

# CFE FD Model Solutions

## Spring 2017

### 1. Learning Objectives:

1. The candidate will understand how a business enterprise funds its activities with considerations for its business model, and the cost and constraints of the sources of capital.
2. The candidate will understand how an enterprise's structure and policies allow its management to prioritize and select among projects or business activities that are competing for scarce capital resources especially when opposing factors are key decision criteria.

### Learning Outcomes:

- (1b) Evaluate capital budgeting approaches and structure policy for insurance and non-insurance organizations.
- (2a) Evaluate how the legal form of an organization, corporate governance and/or compensation dynamics impact business decisions.
- (2b) Recommend an optimal capital structure and how to implement it for a given business strategy.

### Sources:

- Creating Value Through Best-In-Class Capital Allocation, JP Morgan

Corporate Finance, Chapter 28 - Merger and Acquisition - Jonathan Berk and Peter Demarzo,

### Commentary on Question:

*This question tested candidates' understanding of acquisition premiums and strategies, as well as applying market value added calculations to a potential acquisition. Many candidates performed well on this question, although some candidates provided only partial answers for some parts of the question. For part a, many candidates provided reasons but did not explain how they lead to a premium above market. For part c, many candidates did not translate EVA into MVA for the first subpart or did not compare the two options for the second subpart.*

## 1. Continued

### Solution:

- (a) Explain why bidders generally pay a premium to acquire a company.

One reason bidders generally pay a premium to acquire a company is the free rider problem. The bidder believes that the company's current market value is lower than its potential, because of mismanagement or potential efficiency gains, etc. If the bidder offers less than the potential value of the company, shareholders who do not tender their shares will be better off than those that sell for the offer price. This provides an incentive for shareholders not to tender their shares unless the bidder pays a significant premium.

### Commentary on Question:

*Other acceptable responses included a discussion of competition, takeover defenses or synergies.*

- (b) Describe the following two potential strategies to limit the costs of an acquisition.

(i) Leveraged buyout

(ii) Freeze out merger

(i) In a leveraged buyout, the acquirer issues debt from a shell corporation to pay the target shareholders for their shares, using the acquirer's future shares as collateral. Once the buyout succeeds, the acquirer merges the target company with the shell corporation, attaching the debt to the target corporation. Because of the attached debt to the merged corporation, the share value after the tender need not be higher than the tender price, eliminating the Free Rider Problem.

(ii) The acquirer can merge with the acquired company if the tender offer succeeds. Because the target corporation no longer exists, the existing shareholders no longer have shares, but must be compensated for at least the tender offer price. Because they only achieve the tender offer price, there is less incentive to hold out if the tender offer is above the current share price.

- (c)

(i) Calculate the MVA of renovating the lounges. Show your work.

(ii) Calculate the maximum offer Blue Jay Air should make for Luxury Lounges. Show your work.

## 1. Continued

(i)

$$\begin{aligned} \text{Market Value Added (MVA)} \\ &= \sum \text{Present Value of Economic Value Added (EVA)} \end{aligned}$$

$$EVA = (ROIC - WACC) * \text{Invested Capital}$$

$$\begin{aligned} WACC &= \text{Equity Percentage} * \text{Return on Equity} + \text{Debt Percentage} \\ &\quad * \text{Return on Debt} * (1 - \text{tax}) \\ &= .35 * 12\% + .65 * 10\% * (1 - 35\%) = 8.425\% \end{aligned}$$

$$EVA = (12.5\% - 8.425\%) * \$10 \text{ Million} = \$407.5K$$

$$MVA = \sum PV(EVA)$$

which is a perpetuity paying \$407.5K annually.

$$MVA = \frac{\$407.5K}{8.425\%} = \$4.84 \text{ Million}$$

(ii)

The value added from the acquisition must be at least that of the renovation option. Additionally, the market value added will be larger if the economic value added is larger.

$$\begin{aligned} EVA &= \text{Net Operating Profits After Tax} - \text{Capital Charge} \\ &= \$4 \text{ million} - \text{Invested Capital} * WACC \\ &= \$4 \text{ million} - \text{Offer Price} * 8.425\% \end{aligned}$$

$$\$ .4075 \text{ million} = \$4 \text{ million} - \text{Offer Price} * 8.425\%$$

$$\text{Max Offer Price} = \frac{(\$4 \text{ million} - \$ .4075 \text{ million})}{8.425\%} = \$42.6 \text{ million}$$

## 1. Continued

- (d) Identify two considerations of a capital allocation framework specific to Blue Jay Air that can be used to decide between these options.
1. How does each option fit the brand management and business strategy of Blue Jay Air?

Blue Jay Air is attempting to become the most customer-oriented airline company in the world, with comfort as an important virtue. The second option seems to fit this rebranding effort particularly well.

2. How do these investments fit within the rest of the company's investment options?

A significant concern for Blue Jay Air is the liquidity of the company, given that it's highly-leveraged and capital intensive. Additionally, both for international and domestic travel, Blue Jay Air will need to fund significant investments. The larger investment for the acquisition provides an obstacle; this issue could be avoided if Blue Jay Air is able to use shares of its own stock to purchase Luxury Lounges.

### **Commentary on Question:**

*Other acceptable answers were possible if they both came from a capital allocation framework and were evaluated with respect to Blue Jay Air's specific circumstances.*

## 2. Learning Objectives:

1. The candidate will understand how a business enterprise funds its activities with considerations for its business model, and the cost and constraints of the sources of capital.
2. The candidate will understand how an enterprise's structure and policies allow its management to prioritize and select among projects or business activities that are competing for scarce capital resources especially when opposing factors are key decision criteria.

### Learning Outcomes:

- (1b) Evaluate capital budgeting approaches and structure policy for insurance and non-insurance organizations.
- (2b) Recommend an optimal capital structure and how to implement it for a given business strategy.
- (2c) Design a risk management plan to optimize the risk reward trade off of employed capital.

### Sources:

Corporate Finance, Chapter 24 – Debt Financing - Jonathan Berk and Peter Demarzo

Corporate Finance, Chapter 27 – Short Term Financing - Jonathan Berk and Peter Demarzo

### Commentary on Question:

*For question 2 candidates needed to distinguish between temporary and permanent working capital needs, to calculate a company's permanent working capital, and to evaluate the best source of short term financing.*

*Overall, candidates performed well, providing well-reasoned answers when asked to make recommendations. Part c's calculations were difficult for some candidates.*

### Solution:

- (a) Describe three situations in which a company may employ temporary working capital.

### Commentary on Question:

*Candidates did well but some only provided a list. To receive full credit, a description of each was required.*

## 2. Continued

Seasonality – cyclical business causing months of deficit (production) offset by months of large surplus (sales)

Negative cash flow shock – temporarily negative cash flows due to an unforeseen reason such as equipment replacement

Positive cash flow shock – initial cash deficits from additional expenses to support future growth

- (b) Calculate Blue Jay Tire's permanent working capital (Case Study Section 3.4).

### Commentary on Question:

*Several candidates incorrectly used some variation of Blue Jay Tire's balance sheet items other than illustrated below for net working capital. However, most candidates correctly used the minimum of all years available for permanent working capital.*

Net working capital = current assets – current liabilities

Permanent working capital = Min (net working capital)

	Current Assets	-	Current Liabilities	=	Net Working Capital
2009	201		3		198
2010	198		10		188
2011	207		11		196
2012	205		13		192
2013	220		13		207
2014	269		15		254

Min (net working capital) = 188

- (c) Calculate the effective annual rate for each of the following financing options to fund the increased capital need.

Note: Annual Percentage Rate (APR) is compounded semi-annually.

