation | | | | |
|---|---|---|---|---|---|
| Asset class | I | II | III | IV | V |
| Local Equities | 100.0% | 75.0% | 50.0% | 25.0% | 0.0% |
| International Equities | 0.0% | 25.0% | 15.0% | 20.0% | 15.0% |
| Medium-Term Bonds | 0.0% | 0.0% | 15.0% | 30.0% | 40.0% |
| Long-Term Bonds | 0.0% | 0.0% | 20.0% | 25.0% | 45.0% |
| | | | | | |
| Expected Return | 12.0% | 11.0% | 10.0% | 9.0% | 8.0% |
| Standard Deviation | 21.0% | 16.0% | 12.0% | 8.0% | 6.0% |
| Risk Adjusted Return | 3.18% | 5.88% | 7.12% | | |
| Sharpe Ratio | 0.429 | 0.500 | 0.583 | | |
| Safety-First Ratio | 0.286 | 0.312 | 0.333 | | |

(d) (*2 points*) Determine and justify the strategic asset allocation most appropriate for VNT based on mean-variance analysis as well as VNT's risk objective and constraints.

(e) (*1 point*) Identify the corner portfolio most likely to be the tangency portfolio.

**16. Continued**

(f) (*1 point*) Describe the utility and the limitations of the tangency portfolio in the process of selecting an optimal strategic asset allocation.

A year after implementing the optimal allocation from the mean-variance analysis, VNT's funding ratio changed from 94% to 102%. As a result, a Board member makes the following statement:

> *"Given the pension plan is now overfunded, we can update the risk constraint by increasing maximum acceptable standard deviation in the investment policy."*

(g) (*1 point*) Critique the Board member's statement and recommend potential change(s) in the investment policy, if any. Justify your answer.

**17.** (*4 points*) You are a fund manager at a large defined benefit pension plan.

You are choosing between assets Portfolio A and Portfolio B to back the liabilities of the plan.

| | Pension Liabilities | Portfolio A | Portfolio B |
|---|---|---|---|
| Expected Annual Portfolio Return | 5% | 6% | 7% |
| Standard Deviation of Portfolio Return | 10% | 12% | 15% |
| Correlation with Liabilities | 1.0 | 0.65 | 0.35 |
| Portfolio Value at Year-End Last Year | 100 | 120 | 120 |

The risk free rate is 1% per annum.

(a) (*1 point*) Assess which asset portfolio should be selected, according to the Sharpe ratio, in an asset-only approach to strategic asset allocation. Justify your answer.

You have previously calculated the Risk Adjusted Change in Surplus (RACS) for Portfolio A to be equal to 0.18.

(b) (*2 points*) Assess which asset portfolio should be selected, according to RACS, in an Asset/Liability Management approach to strategic asset allocation.

(c) (*1 point*) Compare the appropriateness of the two approaches when managing the assets of the pension plan.

****END OF EXAMINATION****
**Afternoon Session**

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