SOCIETY OF ACTUARIES
Quantitative Finance and Investment Core

Exam QFICORE

AFTERNOON SESSION

Date: Wednesday, April 26, 2017
Time: 1:30 p.m. – 3:45 p.m.

INSTRUCTIONS TO CANDIDATES

General Instructions

1. This afternoon session consists of 7 questions numbered 11 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 11

11. (*7 points*) For annual coupon Treasuries bought at par, the current annualized effective yields to maturity (YTM) are shown below:

Maturity	1-year	2-year	3-year
YTM	3.00%	4.50%	5.50%

$f(x,y) = y$-year forward rate beginning x years from now.

(a) (*2 points*) Calculate the following to the nearest 1 basis point:

(i) $f(1,2)$

(ii) $f(2,1)$

(iii) The YTM of a 2-year, annual-coupon, Treasury bond purchased at par a year from now assuming that spot rates in the future are those implied by today's forward rates.

A 3-year A-rated corporate bond with face value of $100 and annual coupon of 6% is purchased today at par. The purchaser has an investment horizon of one year.

Over the next year, the corporate bond is subject to the following potential rating migrations, with, after the payment of (or default on) the coupon, the corresponding end-of-year YTM spread over treasuries.

End-of-year rating	**A**	**BBB**	**Default**
End-of-year YTM spread over Treasuries (basis points)	80	200	-
Probability	90%	9%	1%

When there is a default, the recovery value is 40% of face value. The recovery value applies only if the bond defaults.

Assume that the YTMs on 1-year, 2-year, and 3-year Treasuries are the same a year from now.

11. Continued

(b) (*2.5 points*)

(i) Complete the following table:

End-of-year rating	**A**	**BBB**	**Default**
Market value of remaining payments			
Total return over the year			

(ii) Calculate the expected total return for the bond over the one year.

The investor purchases an upfront 1-year binary credit put option on the corporate bond. The premium of the put option is 1% of face value. The option expires in one year and pays the option buyer if the rating of the bond on expiration date is below investment grade. The payoff, if any, is the difference between the strike price and the value of the bond at expiration.

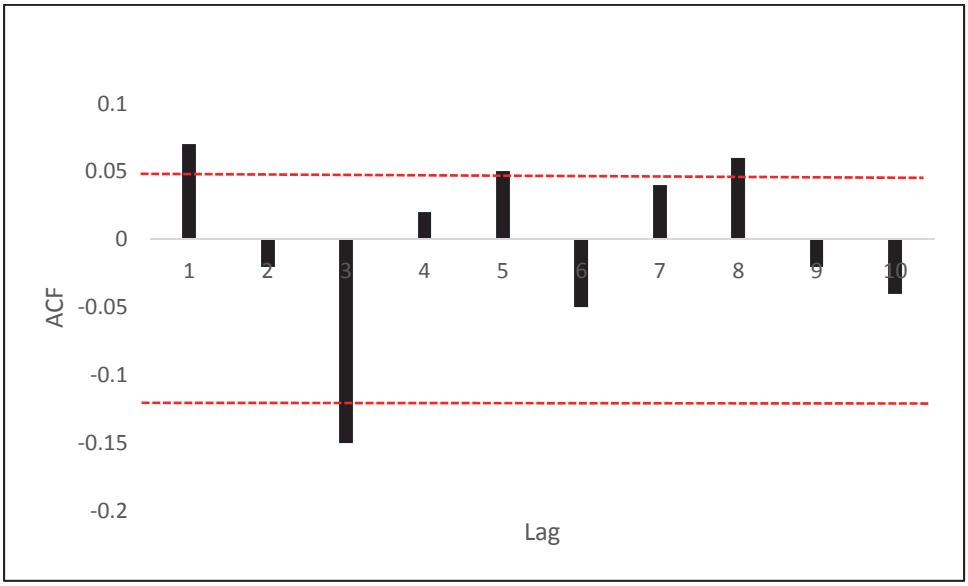
(c) (*1.5 points*) Calculate the investor's revised expected overall total return over the year, given a strike price of $99.5.

(d) (*0.5 points*) Describe three types of credit risk.