- I. Promissory note with 5% compensating balance requirement bearing 1% APR interest. Loan interest is 9% APR.
- II. Commercial paper offering \$95 for \$100 of face value
- III. Secured loan collateralized by inventory with an upfront field warehouse cost of \$200,000, 10% APR

## 2. Continued

### **Commentary on Question:**

*Candidates had the most difficulty with this part. Often they'd compute the right components but place this wrongly in the numerator (balance in 6 months) or denominator (balance today). Several candidates made mistakes around converting the APR and EAR between annual and semi-annual. Showing work was important to receive partial credit for small mistakes.*

I.

$$t(0) = \text{loan} * (1 - \text{compensating balance req}) = 50 * (1 - 0.05) = 47.5$$

$$t(0.5) = \text{loan} * (1 + \text{APR}_{\text{loan}}/2) - \text{compensating balance} * (1 + \text{APR}_{\text{balance}}/2) = 50 * (1 + 0.045) - 2.5 * (1 + 0.005) = 49.7375$$

$$i = t(0.5) / t(0) - 1 = 49.7375 / 47.5 - 1 = 0.047105$$

$$\text{EAR} = (1 + 0.047105)^2 - 1 = 0.096429$$

II.

$$t(0) = \text{amount issued} * \text{price} / \text{face value} = 50 * 95 / 100 = 47.5$$

$$t(0.5) = \text{amount issued} = 50$$

$$i = t(0.5) / t(0) - 1 = 50 / 47.5 - 1 = 0.052632$$

$$\text{EAR} = (1 + 0.052632)^2 - 1 = 0.108033$$

III.

$$t(0) = \text{loan} - \text{upfront expense} = 50 - 0.2 = 49.8$$

$$t(0.5) = \text{loan} * (1 + \text{APR}/2) = 50 * (1.05) = 52.5$$

$$i = t(0.5) / t(0) - 1 = 52.5 / 49.8 - 1 = 0.054217$$

$$\text{EAR} = (1 + 0.054217)^2 - 1 = 0.1111373$$

- (d) Recommend one financing option from part (c) for Blue Jay Tire. Support your recommendation.

### **Commentary on Question:**

*Candidates were required to provide a well justified reason for their recommendation; most did support their recommendation. Candidates were not penalized if they picked a different option based on a miscalculation from part c.*

The promissory note with compensating balance should be used as it results in the lowest effective annual rate.

## 2. Continued

- (e)
- (i) Describe each of the financing options A-D above.
  - (ii) Evaluate the appropriateness of each of the financing options to address Blue Jay Tire's liquidity concerns.
  - (iii) Recommend the financing option that Blue Jay Tire should utilize. Support your recommendation.

### **Commentary on Question:**

*For (i) a description was required that provided more detail than is apparent from the name of the financing option itself. Many candidates were unfamiliar with a bridge loan but could describe the others.*

*For parts (ii) and (iii), most candidates correctly identified the short-term nature of Blue Jay Tire's capital need was an important factor in the evaluation of each financing option.*

- (i)
- A. Line of credit - flexible agreement allowing the company to choose when to draw funds up to a stated maximum.
  - B. Bridge loan - a short term arrangement until long term financing can be secured.
  - C. Sale and lease back - sell assets and immediately start paying the buyer for continued use of the assets for an agreed period of time; helpful for raising capital and still getting use of the assets.
  - D. Long-term debt - financing for more than the period of a year, often through issuing bonds.

- (ii)
- A. letter of credit - raises cash, matches short-term timing, easy to implement
  - B. bridge loan - raises cash, matches short-term timing, some negotiation with lender needed
  - C. sale and lease back - raises cash, but usually for longer term, complex negotiations
  - D. long-term debt - raises cash, does not match timing of need, higher costs due to term, covenant issue

- (iii)
- Based on the matching principle, Blue Jay would be best served to employ short term financing for this short-term need. An LOC would offer the company flexibility on when and how much to borrow over the course of the year assuming they will be capable of paying off the balance.

### 3. Learning Objectives:

2. The candidate will understand how an enterprise's structure and policies allow its management to prioritize and select among projects or business activities that are competing for scarce capital resources especially when opposing factors are key decision criteria.

#### Learning Outcomes:

- (2a) Evaluate how the legal form of an organization, corporate governance and/or compensation dynamics impact business decisions.
- (2b) Recommend an optimal capital structure and how to implement it for a given business strategy.
- (2c) Design a risk management plan to optimize the risk reward trade off of employed capital.

#### Sources:

Corporate Finance, Chapter 17 – Payout Policy - Jonathan Berk and Peter Demarzo,

Corporate Finance, Chapter 26 – Working Capital - Jonathan Berk and Peter Demarzo,

Corporate Finance, Chapter 29 – Corporate Governance - Jonathan Berk and Peter Demarzo,

#### Commentary on Question:

*Commentary listed underneath question component.*

#### Solution:

- (a) Explain two reasons why it may be desirable for Frenz to retain earnings as cash (Case Study Section 4.3).

#### Commentary on Question:

*In case study questions it is important to apply the answer to the company. To get full credit candidates had to apply their answers to Frenz. They did not need to specifically mention the exact vocabulary, but they did need to describe it well enough and apply it to Frenz' situation.*

**Transactions balance:** to meet the company's day-to-day needs. Frenz must maintain enough cash to pay near-term liabilities.

**Precautionary balance:** to compensate for the uncertainty associated with its cash flows. Frenz must maintain enough cash to counter the uncertainty surrounding cash flows.

### 3. Continued

*Other successful answers might include:*

**Compensating balance:** to satisfy bank requirements. Frenz's bank may require the company to hold cash in an account as compensation for the services it provides.

**Expansion balance:** since the company is looking to expand, Frenz may want to retain earnings to preserve financial slack for future growth opportunities and to avoid financial distress costs.

- (b) All calculations are as of December 31, 2014.
- (i) Calculate Frenz's share price.
  - (ii) Calculate the share price if Frenz repurchases \$100M worth of shares using retained earnings.
  - (iii) Calculate the share price if Frenz invests in the Vietombia project using retained earnings (Case Study Section 4.3, Exhibit 5).

**Commentary on Question:**

*It is important in calculation questions to ensure that the grader can follow along with your train of thought. For answers that are incorrect, partial credit may be awarded for a correct approach. For example, show the formula you are using and, if appropriate, label the inputs. This will help the grader understand your train of thought and could prevent you from making an error.*

Part (i)

$$\text{Share Price} = (\text{Shareholder's Equity}) / (\# \text{ Shares Outstanding}) = (\$875\text{M} / 500\text{M}) = \$1.75$$

*Common mistake was using Equity + Debt to calculate the Share Price*

Part (ii)

$$\text{New Share Price} = (\$875\text{M} - \$100\text{M}) / (500\text{M} - 57.14\text{M}) = \$1.75$$

*Also stating that an open market repurchase has no effect on stock price was acceptable for full credit*

Part (iii)

$$\text{New Share Price} = (\$875\text{M} - \$50\text{M}) / (500\text{M}) = \$1.65$$

### 3. Continued

- (c) Assess whether the company should invest \$100M in the Vietombia project or repurchase \$100M worth of shares from the perspective of the following two stakeholders:

- (i) Shareholders
- (ii) Management

**Commentary on Question:**

*Candidates were quick to pick up on the differing opinions of management and shareholders.*

Part (i)

Shareholders would not approve of the Vietombia project because it is a negative NPV project and lowers the share price \$0.10 per share.

Part (ii)

Management would approve of this project because Frenz's resulting increased earnings would lead to larger bonuses.

- (d) Design an alternative compensation package that aligns management compensation with shareholders' interest without overexposing managers to Frenz's risks. Justify your reasoning.

**Commentary on Question:**

*Some candidates merely listed a few ways to align a generic compensation package. Stronger candidates highlighted specific changes to Frenz' compensation package and had solid reasons to justify their recommendations.*

*Some correct answers included:*

Rather than linking bonuses to revenue, bonuses should be tied to earnings either through metrics like pre-tax income or through stock options and grants that allow managers to participate in Frenz's performance.

### 3. Continued

Bonuses should be awarded partly in the form of stock options. Stock option awards will maintain employee focus on the stock price.

The strike price of the options should be set as the average share price over the course of the previous quarter. Managers should not be able to manipulate the share price by timing of a news release in order to impact strike price of options

Managers should not be able to exercise options until a year after they are granted. Waiting until a year after they are granted to exercise the options will encourage management to focus on continued growth in company value and further minimize share price manipulation.

Managers should also receive a salary that is independent of company earnings. A base salary will give managers the comfort of knowing they will for sure receive a baseline income and won't be overexposed to Frenz's risks. Therefore, managers will have the courage to invest in projects they project to be positive-NPV, but if they are wrong they won't lose all of their compensation.

- (e) Describe three transaction types that Frenz could use to repurchase its shares.

