
SOCIETY OF ACTUARIES
Foundations of CFE Exam

Exam CFEFD

MORNING SESSION

Date: Wednesday, April 29, 2015

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 8 questions numbered 1 through 8.
 - b) The afternoon session consists of 5 questions numbered 9 through 13.

The points for each question are indicated at the beginning of the question. There are no questions in the Morning Session that pertain to the Case Study.
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.
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 CFEFD.
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****
Morning Session

- 1.** (6 points) You are given the following information about Chippewa-Washington, Inc. (CW):

	<u>2012</u>	<u>2013</u>
Net income	190	200
Cash	50	30
Accounts receivable	900	800
Inventories	1,200	1,400
Long-term assets	5,000	5,500
Capital expenditures	300	760
Accounts payable	1,000	1,200
Notes payable	300	500
Current maturities of long-term debt	500	650
Long-term liabilities	2,000	3,000
Net sales	8,500	9,000
Costs and expenses	7,000	7,500
Accumulated depreciation	(1,100)	(1,260)
Dividends paid	-0-	100
Total tax	250	300

- (a) (1 point) Evaluate the change in CW's liquidity from 2012 to 2013. Support your evaluation.
- (b) (3 points)
- (i) Calculate the cash generated by CW from its operating activities in 2013. Show your work.
- (ii) Calculate the change in CW's retained earnings from 2012 to 2013. Show your work.

CW's mid-level managers tend to have risk-averse behaviors such as loss aversion and narrow framing even when the expected value of projects is positive.

- (c) (2 points) Explain three company-wide policies CW could implement to address its mid-level management's risk-averse behavior.

2. (7 points) Liberty-Lafayette Life (LLL), is considering a new Universal Life with Secondary Guarantee (ULSG) product line. The ULSG product is expected to produce an acceptable IRR.

(a) (2 points)

- (i) Describe two potential pitfalls of relying on IRR to make investment decisions for stand-alone projects.
- (ii) Recommend three methods, other than relying on IRR, that a company should use to make investment decisions.

With the help of Freedom-French Consultants (FFC), LLL has estimated the economic capital and expected present value of economic profits for its existing business and the ULSG product:

	LLL (excluding ULSG)	Stand-Alone ULSG
Expected Economic Profits	40	5
Economic Capital Requirements	100	40

Additionally, FFC has estimated that LLL's total deadweight cost of capital is 25% of its economic capital requirement.

(b) (4 points)

- (i) Determine the stand-alone profits, net of deadweight costs, for both LLL (excluding the ULSG product) and the ULSG product. Show your work.
- (ii) Explain the effects of business unit diversification on firm-wide deadweight costs of capital and investment decisions.
- (iii) Determine the economic capital requirement, net of diversification effects, that would make LLL indifferent in its decision to move forward with the ULSG product. Show your work.

FFC estimates the marginal economic capital requirement of the ULSG product is 15.

(c) (1 point) Recommend whether or not LLL should proceed with the ULSG product offering. Justify your recommendation.

3. (8 points) You are a consultant hired by Emmet, Inc., a pharmaceutical company, and are given the following financial information for Emmet:

Market value of debt	30,000 million
Market value of equity	80,000 million
Book value of debt	40,000 million
Book value of equity	90,000 million
Cash on balance sheet	10,000 million
Marginal corporation tax rate	35%
Equity cost of capital	12%
Debt cost of capital	5%

- (a) (1 point) Determine Emmet's weighted average cost of capital (WACC).

Emmet is considering a project to develop a cancer drug. You are given the following information on the project:

- Initial investment of 30 million
- Expected free cash flow (FCF):
 - 5 million at the end of year 1
 - 10 million at the end of year 2
 - After year 2, expected to grow 2% per year forever
- Both market risk and leverage are similar to Emmet as a whole.

- (b) (2 points) Determine the value of the project. Show your work.

Emmet plans to launch a separate medical device division and expects that it will face different market risks than in its main pharmaceutical business.

Two companies in the medical device business have the following characteristics:

Firm	Equity Cost of Capital	Debt cost of capital	Debt-to-Value Ratio	Marginal Tax Rate
Comparable #1	15.5%	7.5%	50%	32.5%
Comparable #2	13.0%	6.5%	20%	40.0%

Assume the debt-to-equity ratio of the incremental financing used for the medical device division will be 200% and the borrowing cost is expected to be 5.0%.

