Exam CFEFD

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 5 questions numbered 8 through 12 for a total of 40 points. The points for each question are indicated at the beginning of the question. No questions 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.

8. (*8 points*) Peony, Inc. is selling 500,000 shares of stock at an auction IPO. Peony has received the following bids:

Price ($)	Number of Shares Bid
21.00	75,000
20.75	150,000
20.50	100,000
20.25	200,000
20.00	275,000
19.75	250,000

(a) (*2 points*)

(i) Describe the process of an auction IPO.

(ii) Calculate the share price at the IPO.

Five years later, though still small, Peony has grown rapidly and now has the opportunity to invest in a project with a high estimated NPV. At a board meeting, Peony's CFO leads a discussion evaluating potential financing options. She expresses concern that Peony's current stock price is undervalued, and she anticipates future market bond yields will decline.

(b) (*3 points*) Evaluate the appropriateness of the following financing options for Peony:

(i) Equity

(ii) Non-convertible, non-callable bonds

(iii) Convertible bonds

(iv) Callable bonds

8. **Continued**

Peony has decided to issue either a callable bond or a convertible bond for its next round of financing.

The callable bond would be a four-year, 5% coupon bond with annual payments. The bond can be called after one year and has a price of $1,015 per $1,000 face value.

(c)   (*2 points*)

      (i)   Calculate the yield to call.

      (ii)   Explain why the price of the callable bond would be higher or lower than the price of an otherwise identical, non-callable bond.

The convertible bond has a conversion ratio of 45 per $1,000 face value. At maturity of the convertible bond, the stock price is $30.

(d)   (*1 point*) Determine if the bond holder should choose to convert the bond at maturity. Support your answer.

9. (*9 points*) You are an actuary at GRW Life Insurance Co. working on a project to build the company's internal solvency model.

GRW currently estimates its capital requirements with 100 model runs. This is not sufficient to calculate the VaR(99.5) required by regulators.

You are asked to develop a proposal for a proxy model.

    (a)   (*1 point*)

        (i)   Define a proxy model.

        (ii)   Describe the parameters of a proxy model.

GRW has decided to use the following polynomial proxy function as its internal solvency model:

$$Y = a_0 \cdot RF_1 + a_1 \cdot RF_2 + a_2 \cdot RF_1 \cdot RF_2 + a_3$$

    where, RF_1 and RF_2 are the two risk factors and
           a_0, a_1, a_2 and a_3 are parameters to be calibrated.

Two methods have been suggested to calibrate the model:

        I.   Regression fitting method

        II.   Precise interpolation method

    (b)   (*2 points*)

        (i)   Contrast calibration methods I and II.

        (ii)   Recommend one of the calibration methods above. Support your response.

9. Continued

Assume that 5 fitting points are enough to calibrate the parameters (a_0, a_1, a_2, and a_3) of the polynomial proxy function.

Fitting Point	1	2	3	4	5
RF$_1$	2.5	-0.9	0.2	1.0	2.0
RF$_2$	0.3	1.5	2.0	-1.0	0.6
Y	2.2	-0.28	1.9	-0.5	2.7
Non-linearity Component	-0.29	-0.67	0.12	???	???

Given $a_0 = 0.9$, $a_1 = 0.8$

(c)   (*3 points*)

   (i)   Calculate the non-linearity component for fitting points 4 and 5. Show your work.

   (ii)   Calculate a_2 and a_3 by using the method of least squares. Show your work.