**Open Market Repurchase** - Frenz announces its intention to buy its own shares in the open market, then proceeds to do so over time like any other investor.

**Tender Offer** - Frenz offers to buy shares at a specified price during a short time period. The price is usually set at a premium to the current market price.

**Targeted Repurchase** - Frenz purchases shares directly from a major shareholder. The purchase price is negotiated directly with the seller.

#### **4. Learning Objectives:**

4. The candidate should understand how and when to apply various advanced techniques to evaluate risk or uncertainty in any business enterprise especially non-insurance organizations.

#### **Learning Outcomes:**

- (4a) Critique methods for determining long term discount rates.

#### **Sources:**

Yield Curve Extrapolation: Work in Progress, Moody's Analytics

A Risk Management Tool for Long Liabilities: The Static Control Model

#### **Commentary on Question:**

*The focus of the question is understanding yield curve extrapolation and how it can be used to value long term liabilities. Candidates were asked to evaluate how a hedging team would support different goals than a pension accountant; namely market consistent prices required for hedging and stability required for pension valuation. Candidates struggled to show a deep understanding of the challenges and goals of yield curve extrapolation.*

#### **Solution:**

- (a) Describe three parts of the long-term interest rate extrapolation problem that the "macroeconomic" approach addresses.

#### **Commentary on Question:**

*Candidates either understood the steps of the macroeconomic approach or they didn't. Candidates could describe the extrapolation problems, or describe the steps to the macroeconomic approach. For full credit, candidates needed to comment on the fact that the approach also determines the speed at which the observable rates adjust/combine to the UFR.*

The macroeconomic approach solves three problems to the extrapolation exercise:

- 1) It provides a fit to some set of observable bond prices or interest rate quotations (spot rates)
- 2) It sets an assumption for a limiting/unconditional/ultimate interest rate which is usually an unconditional forward rate (UFR)
- 3) It combines the observed rate curve and the ultimate interest rate assumption, including the speed at which the curve adjusts to the chosen forward rate.

## 4. Continued

- (b) Describe two goals of developing extrapolated yield curves.

**Commentary on Question:**

*Candidates didn't need to provide exact wording, but one goal had to mention the faithful estimate of a market transaction, while the other goal focused more on creating a stable estimate for valuing long-term liabilities*

- 1) To establish a faithful estimate of where a market transaction would take place today, also known as the trader view of a realistic transaction price.
- 2) To create a reasonably stable estimated value of long-term liabilities.

- (c)

- (i) Explain which goal from part (b) Darwin's VA Hedging Actuary would support.
- (ii) Describe the primary issue Darwin's VA Hedging Actuary would encounter if the alternative goal from part (b) is prioritized.

**Commentary on Question:**

*If candidates failed to identify the correct goals in part b, they could still receive partial credit if their reasoning made sense. Ideally, candidates should demonstrate their understanding that a hedging actuary is concerned with setting up an accurate hedge and would need observable market rates to do so.*

- (i) The VA Hedging Actuary would support the view of establishing a faithful estimate of a market transaction price today to properly align market prices of assets and liabilities for accurate hedging.
- (ii) If stability was supported, the liabilities would be artificially stable and therefore liabilities and assets wouldn't respond the same way to market movements. This would make hedging accurately extremely difficult as assets and liabilities would have different market greeks.

- (d)

- (i) Explain which goal from part (b) Blue Jay Air's Chief Pension Accountant would support.
- (ii) Describe the primary issue Blue Jay Air's Chief Pension Accountant would encounter if the alternative goal from part (b) is prioritized.

## 4. Continued

### **Commentary on Question:**

*If candidates failed to identify the correct goals in part b, they could still receive partial credit if their reasoning made sense. Candidates should demonstrate their understanding that a pension accountant is concerned with long-term liabilities and stability, particularly when it comes to optics for stakeholders.*

- (i) The Chief Pension Accountant would support the goal of stable estimates for the value of long-term liabilities as Pension liabilities are long-term and short-term movements would only create accounting noise.
  - (ii) If the goal of establishing a faithful estimate of transaction price based on market prices was supported, the accountant would see more volatility in the pension liability which could cause the company to post more capital, and then have to explain to investors and other stakeholders why there's so much volatility and noise.
- (e) Describe the expected impact of each scenario I and II on:
- (i) Darwin's VA Hedging Actuary's ability to effectively hedge.
  - (ii) Blue Jay Air's Chief Pension Accountant's ability to value the pension liability.

### **Commentary on Question:**

*Candidates did poorly on this section. The most common error was thinking about hedging transaction costs for the VA hedging actuary as opposed to focusing on creating an accurate and effective hedge.*

#### VA Hedging Actuary:

I: Speed over convergence reduced from 40 to 10 years would cause the liability to artificially stabilize, making it more difficult for the VA Hedging Actuary to accurately hedge with market assets.

II: With LRH increasing, the grading to the UFR will begin later in the projection so the extrapolated curve would be more sensitive to changes in observable rates, making it easier for the actuary to effectively hedge.

#### Chief Pension Accountant:

I: Speed of convergence reduced from 40 to 10 years would dampen the impact of changes in the long-term rate which would reduce the volatility of the accounting results, helping the Accountant.

II: If the LRH is increased, the extrapolated curve will be more sensitive to changes in observable rates, creating more accounting noise for the pension liability and causing the Chief Pension Accountant to have to explain the volatility to stakeholders.

## 4. Continued

- (f) Evaluate the appropriateness of implementing the Static Control Model for each scenario A, B and C above.

**Commentary on Question:**

*Candidates struggled on this question. For full credit, candidates needed to identify appropriate/inappropriate correctly as well as provide supporting statements for their conclusions.*

Scenario 1: Low Interest Rates

The Static Control Model is inappropriate in this environment as the total return requirements in the model become unmanageable. To compensate, the company would have to adjust the parameters of the model, which is inherently inappropriate.

Scenario 2: Market Consistent Models

The SCM would be appropriate as it is a market consistent model so that principle would not be violated. The model is also subadditive.

Scenario 3: Models must use continuous forward rates

The SCM would be inappropriate as the MCYC extrapolates forward rates that are on a discrete basis with “jumps” and these rates can even go negative.

- (g) Recommend four improvements to Darwin’s interest rate risk management strategy. Justify your recommendation.

**Commentary on Question:**

*Candidates did well on this question as there are many options available. For full credit, candidates needed to comment on an existing (or lack of) risk management strategy within Darwin and how it could be improved, and improvements had to focus specifically on interest rate risk.*

Darwin could improve their interest rate risk management in the following ways:

- Update interest rate hedging factors more often than weekly, potentially daily to improve effectiveness.
- Hedge more of the risk. Currently rho is only hedged to 50%, and increasing to 80 or 90% would reduce interest rate risk.
- Hedge more general account risk: Currently general account and group annuity interest rate risk is unhedged.
- Increase frequency of duration matching which is currently only done on a semi-annual basis.
- Reduce the duration mismatch threshold (currently at 0.5) to reduce ineffective hedging.
- Hedge convexity to capture second-order interest rate risk in addition to duration mismatch.

## 5. Learning Objectives:

3. The candidate will understand how and when to apply various stochastic techniques to situations which have uncertain financial outcomes.
4. The candidate should understand how and when to apply various advanced techniques to evaluate risk or uncertainty in any business enterprise especially non-insurance organizations.
5. The candidate will understand how to identify and recommend appropriate risk assessment and monitoring techniques for financial risk management.

### Learning Outcomes:

- (3c) Assess the results of a given application of stochastic modelling and calibration processes.
- (3e) Explain what risk exposures are or are not identified with a given risk metric, assess implications, and recommend further action.
- (4c) Apply Applied Information Economics (AIE) concepts to Enterprise Risk Management (ERM).
- (5b) Assess methods and process for quantifying and managing model risk within any business enterprise.

### Sources:

How to Measure Anything Chapters 5-7, Hubbard

Measuring Market Risk 2<sup>nd</sup> ed., Chapter 12, Dowd

### Commentary on Question:

*Commentary listed underneath each question component.*

### Solution:

- (a)
  - (i) Describe the “Equivalent Bets” test.
  - (ii) Describe how management could utilize the “Equivalent Bets” test for project evaluation.