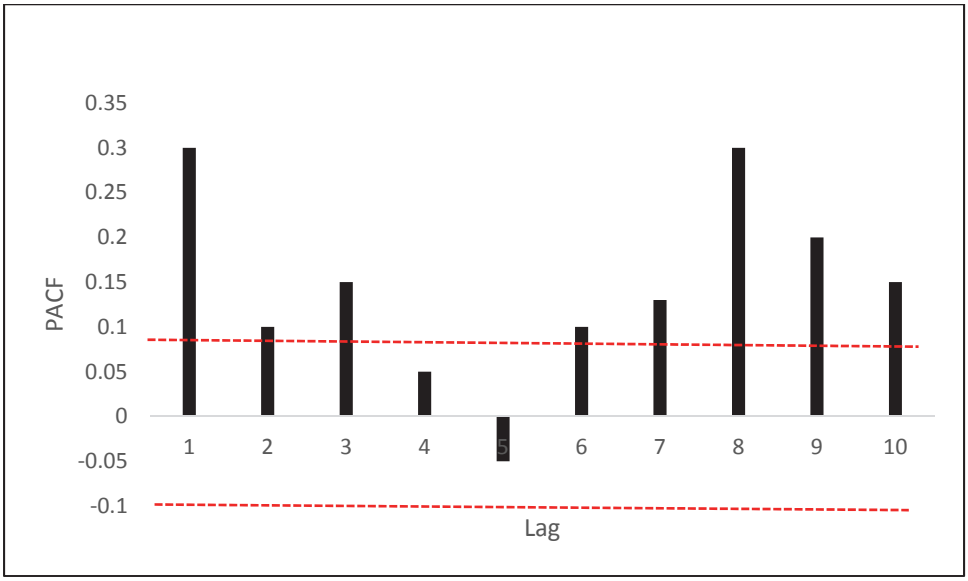
(e) (*0.5 points*) List 2 other instruments that the investor can use to limit the credit risk of the bond.

12. (*5 points*) Your assistant, John Doe, is analyzing the daily excess returns of ABC stock, r_t, in order to fit a time series model. He first plotted Graph A and Graph B below to see the patterns, then he fitted a GARCH (1,1) model and checked the model by plotting Graph C and Graph D below.

Graph A: Sample Auto Correlation Function (ACF) of daily excess returns r_t

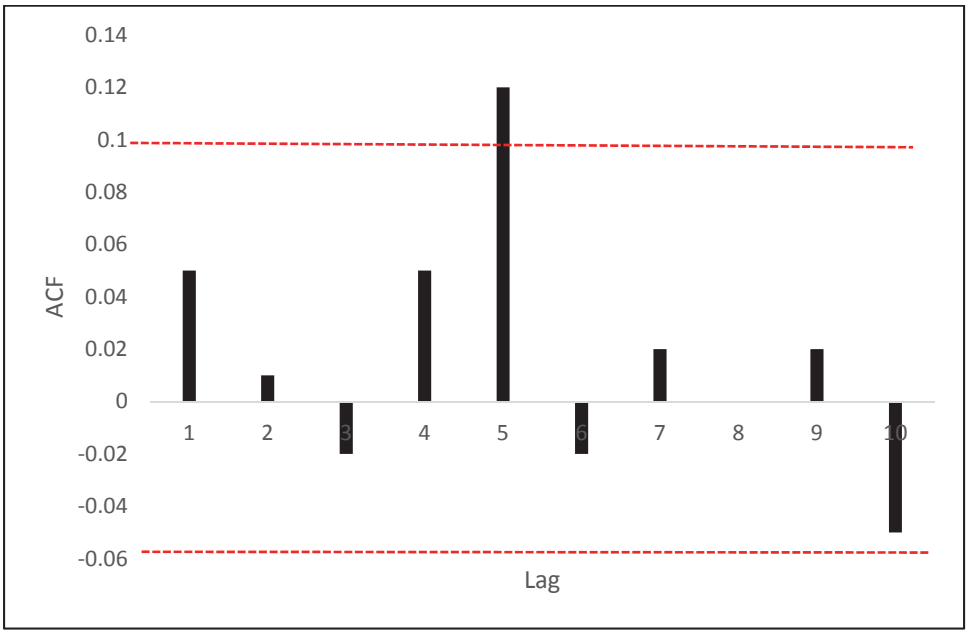


Graph B: Sample Partial Auto Correlation Function (PACF) of squared daily excess returns r_t^2

