
SOCIETY OF ACTUARIES
Quantitative Finance and Investment Core
Exam QFICORE
AFTERNOON SESSION

Date: Wednesday, April 29, 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.
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.

Written-Answer Instructions

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

****BEGINNING OF EXAMINATION****

Afternoon Session
Beginning with Question 10

- 10.** (5 points) ABC Life's management is concerned by the losses arising from the dynamic delta hedging with constant volatility of the options embedded in its equity indexed annuities.

Denote by r_n the continuously compound returns and σ_n the volatilities of the equity index. It is assumed that $r_n = \sigma_n \varepsilon_n$, where ε_n is an independent standard normal distribution.

You use the following 3 models to estimate the volatilities σ_n :

Model I: $\sigma_n^2 = 0.0388 + 0.0615r_{n-1}^2$

Model II: $\sigma_n^2 = 0.9247\sigma_{n-1}^2 + 0.0753r_{n-1}^2$

Model III: $\sigma_n^2 = 0.0000024 + 0.0615r_{n-1}^2 + 0.9385\sigma_{n-1}^2$

$\sigma_n^2(k)$ = k days step ahead expected forecast volatilities with n as the forecast origin.

- (a) (2 points) Identify, describe, and compare strengths and weaknesses of Model I and II.
- (b) (1 point) Determine $\text{Var}(r_n)$ of Model I (assuming r_n and σ_n are stationary processes).
- (c) (2 points) Using, $\sigma_n^2(1) = 0.0016\%$,
- (i) Calculate $\sigma_n^2(20)$, the expected variance of daily returns for Model II.
- (ii) Calculate $\sigma_n^2(20)$, the expected variance of daily returns for Model III.

11. (5 points) John Smith is a manager of a money market fund in the United States. The fund's overriding investment objective is to minimize risk to capital. To achieve this objective, it currently invests only in treasury assets.

- (a) (1 point) List the four types of securities issued by the U.S. Treasury, describe their cash flow characteristics and discuss appropriateness of each of them for a money market fund.

The board of this money market fund is considering revising the investment policy to allow investment in higher yielding assets in the private money market, whilst leaving the overall investment objective unchanged. The following assets are being considered as possibilities:

- I. Commercial paper
 - II. Certificate of Deposit
 - III. Repurchase agreement
- (b) (1.5 points) Describe the characteristics of the three assets listed above and explain why they offer higher return possibilities than U.S. treasuries.
- (c) (1.5 points) Identify and describe the characteristics of these assets that reduce market risk and liquidity risk.
- (d) (1 point) Describe the following risk-quantification metrics for the fund and recommend one:
- (i) Roy's Safety First Criterion
 - (ii) Risk adjusted expected return

12. (7 points) You work for a U.S. Life insurer. The Chief Risk Officer wants to periodically review and reset the ALM and Strategic Asset Allocation (SAA) within the context of changing markets, business mixes and regulatory regimes.

(a) (1 point) Describe a typical ALM approach from a “bottom-up” perspective.

In an effort to build an integrated ALM and SAA framework, your company has hired a consulting firm. They propose a six-step plan:

1. Investment objectives and constraints
2. Asset universe and assumptions
3. Liability cash flows and replicating portfolio
4. Risk measures
5. Risk-return trade-offs
6. ALM and SAA

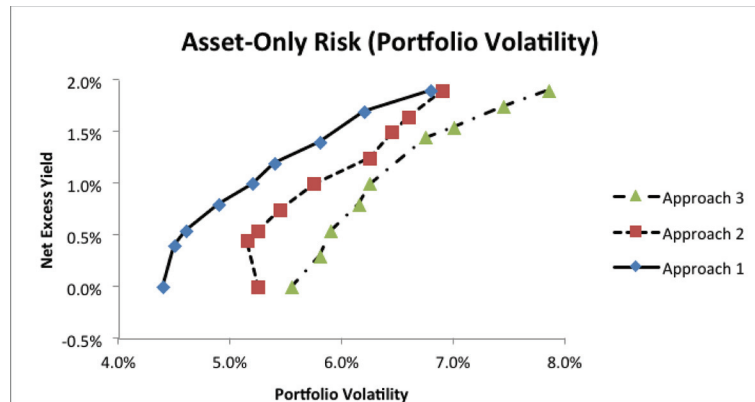
(b) (1.5 points) Propose an action plan to accomplish the third step if the investment portfolio is required to support liability cash flows as well as adequate surplus.

(c) (1.5 points) List four risk metrics that can be used to quantify the risk characteristics of an investment strategy in the context of ALM and SAA.