### Commentary on Question:

*Candidates needed to recognize that “Equivalent Bets” is a tool to quantify estimators, and had to describe a comparison of a project to a bet with  $x\%$  chance of payoff.*

## 5. Continued

- (i) The equivalent bets test is used to calibrate estimators, or estimates of a project payoff. It is a hypothetical exercise to assess uncertainty: that if there are two bets available to measure uncertainty of these different projects with the same expected payoff if managements' estimation is perfectly calibrated then management would be indifferent as to which bet to take.
  - (ii) Management could utilize this technique to evaluate different projects by proposing a bet with  $x\%$  chance of payoff compared to the projects' expected payoff. When management is indifferent between the bet or taking on the project, then the estimator is calibrated.
- (b) List four disadvantages of the “high-medium-low” risk categorization method.

### **Commentary on Question:**

*Candidates did generally well on this part. The examples below are not exhaustive.*

- The ratings are not well defined- for example, does "high" mean 5% chance of losing \$1M, or a 20% chance of losing \$100k? Is a "medium" risk investment with 15% return better or worse than a "high" risk with 50% return?
  - Forces a kind of rounding error that could give the same score to hugely different risks
  - Leads to assessing what's easy, understood, and routine while ignoring what's not easy, ambiguous, and potentially catastrophic.
  - Ambiguity leads to human error when assessing due to over-confidence in assessing risk.
  - This is not how insurers measure risk- you have to pay a specific premium amount, not just a "high" "medium" or "low" amount.
  - These risk ratings are impossible to add, divide, average, or perform any other math upon.
  - Some "high" risks may be "higher" than others; or otherwise can be "lumped" together and lose distinction
- (c)
- (i) Design criteria that quantify the high, medium and low risk categories using the information in the table above. Show your work.
  - (ii) Describe one flaw of using a simple sum of standard deviation of PV of profits for all projects to calculate “Total” risk.

## 5. Continued

### **Commentary on Question:**

*Candidates generally did well on this question. The key was to recognize that the risk measure should be a function of expected payoff and the variance or standard deviation of the payoff, and to show how this proposed system calibrates to the current 5 projects.*

The risk categories are based on expected standard deviation of profit divided by the expected profit. A = 0.20; B = 0.40; C = 0.40; D = 0.20; E = 0.12. When standard deviation of profit is a percent of expected present value of profit, the risk rating system is defined as: <20% = Low; 20% - <25% = Medium; 25%+ = High

A simple sum of standard deviations may not be mathematically accurate. Some projects could have offsetting or aggregate effects.

- (d) Calculate the Expected Opportunity Loss of:
- (i) Entering into labor negotiations.
  - (ii) Not entering into labor negotiations.

### **Commentary on Question:**

*Many candidates forgot that Expected Opportunity Loss is defined as the chance of being wrong times the cost of being wrong.*

- (i) Expected Opportunity Loss if they enter negotiations:  $65\% * (150 - 80) = 45.5$
  - (ii) Expected Opportunity Loss if they don't enter:  $35\% * (80 - 50) = 10.5$
- (e) Categorize the risk of this new project, according to the criteria in part (c)(i). Show your work.

### **Commentary on Question:**

*This is a relatively straightforward math problem. Candidates who received full credit successfully calculated the expected profit and standard deviation of profit then utilized these in the framework from part c.*

Expected profit =  $35\% * (150 - 50) + 65\% * (150 - 150) = 35$

Variance of profit =  $4,333 - 35^2$ ; standard deviation = 55.75

Under the framework of standard deviation / profit, this is  $55.75 / 35$ , or 160%.

This rates as (very!) high risk.

## 5. Continued

- (f)
- (i) Calculate the Expected Value of Information of hiring RCC.
  - (ii) Recommend whether or not to hire RCC. Justify your recommendation.

**Commentary on Question:**

*Costs exactly equal the benefits if the calculation was done correctly. Candidates could argue to hire/not hire RCC and receive full credit if they supported their recommendation. Stronger candidates noted that additional criteria are needed to break the tie.*

Expected costs w/o RCC:  $35\% \cdot 50 + 65\% \cdot 150 = \$115$

Expected costs w/ RCC:  $40\% \cdot 50 + 60\% \cdot 150 = \$110$

Expected value of information = \$5.

Recommend not hiring RCC because the value of information is not greater than the cost of hiring them.

- (g) Explain why the risk categorization of the 6th project could change based on the revised assumption.

**Commentary on Question:**

*Candidates should recognize that both the mean and standard deviation will be impacted, and will affect the categorization.*

The revised distribution will decrease the variance of the costs, and the projects as a whole. The revision will also increase expected profits. Thus, overall the risk will be lowered.

## 6. Learning Objectives:

2. The candidate will understand how an enterprise's structure and policies allow its management to prioritize and select among projects or business activities that are competing for scarce capital resources especially when opposing factors are key decision criteria.

### Learning Outcomes:

- (2a) Evaluate how the legal form of an organization, corporate governance and/or compensation dynamics impact business decisions.
- (2d) Assess the impact of behavioral factors in capital budgeting methods and capital structure policies.

### Sources:

Handbook of the Economics and Finance, Ch5: Baker & Wurgler, Behavioral Corporate Finance: An Updated Survey

### Commentary on Question:

*Candidates did poorly on this question. Recurring problems seemed to be that candidates were unfamiliar with the equation given in part (c) and failed to answer the questions in the context of the CFO's compensation scheme in parts (d) and (e).*

### Solution:

- (a) Describe three behavioral reasons why an investor would continue to hold BECC stock at this time.

#### Commentary on Question:

*Candidates did well answering this question.*

Categorization – Since the BECC stock was recently added to the index, investors may group its performance with other construction stocks in the index.

Loss Aversion - Investors tend to avoid realizing losses.

Anchoring – Investors form beliefs from an arbitrary starting point, which can be the initial purchase price.

*Other answers were also considered if they addressed the behavioral aspects of not selling BECC stock.*

- (b)
  - (i) Explain two goals of the CFO according to the rational manager theoretical framework and assuming perfect capital markets.
  - (ii) Describe the additional goal the CFO has to consider when the assumption of investor rationality is relaxed.

## 6. Continued

- (i) Maximize fundamental value – select investment projects to increase the risk adjusted present value of future cash flows.  
Maximize current share price – Cater to short term projects that increase the value of the firm. Present the firm in a way that is currently appealing to investors.
  - (ii) Exploit current mispricing – Company will issue shares if they believe shares are currently overvalued.
- (c) Describe the following components of the objective function:

(i)  $f(K, \cdot) - K$

(ii)  $e\delta(\cdot)$

(iii)  $\delta(\cdot)$

(iv)  $\lambda$

**Commentary on Question:**

*Candidates struggled in applying the concepts presented in the course of reading even with the basic framework given and the components explicitly identified in the question.*

- (i) Maximize fundamental value
  - (ii) Exploit current mispricing for the benefit of long-term shareholders
  - (iii) Maximize current share price
  - (iv) Manager's time horizon
- (d) Evaluate how the compensation arrangement impacts the components of the objective function in part (c).

**Commentary on Question:**

*Candidates who did well on part (c) had little difficulty in analyzing the CFO's compensation arrangement under the framework. Although, some candidates gave generic responses that were not related to the CFO's situation.*

## 6. Continued

- (i) Since this represents the fundamental value of the company and is the risk adjusted present value of future cash flows it is a long term goal. Therefore, the short term nature of the compensation package should have little effect on this measure.
  - (ii) Since this component attempts to benefit long-term investors by exploiting current mispricing, the compensation package should have little impact.
  - (iii) This component represents the current share price and the compensation package will have an impact on this measure.
  - (iv) Due to the short term goals of the compensation package, the time horizon will also likely be short.
- (e) Assess whether the CFO would take the following actions in light of her compensation package. Justify your assessment.
- (i) Acquire an undervalued company
  - (ii) Manage accruals in reported earnings
  - (iii) Issue new equity shares

### **Commentary on Question:**

*Candidates generally did well on part (e). For i) the best answer is “no” but some candidates received credit for a “yes” response and description of how the company value could be realized in the short term (<1 year) timeframe of the CFO’s compensation package.*

- (i) No – while in the long run, acquiring an undervalued company would theoretically increase the value of the firm, the manager’s compensation package rewards actions that will increase the stock price in the short term.
- (ii) Yes – by managing accruals, the manager can increase EPS in the short term which may increase stock price, which is consistent with her compensation package.
- (iii) No – issuing new stock is a signal that it is overvalued and dilutes EPS in the short run, which would decrease the stock price in the near term.