Several useful statistical tests for quality-of-fit are listed below:
- Cramer Von Mises
- Chi-Squared
- QQ Plots
- PP Plots
- Anderson-Darling
- Akaike Information Criterion
- Bayes Information Criterion
- Kolmogrov-Smirnov

(d)   (*1 point*) Identify one statistical test from above to meet each of the following quality-of-fit goals:

   I.   The distribution is an appropriate representation of the observed data.
   II.   The trade-off between the complexity of the model and the goodness-of-fit is optimized.
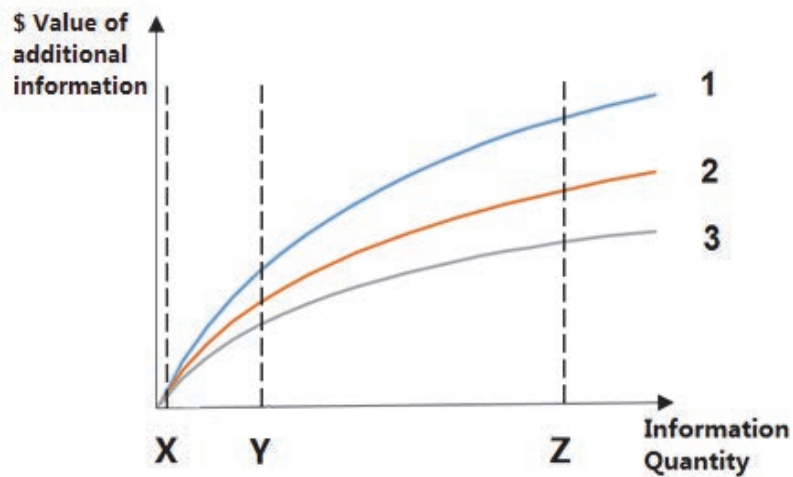   III.   Goodness-of-fit across quantiles or percentiles is appropriate.

Your intern questions, "Why are we using risk neutral scenarios to calculate VaR in our original model?" The intern adds, "My professor said that expected shortfall is a much better risk measure."

(e)   (*2 points*) Critique your intern's statements. Support your critique.

10. (*9 points*) Petunia Bank has recently launched an equity-linked investment product with the following features:

- Petunia guarantees a minimum of 0% annual return when equity return is negative.
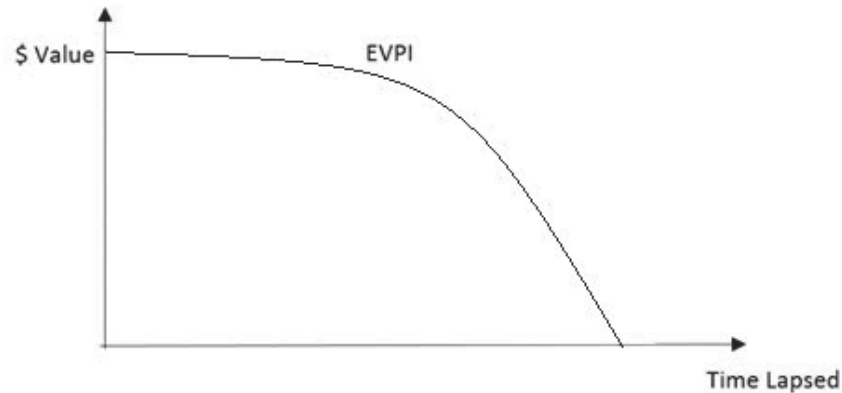- The policyholder can surrender for the guarantee at any time.

Petunia Bank is trying to evaluate policyholder surrender behavior, in order to determine the value of the guarantee and model the risks appropriately.

(a) (*2 points*) Explain which curve (1, 2 or 3) corresponds to the following situations:

    (i) Petunia Bank initially has a lot of experience and data on consumer behavior.

    (ii) Petunia Bank initially has almost no knowledge of consumer behavior.

    (iii) Petunia Bank initially has some knowledge of consumer behavior.

(b) (*1 point*) Assess at which of the points (X, Y or Z) above, the value of incremental information is the highest.

10. Continued

The following chart illustrates the Expected Value of Perfect Information (EVPI).

(c) (*2 points*)

    (i) Sketch a realistic pattern of Expected Value of Information (EVI), and Expected Cost of Information (ECI) given the graph of EVPI above.

    (ii) Interpret the shapes of EVPI, EVI and ECI in your graph in part (i).

Petunia Bank will initially measure the equity risk of this product using the Delta-Gamma approach to estimate VaR.

(d) (*1 point*) Identify one limitation and one benefit of the Delta-Gamma approach.