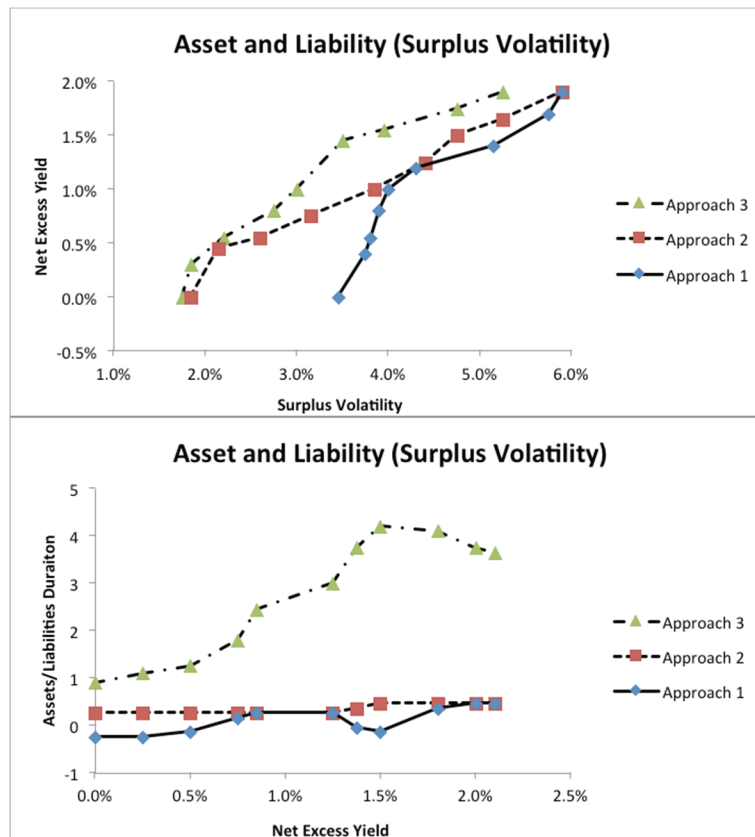
To apply the integrated ALM and SAA approach, you decide to carry out a case study. The objective of the study is, for a given level of net excess yield, to find the optimal asset allocation, with the certain risk and ALM constraints:

Approach #	Objective	Constraints
1	Minimize asset-only risk	Control asset-liability duration gap
2	Minimize economic surplus risk	Control asset-liability duration gap
3	Minimize economic surplus risk	Relax asset-liability duration gap

12. Continued



- (d) (0.5 points) Identify which approach is the most efficient in an asset-only framework based on the case study result shown above. Explain why.



- (e) (0.5 points) Identify which approach is the most efficient if both the asset and the liability are taken into consideration. Explain why.

Question 12 continued on next page

12. Continued

- (f) *(0.5 points)* Identify any potential risk for the approach you have identified in (e). Explain if you should be concerned.
- (g) *(1.5 points)* Rank the three approaches in terms of the following key measures:
- Asset portfolio risk
 - Surplus risk
 - Economic capital requirement
 - Diversification across market risk

13. (5 points) The pension fund that you manage has the following asset and liability characteristics:

	Bond Portfolio	Pension Liability
Market Value (\$mm)	20	20
Duration	12	15

You want to extend the duration of the portfolio to match the liability duration. You are considering entering into a forward contract for delivery in 1 year of a 29-year zero coupon bond. Assume the forward contract is entered at zero upfront cost.

The following interest rate information is available:

- 1-year spot rate = 2%
 - 30-year spot rate = 3%
- (a) (0.5 points) List advantages and disadvantages of using forwards rather than futures to lengthen the duration of the bond portfolio to match liabilities.
- (b) (0.5 points) Calculate the forward price in 1 year per \$1,000,000 notional of the underlying to the nearest dollar.
- (c) (1 point) Calculate the change in value per \$1,000,000 notional of the forward for a 1 basis point movement in spot rates.
- (d) (1 point) Recommend the position and the notional value (in millions) of forward contracts that need to be entered into to match the durations of the liability and asset portfolios.
- (e) (2 points) Estimate and interpret the impact on the forward contract value of each of the following changes in interest rates:
- (i) 0.1% increase in 1-year spot rate;
 - (ii) 0.1% increase in 30-year spot rate.

- 14.** (5 points) You are the domestic equity investment manager in a life insurance company. You manage a \$1 billion fund which is benchmarked to the S&P 500 index and allocate it to three different investment managers who also benchmark to the S&P 500 index. The following table shows the planned allocations to such managers for next year. Assume that there is no correlation between managers' excess returns.