## 7. Learning Objectives:

5. The candidate will understand how to identify and recommend appropriate risk assessment and monitoring techniques for financial risk management.

### Learning Outcomes:

- (5a) Evaluate the methods and processes for measuring and monitoring market risk positions.
- (5b) Assess the methods and process for quantifying and managing model risk within any business enterprise.
- (5c) Design and evaluate stress-testing and back-testing processes.

### Sources:

Measuring Market Risk – Chapter 12, Kevin Dowd, 2<sup>nd</sup> edition

Measuring Market Risk – Chapter 13, Kevin Dowd, 2<sup>nd</sup> edition

### Commentary on Question:

*This was a simple question on utilizing mapping as a technique for risk management. The VaR calculation was kept straightforward for exam purposes. One of the keys for successful candidates was to understand the importance of correlation in the analysis.*

### Solution:

- (a) List three reasons for mapping positions to risk factors.

#### Commentary on Question:

*Candidates did well on this question. Credit was awarded to candidates who mentioned a reduction in complexity, but credit was not awarded for ambiguous responses such as “better risk management” without further explanation.*

- Not enough data
  - Reduces run time
  - Reduces dimensionality of the covariance matrix
  - Avoids the collinearity/ranking problem of highly correlated factors
- (b) Calculate VaR(95) over a 1-year horizon by mapping both stocks to Zoo Composite.

#### Commentary on Question:

*This was a relatively straightforward VaR calculation that most candidates were able to do.*

$$\begin{aligned} VaR &= x_A \beta_A \sigma_m z_\alpha + x_B \beta_B \sigma_m z_\alpha = (x_A \beta_A + x_B \beta_B) \sigma_m z_\alpha \\ VaR &= (\$10M * 50% * 1.2 + \$10M * 50% * 0.8) * 20% * 1.645 = \$3.29M \end{aligned}$$

## 7. Continued

- (c)
- (i) Describe two assumptions made in the mapping process.
  - (ii) Explain how your result in part (b) would compare to a VaR(95) result without mapping (i.e. overestimate, underestimate, equal to, or uncertain). Justify your answer.

### **Commentary on Question:**

*Candidates struggled with this question. For part (i), many candidates incorrectly stated that an assumption of risk mapping is that the stocks are normally distributed and that volatility is constant. For part (ii), very few candidates were able to explain both the impact of volatility and correlation on mapped vs. unmapped VaR.*

- (i)
    - Firm-specific volatility components are negligible
    - The portfolio is diversified / there is no correlation between stocks
  - (ii)
    - Uncertain.
    - Volatility – ignoring firm-specific volatility underestimates VaR, so mapped VaR would be lower than unmapped VaR, however,
    - Correlation between the return of these two stocks is unknown. If positive correlation exists, then overall VaR is underestimated. If negative correlation, then VaR is lower.
- (d) Rank the effectiveness of the stress tests I, II and III above. Justify your ranking.

### **Commentary on Question:**

*Most candidates were able to correctly rank the stress scenarios. Stronger candidates were able to discuss the impact on VaR under each scenario.*

Ranking: III, I, II

- (1) III – an increase in stock volatility and an increase in correlation reflects historical market turmoil
- (2) I – increasing only the stock volatility is a valid stress test but not as robust as III
- (3) II – an increase in volatility with a reduction in correlation is not a useful shock since this would result in an increased diversification benefit, thereby lowering VaR

## 8. Learning Objectives:

1. The candidate will understand how a business enterprise funds its activities with considerations for its business model, and the cost and constraints of the sources of capital.
2. The candidate will understand how an enterprise's structure and policies allow its management to prioritize and select among projects or business activities that are competing for scarce capital resources especially when opposing factors are key decision criteria.

### Learning Outcomes:

- (1a) Identify and critique the available sources of funding to start or grow a business entity.
- (1b) Evaluate capital budgeting approaches and structure policy for insurance and non-insurance organizations.
- (2b) Recommend an optimal capital structure and how to implement it for a given business strategy.

### Sources:

How Do CFOs Make Capital Budgeting and Capital Structure Decisions?Graham & Harvey (Duke University),

Corporate Finance, Chapter 18: Capital Budgeting and Valuation with Leverage, Jonathan Berk and Peter Demarzo, Third Edition

Corporate Finance, Chapter 23: Raising Equity Capital, Jonathan Berk and Peter Demarzo, Third Edition

Corporate Finance, Chapter 24: Debt Financing, Jonathan Berk and Peter Demarzo, Third Edition

### Commentary on Question:

*This question focused on the candidate's ability to evaluate financing options for a corporation. Most candidates did very well on many parts of this question, but many candidates failed to evaluate financing options in the context of Peony's business structure in part (b).*

### Solution:

- (a)
  - (i) Describe the process of an auction IPO.
  - (ii) Calculate the share price at the IPO.

## 8. Continued

### Commentary on Question:

*Candidates did very well on this section. Most candidates described an auction IPO and identified the correct price. Some candidates calculated the wrong IPO price because they summed shares for the lowest bids rather than the highest, and a few candidates described the process of IPOs more generally rather than explaining the specifics of an auction IPO.*

- (i) In an auction IPO, rather than setting the price in advance, the price is determined by investors who place bids over a set period of time.
- Each potential investor submits the number of shares they would like to purchase and a price they are willing to pay
  - The price is then set where the number of shares bid at or above that price equals the number of offered shares. All winning bidders pay this price, even if their bid was higher
  - If total demand at this price is greater than supply, auction participants who bid higher than the winning price receive their full bid at the winning price, and participants who bid at the winning price would receive shares on a pro rata basis

(ii)

Price (\$)	Number of shares bid	Cumulative demand
21.00	75,000	75,000
20.75	150,000	225,000
20.50	100,000	325,000
20.25	200,000	525,000
20.00	275,000	800,000
19.75	250,000	1,050,000

Since at least 500,000 bids were received at 20.25, that is the share price of the offer. Shares would be allocated pro rata to participants who bid 20.25.

- (b) Evaluate the appropriateness of the following financing options for Peony:
- Equity
  - Non-convertible, non-callable bonds
  - Convertible bonds
  - Callable bonds

## 8. Continued

### **Commentary on Question:**

*Candidates did not perform well on this section. Most candidates failed to evaluate the appropriateness of non-convertible, non-callable bonds. However, many candidates did a good job describing the problems with equity issues for an undervalued company, and most candidates received full credit for their evaluation of callable bonds. Candidates did not need to include all points below in order to receive full credit but they did need to relate their responses to Peony's situation as stated in the question.*

- (i) Equity would be an inappropriate choice for Peony. Peony's current stock is undervalued, and equity issues signal overvalue to the market. Managers normally are reluctant to issue underpriced equity due to a fear of dilution of value, and stock prices often drop after an equity issue. Furthermore, because Peony is a small, fast growing company, they will face a greater information gap when they issue equity.
  - (ii) Non-convertible, non-callable bonds would be an inappropriate choice for Peony. The trade-off theory states that small, fast growing companies should limit the use of debt. Additionally, because Peony is small, debt may carry higher costs of distress.
  - (iii) Convertible bonds would be an appropriate choice for Peony. Convertible bonds are more insensitive to information disparities, which is especially important given the higher information gap that Peony faces as a small company. Peony's stock is undervalued, and convertible debt avoids further stock dilution. Convertible debt also reduces distress costs of a high leverage ratio.
  - (iv) Callable bonds give the right but not the obligation to retire bonds early at a set price. Because market bond yields may decrease, callable bonds offer Peony the opportunity to retire the debt and refinance at a lower borrowing cost in the future.
- (c)
- (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.