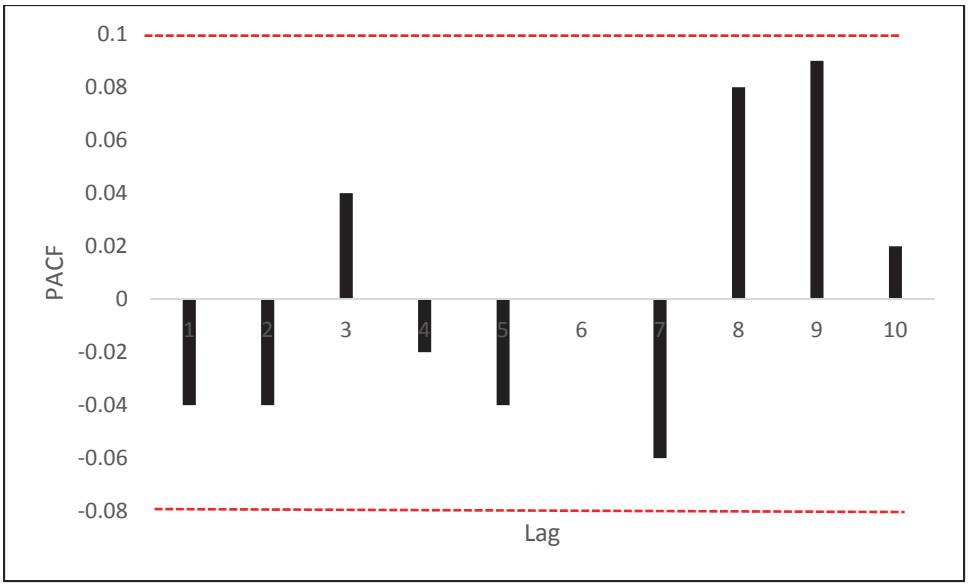


12. Continued

Graph C: Sample Auto Correlation Function (ACF) of standardized residuals.



Graph D: Sample Partial Auto Correlation Function (PACF) of the squared standardized residuals



(a) (*2 points*) Determine if the GARCH model is appropriate for the data series by analyzing the patterns of the graphs A through D. Support your reasoning.

Question 12 continued on the next page.

12. Continued

John presented to you the following information:

- The fitted model:

$$r_t = \mu + \sigma_t \in_t$$
$$\sigma_t^2 = \omega + \alpha\left(r_{t-1} - \mu\right)^2 + \beta\sigma_{t-1}^2$$

where:

- $\omega = 0.00002, \alpha = 0.1, \mu = 0,$ and $\beta = 0.8$
- $\in_t, t = 1, 2, \ldots$ are independent and identically distributed standard normal random variables
- $r_t = \frac{P_t}{P_{t-1}} - 1$ with P_t denoting the closing price of the stock on day *t*

- Part of the data used to fit the model and the daily volatility estimated from the fitted model:

Table 1

Date	ABC Stock Closing Price	Daily Volatility Estimated from the Fitted GARCH(1,1) Model
9/14/2015	\$10.1	1.03%
9/15/2015	\$11.2	1.07%
9/16/2015	\$10.0	1.09%
9/17/2015	\$10.5	1.17%
9/18/2015	\$10.4	1.67%
…	…	...
9/20/2016	\$14.8	1.70%

John later informed you that his report had two typos: he mis-typed the α value and ABC stock's closing price on 9/15/2015 in his report. All other numbers in his report are correct.

(b) (*1.5 points*) Determine the correct value of α and ABC's closing price on 9/15/2015.

(c) (*1.5 points*) Provide your best-estimate forecast of annual volatility of ABC's stock price on 9/23/2016 based on the available information in Table 1, assuming that there are 256 trading days in a year.