- (c) (2 points) Estimate the WACC to use in valuing Emmet's new medical device division. Show your work.

3. Continued

Assume the following about the new medical device division:

- 2,500 million up-front investment
- Risk free rate is constant at 3% per year
- Risk-neutral probability of 30% that the initial investment will generate 200 million FCF per year forever
- Risk-neutral probability of 70% that the initial investment will generate nothing

In one year, Emmet will find out whether the division is successful. If it is successful, Emmet can invest an additional 4,000 million to generate an additional 400 million FCF per year forever.

At Emmet's recent board meeting, one member made the following comment:

“Since the NPV of the new medical device division is negative, we should not invest today.”

(d) (3 points)

- (i) Critique the statement.
- (ii) Determine the value to Emmet of an investment in the medical device division. Show your work.

4. (6 points) Sloane Insurance Company is considering a stochastic valuation process for its variable annuity block. To prepare for a meeting on Monte Carlo simulation, you asked Caesar, a co-op student, for a graph of daily returns of the S&P 500 index for the past year. Caesar forgot to label his graph and found the following four figures at the printer:

Figure 1

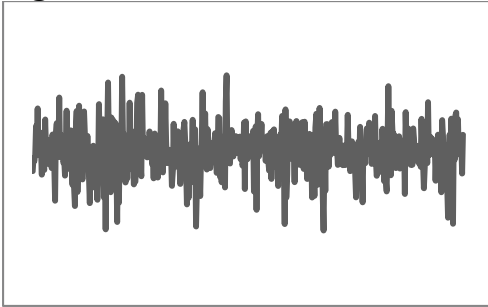


Figure 2

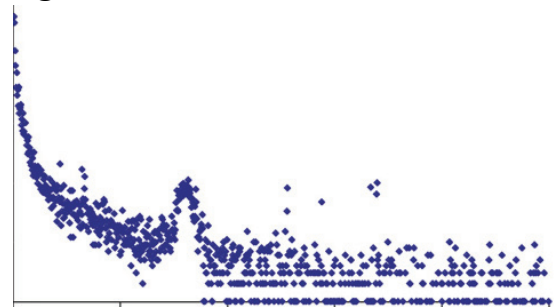


Figure 3

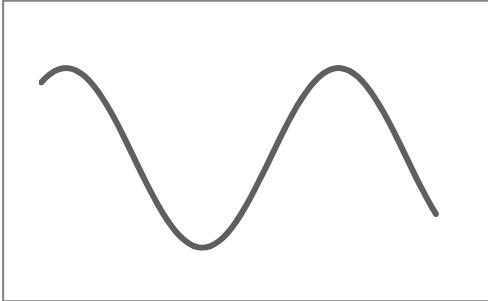
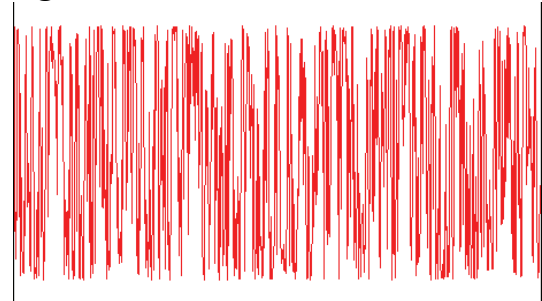


Figure 4



- (a) (1 point) Identify the figure that represents daily returns of the S&P 500 index. Support your answer.

In the meeting, your manager would like to demonstrate how to simulate stock prices using geometric Brownian motion. During the meeting you are asked for the terminal stock price.

You recall the discrete-form of geometric Brownian motion:

$$\frac{\Delta S}{S} = \mu \Delta t + \sigma \phi \sqrt{\Delta t}$$

	0	1	2	...	T-1	T
S	1.0000	1.0292	1.1522	...	1.0373	?
ϕ	0.0163	0.1168	0.4779	...	0.7650	0.2440

- (b) (1 point) Calculate the terminal stock price.