### **Commentary on Question:**

*Most candidates did very well on this section. Some candidates tried to calculate yield to maturity for a longer duration, and some candidates incorrectly stated that the investor held the option in a callable bond.*

## 8. Continued

- (i) To calculate the payment in the year of maturity of an annual bond:

$$Price = \frac{Face * Coupon + Face}{(1 + Yield)^{Period}}$$

$$1,015 = \frac{1,000 * 5\% + 1,000}{(1 + YTC)^1}$$

$$YTC = 3.448\%$$

- (ii) The price of a callable bond would be lower than an otherwise identical non-callable bond. The issuer of a callable bond retains an option to recall the bond. That option has value to the issuer, which means the investor pays a lower price (requires a higher yield).
- (d) Determine if the bond holder should choose to convert the bond at maturity. Support your answer.

### **Commentary on Question:**

*Most candidates did very well on this section. Candidates also received full credit for calculating the total gain of the conversion rather than the gain per share.*

$$Implied\ price = \frac{face\ value}{conversion\ ratio} = \frac{1,000}{45} = \$22.22$$

If the bondholder chose to convert, they would receive 45 shares worth \$30 each for an implied price of \$22.22. Since the implied price of the conversion is less than the actual stock price, the bondholder should choose to convert.

## 9. Learning Objectives:

3. The candidate will understand how and when to apply various stochastic techniques to situations which have uncertain financial outcomes.

### Learning Outcomes:

- (3b) Recommend the use of techniques that balance the reduction of computational demand versus model accuracy when applying stochastic methodology.
- (3c) Assess the results of a given application of stochastic modelling and calibration processes.
- (3d) Explain the differences and implications of the use of P-measure and Q-measure for risk assessment.
- (3e) Explain what risk exposures are or are not identified with a given risk metric, assess implications, and recommend further action.

### Sources:

Interest Rate Swap – Exposed - Ferrara & Nezzamodini

Heavy Models, Light Models, and Proxy Models

Monte Carlo Methods and Models in Finance and Insurance, Chapter 8 – Korn

### Commentary on Question:

*This question focused on applications and considerations of using a proxy model, including calibration methods, statistical tests to use, and least squares calibration.*

### Solution:

- (a)
  - (i) Define a proxy model.
  - (ii) Describe the parameters of a proxy model.

### Commentary on Question:

*Most candidates were successful in part i, but only a handful correctly identified the parameters of a proxy model in part ii.*

- (i) A proxy model is a model that approximates the results of another (more complicated) model, rather than directly modeling reality.
- (ii) Proxy models have risk drivers “R” and the functions of those risk drivers “X” run over a number of scenarios “S”.

## 9. Continued

- (b)
- (i) Contrast calibration methods I and II.
  - (ii) Recommend one of the calibration methods above. Support your response.

**Commentary on Question:**

*Few candidates were able to contrast the two calibration methods effectively. For part ii, either method could have been recommended as long as proper justification was provided.*

- (i)
- I – The Regression Fitting Method requires a much larger number of scenarios than parameters ( $S > K$ ) to product a good fit. This method is very sensitive to the distribution chosen.
- II – The Precise Interpolation Method involves fitting the minimum number of scenarios to the parameters ( $S=K$ ). This method requires far fewer scenarios than regression fitting; however the fit is very sensitive to the selected scenarios.

- (ii)
- I recommend they use the regression fitting method, because GRW can run 100 scenarios in their current system and this would be sufficient to provide a good fit with the regression fitting method.

- (c)
- (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.

**Commentary on Question:**

*Most candidates were successful in part i, yet very few set up part ii correctly.*

- (i) Rearrange the given formula to solve for  $a_3$  ->
- $$a_3 = Y - a_0x_{RF1} - a_1x_{RF2} - a_2x_{RF1}x_{RF2}$$
- using fitting points, solve for  $a_3$
- $$a_3 = 2.2 - (0.9 \times 2.5) - (0.8 \times 0.3) - (-0.29) = 0$$

Rearrange to solve for non-linearity component ->

$$a_2x_{RF1}x_{RF2} = Y - a_0x_{RF1} - a_1x_{RF2} - a_3$$

$$\text{point 4} = -0.5 - 0.9 \times 1 - 0.8 \times (-1) - 0 = -0.6$$

$$\text{point 5} = 2.7 - 0.9 \times 2 - 0.8 \times 0.6 - 0 = 0.42$$

## 9. Continued

- (ii) Rearrange formula to be  $Y - a_0x_{RF1} - a_1x_{RF2} = a_2x_{RF1}x_{RF2} - a_3$   
 Set up a matrix where  $y = [Y - a_0x_{RF1} - a_1x_{RF2}]$   
 $X =$  coefficients from the right side of the formula,  $[x_{RF1}x_{RF2}, 1]$   
 Solve the formula  $\beta = [(X^T)X]^{-1} (X^T) (y)$

$$X = \begin{array}{cc} 0.75 & 1 \\ -1.35 & 1 \\ 0.4 & 1 \\ -1 & 1 \\ 1.2 & 1 \end{array}$$

$$y = \begin{array}{c} -0.29 \\ -0.67 \\ 0.12 \\ -0.6 \\ -0.42 \end{array}$$

$$(X^T)X = \begin{array}{cc} 4.99 & 0 \\ 0 & 5 \end{array}$$

$$[(X^T)X]^{-1} = \begin{array}{cc} 0.2 & 0 \\ 0 & 0.2 \end{array}$$

$$[(X^T)X]^{-1} (X^T) = \begin{array}{ccccc} 0.15 & -0.271 & 0.08 & -0.201 & 0.241 \\ 0.2 & 0.2 & 0.2 & 0.2 & 0.2 \end{array}$$

$$[(X^T)X]^{-1} (X^T) y = \begin{array}{c} 0.369 \\ -0.204 \end{array}$$

$$a_2 = 0.369$$

$$a_3 = -0.204$$

- (d) 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.

## 9. Continued

**Commentary on Question:**

*Candidates typically did well on this question. For I, Chi-squared or Cramer Von Mises would also have been accepted. For II, Akaike Information Criterion would also have been accepted. For III, PP Plots would also have been accepted.*

I – Anderson-Darling

II – Bayes Information Criterion

III – QQ Plots

- (e) Critique your intern's statements. Support your critique.

**Commentary on Question:**

*Candidates did well on this question, both parts of the intern's statement needed to be critiqued to receive full credit. The knowledge of when to use real world scenarios vs. risk neutral scenarios is critical knowledge to master this exam.*

The intern is correct that risk neutral scenarios do not make sense in this situation. Risk neutral scenarios are used for pricing, while real world are used for risk management purposes such as this one.

The intern is correct that Expected Shortfall has benefits over VaR. Expected shortfall is a coherent risk measure while VaR is not. Expected Shortfall also gives a sense of the tail risk while VaR does not.

## 10. Learning Objectives:

3. The candidate will understand how and when to apply various stochastic techniques to situations which have uncertain financial outcomes.
4. The candidate will understand how and when to apply various advance techniques to evaluate risk or uncertainty in any business enterprise especially non-insurance organizations.
5. The candidate will understand how to identify and recommend appropriate risk assessment and monitoring techniques for financial risk management.

### Learning Outcomes:

- (3c) Assess the results of a given application of stochastic modelling and calibration processes.
- (4c) Apply Applied Information Economics (AIE) concepts to Enterprise Risk Management (ERM).
- (5a) Evaluate the methods and processes for measuring and monitoring market risk positions.
- (5b) Assess the methods and process for quantifying and managing model risk within any business enterprise.

### Sources:

How to Measure Anything, Chapter 7 - Hubbard

Measuring Market Risk, Chapter 10 – Dowd 2nd ed

Measuring Market Risk, Chapter 16 – Dowd 2nd ed,

### Commentary on Question:

*This question tested the concepts around the value of information and asked candidates to identify sources of model risk and how to manage that risk.*

### Solution:

- (a) 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.

## 10. Continued

### **Commentary on Question:**

*Candidates did well on this question in general. Candidates who correctly identified the correct curve and provided reasonable explanations received full credit.*

(i) Petunia Bank initially has a lot of experience and data on consumer behavior.  
Curve 3

The \$ value of information increases slowly as information quantity increases when a lot of information is already in hand because it is difficult to get any new information that adds much value.

(ii) Petunia Bank initially has almost no knowledge of consumer behavior.  
Curve 1

The \$ value of information increases sharply when Petunia has little information because almost any information can have large marginal value.

(ii) Petunia Bank initially has some knowledge of consumer behavior.  
Curve 2

The speed of \$ value of information increases as information quantity increases should sit in between the situations when Petunia has little knowledge and a lot of knowledge.