13. (*4 points*) As an investment manager at a large financial institution, you want to shift a portion of U.S. Treasury bonds into Treasury Inflation-Protected Securities (TIPS) Exchange Trade Fund (ETF).

(a) (*1.5 points*) Compare and contrast TIPS ETF vs. TIPS under the following metrics:

(i) Intraday liquidity

(ii) Tax efficiency

(iii) Risk control

(b) (*1 point*) Explain how arbitrage plays a role in an ETF's creation/redemption mechanism.

The TIPS market currently trades at a 200 basis points bid/offer spread. The TIPS ETF flow is well balanced between sell orders and buy orders. The execution and hedging cost to facilitate ETF creation is 50 basis points.

(c) (*1.5 points*) Assess whether the TIPS ETF trades at a premium, or a discount, relative to NAV (net asset value), in the ETF creation. Justify your answer by quantifying the ETF's premium/discount.

14. (*5 points*) You are an investment manager who manages an equity mandate for a pension fund in the small country Ruritania. The mandate is currently passive and is to match the performance of the Ruritania Superior Index (RSI). The RSI is an equally weighted index which tracks the performance of the lowest quartile of companies by P/E ratio. The performance of each company is determined by total return including reinvestment and dividends. All companies in higher quartiles are fully excluded. The lowest quartile of companies for inclusion in the index is re-determined each month. A full replication approach is adopted for the fund.

(a) (*0.5 point*) Identify whether the RSI index style is value or growth and explain why.

(b) (*1 point*) Describe four choices to be made when constructing a stock index and explain how each choice is applied to RSI index.

(c) (*1 point*) Explain how the portfolio fund's construction method and the criteria for exclusion impact RSI index trading costs.

(d) (*1 point*) Recommend changes to the construction of RSI index that would make it easier to track.

It is decided to review the long/short strategy vs. the long only strategy on specified stocks. The historical alphas of both strategies are as follows:

Strategy	Source of Alpha	2014	2015	2016
Long-short	Long position	0.30%	0.50%	0.40%
Long-short	Short position	2.20%	2.80%	2.50%
Pure long	Long position	0.20%	0.25%	0.20%

(e) (*0.5 points*) Identify the price inefficiencies based on the data provided.

(f) (*1 point*) Explain why the price inefficiencies identified in part (e) exist.

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15. (*6 points*) Jerry is the chief investment officer at ABC corporation, tasked with managing the equity portion of the firm's pension fund.

Jerry also has a mandate to invest at least 10% of the equity portfolio in socially responsible funds.

(a) (*0.5 points*) Define socially responsible investing (SRI).

(b) (*1.5 points*)

(i) Describe the two commonly used implementation approaches to achieve SRI.

(ii) List two potential risks associated with SRI from the portfolio management point view.

To construct your investment portfolio, Jerry looks at the following managers with the following track records over the past 10 years and characteristics:

			Manager A (large cap)			**Manager B (SRI)**		
Year	S&P 500	Russell 2000	Return	Excess return vs S&P500	Excess return vs Russell 2000	Return	Excess return vs S&P500	Excess return vs Russell 2000
Annualized Return	3.2%	4.0%	4.8%			5.0%		
Standard deviation of returns	7.4%	10.0%	6.9%	1.8%	9.9%	8.5%	9.1%	3.2%

- Manager A is a large cap manager and actively follows 500 stocks; the S&P 500 represents Manager A's investment universe.
- Manager B is specialized in socially responsible investing and actively follows 50 stocks; the Russell 2000 represents Manager B's investment universe.

15. Continued

The pension fund uses the S&P 500 as its benchmark. Jerry recognizes that to evaluate some managers it is useful to divide their total active return into two components: true active return and misfit active return.

(c) (*1 point*) Calculate the following metrics for Managers A and B:

(i) True active return

(ii) Misfit active return

Jerry would like to use the most accurate measure of risk-adjusted performance to assess which manager has better investment skills.

(d) (*1.5 points*)

(i) Recommend the measure for Jerry to use.

(ii) Assess which manager, A or B, has better investment skills.

Jerry suspects that Manager A is using a semiactive stock-selection approach.