4. Continued

Your manager outlines the following steps to estimate the risk measures associated with a fixed-income portfolio using Monte Carlo simulation:

1. Forecast spot rates using a geometric Brownian motion process, since the best forecast for a future spot rate is today's spot rate.
2. Use judgment or available market data to estimate parameters of the process.
3. Determine the starting spot rate for each path.
4. Produce hypothetical portfolio values using this starting spot rate.
5. Repeat steps 3-4 enough times.
6. Infer the risk measures from this proxy distribution.

(c) (2 points) Assess shortcomings in your manager's approach.

Your manager is pleased with your work and asks you to analyze the following projects in order to improve Sloane's model accuracy:

- I. Pricing a European call option with stochastic volatility for which there exists a similar call with a known price
- II. Simulating the value of an out-of-the-money option in which most paths will lead to zero payoff

(d) (2 points)

- (i) Suggest the most applicable variance reduction technique for each of the projects.
- (ii) Provide a brief description for each technique.

5. (6 points) Forsyth, Inc., is evaluating the following investments:

Investment A: A one-year zero coupon bond (ZCB) that pays 200 in one year. The ZCB has 4% default probability and 50% recovery rate.

Investment B: Two independent one-year ZCBs. Each pays 100 in one year. Both ZCBs have 4% default probability and 50% recovery rate.

Investment C: One-year credit default swap that pays 1 at time 0 with the following end-of-year loss and probability:

Probability	Loss
0.94	0
0.06	10

Investment D: One-year credit default swap that pays 1 at time 0 with the following end-of-year loss and probability:

Probability	Loss
0.998	0
0.002	300

- (a) (2 points) Calculate the VaR(95) and CTE(95) at the end of the year for each of the four investments: A, B, C, and D.
- (b) (2 points) Contrast the use of VaR and CTE for evaluating the following:
- (i) Risk concentration for Investments A and B.
 - (ii) Tail risk for Investments C and D.

Forsyth has a one-year life insurance liability that requires paying 200 with 96% probability and 100 otherwise. An actuarial student suggests:

“If we apply no-arbitrage pricing theory, using Investment A to construct a replicating portfolio, then we could perfectly hedge our insurance liability. The implied discount rate derived from the market price of Investment A can be applied to price the insurance liability.”

- (c) (2 points) Critique the student’s statement. Support your critique.

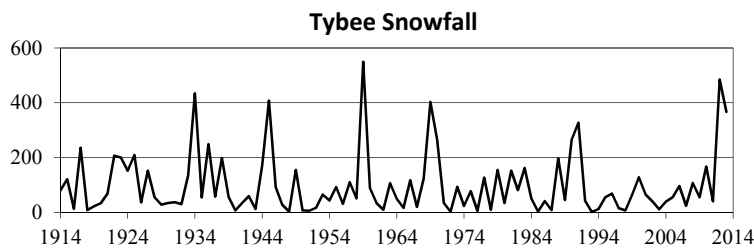
6. (13 points) After running out of snow removal supplies two years in a row, the town council of your small southern hemisphere town, Tybee, enacted an ordinance requiring the purchase of snow removal supplies sufficient for handling:

$$\frac{1}{2}(CTE(90\%) + CTE(98\%))$$

of next year's predicted snowfall distribution. The risk measure, called the Rather Ominous Snow Year (ROSY), is an unfortunate compromise of two distinct proposals you, as a concerned citizen, had suggested. You have been hired by the Tybee town council to provide a simple-to-update spreadsheet that models the predicted snowfall and computes ROSY.

- (a) (1 point) Explain why ROSY is a coherent risk measure.

You retrieve the following snowfall data, measured in centimeters, covering the past 100 years:



Top 10 Snowfall Years

<u>Year</u>	<u>Snowfall</u>
1959	550
2012	485
1934	434
1945	408
1969	403
2013	367
1991	327
1970	266
1990	265
1936	249

<u>Years</u>	<u>Average</u>	<u>Standard Deviation</u>
1914 – 2013	99	112
1964 – 2013	97	111

- (b) (2 points)
- Calculate ROSY using the basic historical simulation approach on all 100 years of data. Show your work.
 - Describe two advantages and two disadvantages of this approach for Tybee.