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

### **Commentary on Question:**

*Candidates scored very well on this question. One of the key thoughts from the exam is the concept that when you have very little information, just about anything is useful in reducing your uncertainty.*

Point X.

When you have a lot of uncertainty, you don't need a lot of data to tell you something useful.

The value of incremental information is the highest when you have least information.

- (c)
- (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).

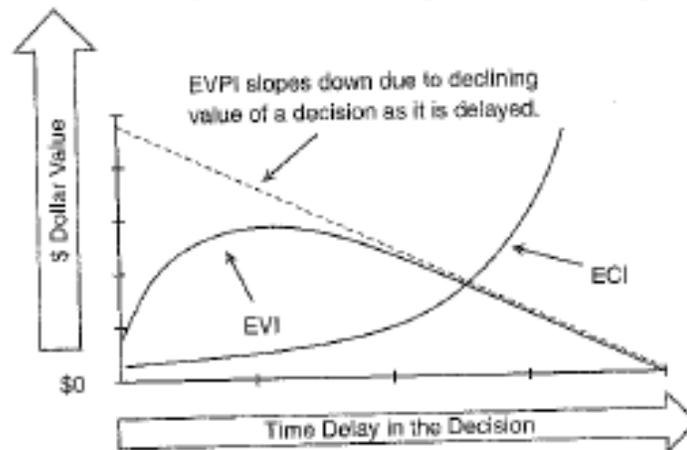
## 10. Continued

### Commentary on Question:

For part (i), most candidates were able to sketch the ECI curve and some candidates drew the EVI curve correctly. Partial credit was awarded to candidates who realized the EVI should never surpass EVPI even if they had an incorrect shape for the EVI curve.

For part (ii), many candidates forgot to comment on the EVPI curve and only received partial credit. Listed in the solution section are examples of justification of different ECI curves. Candidates had to provide a reasonable interpretation consistent with their ECI curve shape to receive full credit.

- (i) EVI - curve should increase and then decrease, but should never surpass EVPI  
ECI - can have just about any shape; below is one possible answer



- (ii) EVPI -the value of perfect information decreases as the decision is pushed further out.

EVI - when you know almost nothing, the incremental value of information is high. As you learn more, the marginal value of the next piece of information starts to decrease. Finally, when you know almost everything, the marginal value of even more information is negligible.

ECI (upward sloping) - cost of acquiring info increases over time as there is a cost to delaying the decision.

ECI (flat) - the info itself is expected to be available for a set price for the foreseeable future.

ECI (downward sloping) - technology is expected to reduce the cost of the information in the future.

ECI (up then down) - expected value of information initially increases as there is a gain to having information, but then the value is outweighed by the opportunity cost of delaying the decision.

## 10. Continued

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

**Commentary on Question:**

*Candidates scored very well on this question. Candidates did not receive credit for addressing benefits/limitations of VaR but only of the Delta-Gamma approach as stated in the question.*

Benefits

Easiest available method; use as initial starting point  
Every reason to believe they are accurate  
Use for mapping purposes

Limitations

Sensitivities may change  
Which approximation to use is not clear  
Unreliable in general  
Difficult to implement

- (e)
- (i) Identify how model misspecification may be present in Petunia's model.
- (ii) Describe two guidelines for managing model risk applicable to Petunia.

**Commentary on Question:**

*Most candidates received partial credit for this question and only a few received full credit. Candidate's responses had to be something that specifically applied to Petunia's situation and not just generic model misspecification issues or model risk guidelines from a list.*

(i)

Stochastic process may be incorrect:  
perhaps stocks don't follow Brownian motion  
policyholder behavior may not be defined properly

Missing risk factors:

Policyholders may react to different factors (e.g., overall economy);  
Might have ignored stochastic volatility

Misspecified relationships:

Policyholders may not care about prior period fund performance;  
Allocation between funds may be contingent on prior period performance

## 10. Continued

Ignoring transaction costs

Frictions may cause the relationships to be much different than in the model.

Assuming markets are perfectly liquid

Frictions may cause the relationships to be much different than in the model.

(ii)

Be aware of model risk- Petunia should realize there are limitations in their model; they can compare it to another model's results; willingly acknowledge limitations to other parties

Check assumptions- confirm appropriateness of stock and/or bond modeling approaches; same for policyholder behavior

Choose simplest reasonable model- specific routines in the model may be overly complex, such as how policyholder behavior is determined

Back/stress test- see if model results held up after time passes post product sale; see if losses were within VaR estimates; see if pricing was profitable.

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

**Commentary on Question:**

*Most candidates were able to describe the two aspects correctly. No credit was awarded for describing generic steps to calculate VaR without discussing elements that are specific to Petunia's product.*

Payoff of the product depends on policyholder's withdrawal behavior, which cannot be known in advance. Petunia must set an assumption for withdrawal behavior.

Payoff of this product is path-dependent, therefore there is no closed-form solution in the VaR calculation.

## 11. Learning Objectives:

3. The candidate will understand how and when to apply various stochastic techniques to situations which have uncertain financial outcomes.

### Learning Outcomes:

- (3a) Assess the appropriateness of a given stochastic technique to quantify market and non-market risk exposures.
- (3c) Assess the results of a given application of stochastic modelling and calibration processes.

### Sources:

Monte Carlo Methods and Models in Finance and Insurance, Chapter 5 – Korn

Monte Carlo Methods and Models in Finance and Insurance, Chapter 8 – Korn

### Commentary on Question:

*It is likely that all stochastic simulations one will encounter in their career will be done on a computer. However, it is critical that successful candidates for this exam understand how to set up such a stochastic simulation and to be able to evaluate the results of that simulation. Candidate performance was very poor on both of these important concepts.*

### Solution:

- (a) 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

### Commentary on Question:

*Successful candidates identified the directionality of tail correlation between lapse and withdrawal behavior then appropriately applied them to the copulas listed in the question. The key was to look for a copula that had both non-symmetric correlations and lower tail dependence.*

## 11. Continued

As mentioned, there is no significant correlation between lapse and withdrawal in normal and high lapse scenarios but there is high correlation in a low lapse scenario. Therefore, this a case of non-symmetric correlation; more specifically the variables have lower tail dependence.

- (i) T-Copula: T-Copula is appropriate for the distributions which have joint tail dependencies but with similar correlation in both tails. Since these two variables require a distribution with lower tail correlation, T-Copula is not appropriate in this scenario.
  - (ii) Gumbell-Copula: Gumbell-Copula is appropriate for the distributions which have asymmetric joint tail dependencies with correlation in upper tails. Since these two variables require a distribution with lower tail correlation, Gumbell-Copula is not appropriate in this scenario.
  - (iii) Clayton-Copula: Clayton-Copula is appropriate for the distributions which have asymmetric joint tail dependencies with correlation in lower tails. Since these two variables require a distribution with lower tail correlation, Clayton-Copula is appropriate in this scenario.
  - (iv) Frank-Copula: Frank-Copula is appropriate for the asymmetric distributions which have no correlation in tails. Since these two variables require a distribution with lower tail correlation, Frank-Copula is not appropriate in this scenario.
- (b)
- (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.

### **Commentary on Question:**

*Candidate performance on the question was mixed. Full credit was awarded for responses less developed than those shown below. Many successful candidates put their responses in bulleted items.*

- (i) Heston model is an equity path simulation model where volatility of the equities is not assumed constant.

Pros of the model:

Heston model has an explicit volatility process which has a mean reversion attribute which ensures the drift of the volatility towards long term value. This is more realistic equity simulation model.

## 11. Continued

Cons of the model:

In Heston model there is a need to explicitly state correlation between stock price and volatility which can be difficult to estimate.

(ii)

The parameters required for Heston model for market consistent valuation are

- Equity drift rate
- Long term volatility
- Speed of the drift towards long term volatility
- Volatility of volatility
- Correlation between stock price and volatility process.

(iii)

Pros of Hull-White Interest rate simulation model:

Hull-White model fits the initial term structure perfectly which helps market consistent valuation for bonds across maturities.

Cons of Hull-White Interest rate simulation model:

There is no explicit mean reversion property of the short rate as there is no real limit to short rate.