(e) (*1.5 points*)

(i) Describe how semiactive equity managers generate alpha using stock selection.

(ii) State the Fundamental Law of Active Management and estimate Manager A's Information Coefficient (IC).

(iii) Describe limitations of the semiactive stock-selection approach.

16. (*4 points*) DFK is a life insurance company that used to primarily underwrite term and whole life insurance. Last year DFK sold a portion of its whole life business line and acquired a block of fixed-rate accumulation annuity business.

As a result of the change in business mix, DFK's surplus has fallen from $100 million to $45 million and the duration of its liabilities has dropped from 14.8 to 12.1.

(a) (*1 points*) Determine whether DFK's ability to take risk has increased or decreased based mainly on the change in business mix.

(b) (*1 point*) Describe two constraints in the investment policy statement that are affected solely by the change in business mix.

You are given the following information on the DFK portfolio:

Statistic	**Current year**
Duration of assets	13.2
Portfolio return	5.3%

Asset Class	**Current Allocation**
Cash	2%
Fixed income – investment grade	33%
Fixed income – high yield	15%
Mortgage-backed securities	27%
Equities	14%
Real estate	9%

XYZ forecasts a rising interest rate environment along with widening credit spreads.

(c) (*2 points*) Assess the likely effect of each of the following risks on DFK's surplus if XYZ's forecast is correct:

1. Valuation risk
2. Cash flow volatility risk
3. Credit risk
4. Reinvestment risk

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17. (*9 points*) You are the investment adviser for a foundation with the following information:

- The capital of the foundation is $500M;
- Every year the foundation needs to pay an award of $20M indexed to inflation from investment income only;
- The investment income needs to also cover annual expenses estimated at 20 basis points of the beginning of year capital;
- The expected inflation is 2% per year;
- The foundation's expected utility is given by $U = E(R) - \alpha\sigma^2$ where R and σ are the return and the standard deviation of returns, respectively, and α is the risk aversion coefficient.

The foundation is using the quantitative mean-variance approach to strategic asset allocation. The analysis produced the following first four adjacent corner portfolios. The tangency portfolio is not part of these first portfolios. All assets are risky assets:

					Asset Class (Portfolio Weight)			
Corner Portfolio	Expected Return	Standard Deviation	Sharpe Ratio	Expected Utility	A	B	C	D
1	9.0%	18%	0.361	1.87%	100%	0%	0%	0%
2	8.0%	15%		3.05%	75%	0%	0%	25%
3	7.7%	13%			65%	5%	0%	30%
4	5.8%	8%			30%	10%	30%	30%

(a) (*0.5 points*) Determine the required return for the foundation.

(b) (*3 points*) Determine which Corner Portfolio, 2 or 3, is preferred based on the following measures, respectively:

(i) Sharpe ratio criterion;

(ii) The foundation's expected utility;

(iii) Roy's safety-first criterion.

(c) (*1.5 points*) Explain the following concepts of the mean-variance approach:

(i) Efficient frontier, minimum-variance frontier (MVF), and sign-constrained MVF;

(ii) Adjacent corner portfolios;

(iii) The tangency portfolio.

17. Continued

Suppose that the foundation will construct its investment portfolio by investing in a combination of the above corner portfolios:

(d) (*1 point*) Determine the most appropriate asset allocation for asset classes A to D given the objective of meeting the minimum required return.

The foundation is interested in another asset and you have collected the following information:

- The expected return of the new asset is 4%
- The volatility of the new asset is 10%
- The correlation of the new asset and the portfolio you have chosen is 0.6

(e) (*1.5 points*) Determine whether the foundation should include the new asset in the portfolio, assuming the use of a linear approximation approach to approximate the standard deviation of the efficient portfolio.

The trustees of the foundation have some concern about the reliability of the results because they were told that the recommended asset allocations under the mean-variance approach are sensitive to small changes in inputs.

(f) (*0.5 points*) Explain why the estimation error is an important issue in using the mean-variance optimization approach (MVO).

(g) (*1 point*) Describe approaches or techniques that can be used to mitigate the impact of the estimation error.

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

USE THIS PAGE FOR YOUR SCRATCH WORK