You look up the following values for the standard normal distribution:

CTE(90%)	CTE(98%)
1.755	2.421

Question 6 continued on next page

6. Continued

(c) (2 points)

- (i) Calculate ROSY using the delta-normal approach on all 100 years of data. Show your work.
- (ii) Explain why the delta-normal approach is inappropriate for this data. Show your work.

You have the following information for the exponential distribution:

$f(x)$	$\lambda e^{-\lambda x}$
$F(x)$	$1 - e^{-\lambda x}$
$E(x)$	$1 / \lambda$
$CTE(\alpha)$	$(1 - \log(1 - \alpha))E(x)$

(d) (2 points)

- (i) Determine the maximum likelihood estimate (MLE) for the exponential distribution parameter λ using all 100 years of data. Show your work.
- (ii) Calculate ROSY using an exponential distribution with the parameter estimated in (d)(i). Show your work.

Concerned about model risk, you decide to build a Monte Carlo simulation using a mixed exponential distribution with a normally distributed mixing parameter. The mixing parameter has a mean equal to the estimate of (d)(i) and volatility equal to the standard error of the estimate.

- (e) (1 point) Explain why using the mixed exponential distribution will cause ROSY to increase compared to the result from (d)(ii).

6. Continued

Due to the potential impact climate change has had on historical snowfall, you consider calibrating your model to the past 50 years of data instead of the past 100 years.

- (f) (3 points) Describe the directional impact moving from 100 years to 50 years of calibration has on ROSY for each of the following approaches. Justify each answer.
 - (i) The non-parametric approach in (b)
 - (ii) The exponential parametric approach in (d)
 - (iii) The mixed exponential parametric approach in (e)
- (g) (1 point) Recommend an approach, of the three in (f), that Tybee should adopt to calculate ROSY. Justify your recommendation.
- (h) (1 point) Recommend an approach that would likely provide a better fit to the historical pattern of snowfall than any of the three in (f). Justify your recommendation.

7. (8 points)

- (a) (2 points) List one advantage and one disadvantage of constructing a parametric model of daily profit/loss using each of the following distributions:
- (i) Normal
 - (ii) t with 5 degrees of freedom
 - (iii) Levy with $\alpha = 1.5$
- (b) (1 point) Recommend a type of distribution from (a) to fit data with a mean of 3, variance of 4, and kurtosis of 5. Justify your answer.

You are given the following information on a two-asset portfolio:

- A bi-variate normal model fit using the method of moments.

	Asset 1	Asset 2
Asset Allocation	\$250	\$750
Daily Expected Return	0.10%	0.25%
Daily Variance	0.20%	0.50%

- $\text{Covariance}_{1,2} = 0.10\%$
 - $z_{0.95} = 1.645$
- (c) (2 points) Calculate the following. Show your work.
- (i) Expected daily portfolio return
 - (ii) Five-day portfolio VaR(95)

The VaR estimate from (c)(ii) is used to forecast extreme losses. Over the next 180 days, 16 five-day losses have exceeded the VaR estimate.

- (d) (2 points) Describe four possible reasons for the ineffectiveness of this approach.
- (e) (1 point) Recommend two ways to improve the forecast of extreme losses.

- 8.** (6 points) You work for a private equity firm specializing in purchasing underperforming non-public companies. Calhoun-Ellis Corporation (CEC) has approached your firm with an offer to sell CEC for \$30 million. CEC's free cash flows were \$2.6 million last year.

You make the following assumptions:

- 50% probability CEC's free cash flows will grow at 8% annually
- 50% probability of immediate CEC bankruptcy
- Your firm discounts expected free cash flows at 12% per annum.

- (a) (1 point) Calculate the value of CEC.

CEC also offers you the option to delay your decision by one year. The sale price a year from now will be \$50 million instead of \$30 million.

- (b) (4 points)

- (i) Sketch the decision tree associated with this decision.
- (ii) Calculate the value of the option to delay your decision.
- (iii) Recommend whether to delay your decision or invest immediately. Support your recommendation.

Assume your firm does not purchase CEC. Two years later, CEC is doing well and its management would like to take CEC public through an IPO.

- (c) (1 point)

- (i) List two costs and two benefits to CEC's current owners of an IPO.
- (ii) List two methods an underwriter may use to value a firm for an IPO.

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

USE THIS PAGE FOR YOUR SCRATCH WORK