	AUM (\$millions)	Expected annual return	Expected Tracking risk
Benchmarked Index	N/A	8.0%	N/A
Manager A	\$600	8.0%	0.0%
Manager B	\$200	9.0%	0.5%
Manager C	\$200	15.0%	9.0%

- (a) (1 point) Identify and describe the investment approach of each manager.
- (b) (1 point) Identify the type of portfolio you plan to construct given the allocation between investment managers, and explain the objectives of your strategy.

One of the stated objectives is to achieve an information ratio of at least 0.6.

- (c) (1.5 points) Evaluate whether the portfolio is expected to achieve its objective.
- (d) (1.5 points) Describe the purpose and characteristics of a completeness fund, and recommend whether you should include one in your portfolio.

- 15.** (4 points) You are an actuary working on a Bank's ALCO (Asset/Liability Management Committee) in charge of overseeing the bank's securities portfolio.

The bank takes deposits to purchase corporate bonds and make loans.

Balance Sheet	Portfolio Securities	Book Value (million)	Market Value (million)	Book Yield per Year	Duration
Liability	Time Deposits	\$20	\$20	3%	5.0
Liability	Demand Deposits	\$80	\$80	1%	0.5
Asset	Corporate Bond	\$60	\$70	6%	2.5
Asset	Commercial Loans	\$30	\$40	8%	3.0
Asset	Cash	\$10	\$10	0%	0.0

- (a) (1 point) List the bank's objectives in managing a securities portfolio, according to the process laid out by Maginn, et al. in "Managing investment portfolios."
- (b) (1 point) Calculate the bank's net interest margin.
- (c) (1 point) Calculate the bank's leverage-adjusted duration gap.
- (d) (1 point) Assess the impact of an unexpected positive interest rate shock of 100 basis points on the bank's balance sheet.

- 16.** (4 points) You are the chief investment officer of an endowment fund. The fund reviews its strategic asset allocation annually and currently has the following allocation:

Asset Class	Current Allocation	Long-term Expected Return	Last Year Return	Long-term Expected Volatility	Last Year Volatility
U.S. S&P 500 Index U.S. Equities	55%	6.9%	14.5%	18%	16%
Dow Jones Stoxx 50 Index European Equities	15%	8.5%	10.4%	22%	20%
Barclays Corporate Bond	30%	5.5%	10.5%	10%	8%

The Investment Policy Statement (IPS) authorizes tactical ranges of +/- 10% in each asset class.

The one-year U.S. Treasury yield is 1.0%.

One analyst in your company suggested a tactical asset allocation change to a portfolio shown below.

Investment Asset Class	New Allocation
U.S. S&P 500 Index U.S. Equities	60%
Dow Jones Stoxx 50 Index European Equities	15%
Barclays Corporate Bond	25%

His rationale is as follows:

- The 1-year U.S. Treasury yield has risen over the past six months. An increase in the yield of a 1-year U.S. Treasury indicates a decrease in the probability of a recession in one year's term.
- The return in the corporate bond index last year was substantially higher than its historical average, while its volatility was lower than its historical average.
- According to a survey of investors, many funds are outweighing equities this year.

16. Continued

- (a) (1 point) Assess the analyst's recommendation.
- (b) (1 point) Identify additional information that should be considered before the tactical asset allocation changes.

Another analyst suggests including TIPS in your portfolio and provides the following reasons:

- TIPS offer investors inflation and deflation protection that complement those of nominal bonds.
 - TIPS returns of all maturities (10 years to 30 years) are strongly correlated with each other.
 - The economics of TIPS is distinct from the economics of nominal bonds. Volatility of TIPS depends on volatility of real interest rates, whereas the volatility of nominal bonds depends on the volatility of nominal rates. Because they reflect the volatility of inflation, the volatilities of nominal rates are generally greater than the volatilities of real rates.
- (c) (2 points) Critique the validity of each of the reasons listed above.

17. (5 points) ABC Life is considering issuing two types of corporate bonds which include mechanisms in the bonds' indentures that allow the company to retire the debt before maturity:

- I. Callable bond
- II. Callable bond with make-whole provision

- (a) (1.5 points) Explain the advantages and disadvantages of each type from the bond issuer's perspective.
- (b) (0.5 points) Compare their coupon rates if issued at par.
- (c) (1 point) Compare their effective convexities.

One year ago ABC Life issued \$10 million of 5-year bonds at par with 4% coupon paying semi-annually. These bonds are redeemable at any time in whole or in part at ABC's option. The make-whole call premium is 20 basis points, and the redemption price is linked to CMT rates. Current CMT rates are shown in the table below:

Maturity	1	2	3	4	5
Yield	0.50%	0.80%	1.10%	1.40%	1.70%

- (d) (2 points) Calculate the current redemption price.

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

USE THIS PAGE FOR YOUR SCRATCH WORK

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