Petunia Bank has built a model to price and quantify various risks associated with the new product. The model views stock returns as a geometric Brownian motion.

(e) (*2 points*)

    (i) Identify how model misspecification may be present in Petunia's model.

    (ii) Describe two guidelines for managing model risk applicable to Petunia.

(f) (*1 point*) Describe two aspects of Petunia's product that influence its VaR calculation.

11. (*8 points*) Evergreen Life Insurance Company has started offering variable annuities. The policyholder's funds are invested in equity funds and withdrawal rates are guaranteed.

After analyzing policyholder experience data, you have determined that:
- There is no significant correlation between lapse and withdrawal behavior in normal lapse and high lapse scenarios.
- There is high correlation between lapse and withdrawal behavior in low lapse scenarios.

You decide to introduce a copula to model dependent random variables.

(a) (*2 points*) Assess the appropriateness of modeling lapse and withdrawal behavior using the following copulas:

      (i)   T-Copula

      (ii)   Gumbell Copula

      (iii)   Clayton Copula

      (iv)   Frank Copula

Evergreen uses equity derivatives and interest rate swaps to hedge the liability. You are presented with an over-the-counter hybrid option with the following payoff function:

$$\text{Payoff} = \begin{cases} Max\left(K - S, 0\right), \text{ if the 10 year swap rate is less than } X \\ 0, \text{ if the 10 year swap rate is greater than } X \end{cases}$$

where K = strike price, S = equity price, X = interest rate threshold

You want to evaluate the possibility of using the Heston model and the Hull-White model for valuing this hybrid option.

11. Continued

(b)   (*3 points*)

     (i)   State pros and cons of using the Heston model to model equities.

     (ii)   Identify the parameters needed to calibrate the Heston model for market consistent valuation.

     (iii)   State pros and cons of using the Hull-White model to model interest rates.

     (iv)   Identify the parameters needed to calibrate the Hull-White model for market consistent valuation.

You are asked to create a valuation framework for the over-the-counter hybrid option, using a Monte Carlo process, the Heston model and the Hull-White model.

(c)   (*3 points*) Construct the detailed steps for this valuation framework.

12. (*6 points*) Freesia Cruise has an opportunity to develop a new route to an exclusive destination:

- Opportunity to sign the contract will expire in 2 years.
- Operating rights expire 10 years from today regardless of the date the contract is signed.

Due to a recent surge in fuel prices, Freesia Cruise is experiencing poor cash flow generation and constraints on its capital.

Freesia has gathered the following information on the opportunity:

Annual Revenue	3 million
Upfront Investment	12 million
Annual Maintenance Cost	1 million
Volatility of the Project's Value	40%

You are given:

Freesia's Current Cost of Capital	8%
Freesia's Long-Term Cost of Capital	6%
Risk Free Rate	4%
Callable Annuity Rate	4.2%

(a) (*1 point*) Identify which cost of capital assumption should be used for the analysis of this opportunity. Justify your reasoning.

(b) (*2 points*) Evaluate if Freesia should take the opportunity today or wait 2 years. Show your work.

The CEO of Freesia thinks that real option analysis is too complicated and would prefer to use a rule of thumb, such as the hurdle rate rule or profitability index rule. The hurdle rate is 12% and the profitability index threshold is 1.

(c) (*1 point*)

    (i)   Describe the hurdle rate rule of thumb.

    (ii)   Describe the profitability index rule of thumb.

    (iii)   Explain why the rules of thumb are appropriate in Freesia's situation.

12. Continued

(d)   (*1 point*)

   (i)   Determine if Freesia should take the opportunity today using the hurdle rate rule of thumb.

   (ii)   Determine if Freesia should take the opportunity today using the profitability index rule of thumb.

The CEO wants to know why the hurdle rate is so high. An analyst suggests it is entirely due to interest rate uncertainty.

(e)   (*1 point*) Critique the analyst's explanation for the high hurdle rate. Support your critique.

END OF EXAMINATION
Afternoon Session

USE THIS PAGE FOR YOUR SCRATCH WORK