(iv)

The parameters needed to calibrate the Hull-White model for market consistent valuation are:

- Term structure fit parameters for short rates
- Volatility of the short rates

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

### **Commentary on Question:**

*Candidate performance was very poor on this question. Many candidates just gave vague generalizations about a simulation process rather than specific steps as asked for in the question. For successful candidates, the key is to set up a Monte-Carlo process with appropriate correlations between variables.*

The valuation framework can be set as below:

Repeat the steps (1-5) for N iterations

1. Initialize stock, stock volatility, short rate volatility process
2. Choose number of steps (n) and timesteps ( $\Delta = T/n$ ) till the maturity (T)
3. For  $j=1$  to n do the following
  - a. Simulate three sets of independent standard random numbers (X,Y,Z)
  - b. Set  $W1 = \rho1Y + \text{sqrt}(1-\rho1^2)$  where  $\rho1$  is the correlation between stock and stock volatility
  - c. Set  $W2 = \rho2Y + \text{sqrt}(1-\rho2^2)$  where  $\rho2$  is correlation between stock and short rate

## 11. Continued

- d. Update Volatility with correlated random process  $W1$
  - e. Update log-stock price  $X(t) = \ln(S(t))$  with random process  $Z$
  - f. Update short rate  $r(t)$  with correlated random process  $W2$
4. Build yield curve  $r(t)$  based on the short rates
  5. Calculate payoffs ( $P$ ) of the instrument and discount back to get present values ( $V$ )

$$V(N) = P(N) * \text{Exp}(-r(T) * T)$$

6. Finally take average values of the present values as the valuation ( $V$ ) of the instrument.

$$V = (1/N) * \Sigma V(N)$$

## 12. Learning Objectives:

1. The candidate will understand how a business enterprise funds its activities with considerations for its business model, and the cost and constraints of the sources of capital.
4. The candidate will understand how and when to apply various advance techniques to evaluate risk or uncertainty in any business enterprise especially non-insurance organizations.

### Learning Outcomes:

- (1a) Identify and critique the available sources of funding to start or grow a business entity.
- (4b) Evaluate the use of cost of capital frameworks for micro and macro level risk assessments.

### Sources:

-Creating Value Through Best-In-Class Capital Allocation, JP Morgan

The Cross-Section of Hurdle Rates for Capital Budgeting: An Empirical

Analysis of Survey Data, National Bureau of Economic Research

Corporate Finance, Chapter 22 – Real Options - Jonathan Berk and Peter Demarzo,

Corporate Finance, Chapter 25 – Leasing - Jonathan Berk and Peter Demarzo,

### Commentary on Question:

*The question tested the concept of real options, a key learning of this exam's syllabus. Additionally, the question asked the candidate to evaluate short-term vs. long-term uses of capital in an organization.*

### Solution:

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

### Commentary on Question:

*This is a straightforward questions in which most candidates identified the correct response.*

Should use Freesia's current cost of capital 8%. This rate is higher and it reflects the constraints on Freesia's due to fuel price surge, this is an increased risk to Freesia. In addition, this opportunity involves a real option, which is more current (within 2 years) than long term.

## 12. Continued

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

### Commentary on Question:

*Classic real options question but half the candidates approached it from another angle. Many candidates did the calculation incorrectly but still drew the appropriate conclusion.*

t	length of opportunity	10 years
i	cost of capital	8%
K	upfront investment	12 million
R	annual revenue	3 million
E	annual maintenance	1 million
T	final decision date	2 years
rf	risk-free rate	4%
$\sigma$	volatility of project's value	40%

$$\begin{aligned} \text{Value of investment today} &= (R - E) * [(1 - (1 / (1 + i)^t)) / i] - \text{investment} \\ &= (3 - 1) * [(1 - (1 / (1.08)^{10})) / 0.08] - 12 \\ &= 1.42 \text{ million} \end{aligned}$$

$$\text{Value of the option to wait} = S^x N(d_1) - PV(K) N(d_2)$$

$$\begin{aligned} \text{Where } d_1 &= \ln[S^x / PV(K)] / \sigma \sqrt{T} + (\sigma \sqrt{T}) / 2 \\ d_2 &= d_1 - \sigma \sqrt{T} \end{aligned}$$

$$\begin{aligned} \text{div} &= \text{free cash flow lost from delaying the decision} \\ &= (R - E) * [(1 - (1 / (1 + i)^T)) / i] \\ &= (3 - 1) * [(1 - (1 / (1.08)^2)) / 0.08] \\ &= 3.57 \text{ million} \end{aligned}$$

$$\begin{aligned} S^x &= \text{project value without div} \\ &= (R - E) * [(1 - (1 / (1 + i)^t)) / i] - \text{div} \\ &= (3 - 1) * [(1 - (1 / (1.08)^{10})) / 0.08] - 3.57 \\ &= 9.85 \text{ million} \end{aligned}$$

$$\begin{aligned} PV(K) &= \text{present value of the initial investment (at risk-free rate)} \\ &= K * (1 / (1 + rf)^T) \\ &= 12 * (1 / (1.04)^2) \\ &= 11.095 \text{ million} \end{aligned}$$

$$\begin{aligned} d_1 &= \ln[9.85 / 11.095] / (0.40 * \sqrt{2}) + (0.40 * \sqrt{2}) / 2 \\ &= 0.073 \end{aligned}$$

$$N(d_1) = N(0.073) = 0.529$$

$$\begin{aligned}
 d_2 &= 0.073 - (0.40 \cdot \sqrt{2}) \\
 &= -0.493 \\
 N(d_2) &= N(-0.493) = 0.311
 \end{aligned}$$

$$\begin{aligned}
 \text{Value of option to wait} &= 9.85 \cdot 0.529 - 11.095 \cdot 0.311 \\
 &= 1.76 \text{ million}
 \end{aligned}$$

Since the value of waiting (1.76 million) is greater than the value of the project today (1.42 million), Freesia should wait 2 years.

- (c)
- (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.

**Commentary on Question:**

*Goal was to have candidates evaluate and use simple rules of thumb. They are not as robust as other methods presented in the course of reading but are still valuable and practical. Candidates did well on this question and many provided a strong discussion of the appropriateness for Freesia in part (iii).*

(i) Hurdle rate rule of thumb is to evaluate a project with a higher discount rate. If the NPV with this higher discount rate is greater than 0, then we should invest.

(ii) Profitability index = NPV / initial investment. Invest only when the NPV of the project exceeds certain threshold percentage of initial investment.

(iii) When an investment opportunity can be delayed, it is optimal to invest only when the NPV of the investment project is sufficiently high. Rules of thumb take into account that the NPV of a project must be higher than a threshold to invest, where the NPV rule would say invest if the NPV of a project is  $> 0$ .

Hurdle rate does this by discounting at a higher interest rate than cost of capital.

Profitability index rule accomplishes this by creating a threshold amount as a % of the initial investment.

## 12. Continued

- (d)
- (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.
- (i)  $NPV(\text{hurdle}) = (\text{revenue} - \text{maintenance}) \times (1 - (1/(1+\text{hurdle rate})^{10} \text{ years}))/\text{hurdle rate} - \text{upfront investment}$   
 $(3 - 1) * (1 - 1/(1.12^{10}))/0.12 - 12 = -0.70$
- Hurdle rate calculation is  $< 0$ ;
- Freesia should not take the opportunity today.
- (ii) NPV from part (b) = \$1.42m.  
Profitability index = NPV/investment = 1.42m/12m = 0.1183  $< 1$ .
- Freesia should not invest today.
- (e) Critique the analyst's explanation for the high hurdle rate. Support your critique.

### **Commentary on Question:**

*Most candidates were able to conclude that the option to wait was the primary determinant of the high hurdle rate. If candidates did the math, they would find that the interest rate uncertainty was responsible for only 10% of the difference in costs; however, this proof was not required for full credit.*

Interest rate uncertainty is only part of the answer, but it is relatively small given how close the callable annuity rate and risk-free rates are (4.2% and 4%).

Hurdle premia are often higher than the cost of capital to reflect the value of real options in high growth firms. The hurdle rate premia is higher when:

- Cash flows / NPV dispersion is high
- Managerial constraints on investments
- Firm has many growth options and must maintain financial flexibility (high cash on hand).

These are more likely drivers of the high hurdle rate relative to the cost of capital.