CFE FD Model Solutions
Fall 2016

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:

(1a) Identify and critique the available sources of funding to start or grow a business entity.

(2b) Recommend an optimal capital structure and how to implement it for a given business strategy.

Sources:

T104-16 Jonathan Berk and Peter Demarzo, Corporate Finance, Third Edition, Ch 23: Raising Equity

N101-16 McKinsey, Capital Management: Banking's New Imperative

N108-16 Froot, Risk Management, Capital Budgeting, and Capital Structure Policy for Insurers and Reinsurers

N109-16 Trainer & Cummins, Securitization, Insurance, and Reinsurance

Commentary on Question:
This question attempted to test candidates' understanding and application of capital budgeting and management approaches, as well as the various reasons credit ratings are important for different types of companies.

Solution:

(a) Recommend a suitable capital management strategy for each of I, II, III and IV. Justify your recommendations.

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1. Continued

Commentary on Question:
Candidates did an excellent job of explaining their choices and not simply naming a strategy. Few candidates were able to correctly answer part III. Candidates did best on part IV, for which most were able to identify securitization as being the suitable strategy.

Many candidates mentioned calculating Economic Capital for parts II and III, which is not a management strategy, but a method of calculating required capital levels.

I: Equity Financing – Frenz management is concerned that additional debt could increase Frenz's leverage ratio above the threshold mandated by the conglomerate. Equity would help to reduce this ratio while raising funds to expand. Reinsurance is not suitable for Frenz.

II: Securitization – Being a P&C insurer in the marine market, their risks are large, asymmetric, and correlated, specifically their concentration in the Atlantic Ocean involving hurricanes. Blue Ocean should use insurance-linked securitization to transfer some of their risk to the capital markets, such as by setting up a SPV and issuing CAT bonds.

III: Reinsurance – Darwin's products are term insurance and universal life. These products have risks that are numerous and statistically independent with relatively small maximum probable losses. For these types of risk, reinsurance works best.

IV: Securitization – Big Ben has the expertise to complete a securitization in order to transfer the risk from its balance sheet. Big Ben can package its long term loans into high quality, high yield, and long duration securities to satisfy investor needs.

(b) Explain why Blue Ocean P&C and Darwin Life company policies require higher credit ratings than Blue Jay Air's.

Commentary on Question:
Most candidates were able to cite the importance of insurance company ratings in giving comfort to their customers of their long term financial security. Few candidates were able to get full credit, which required relating the risk an insurer's policyholder faces to the risk an investor faces. Few also mentioned that the short-term nature of Blue Jay Air's commitments (plane tickets) is not as sensitive to the credit rating.

1. **Continued**

Insurance companies like Blue Ocean and Darwin are sensitive to the level of their credit rating because their policyholders or prospective policyholders are sensitive to their financial standing. These customers face contractual performance risks that are large relative to their personal wealth, so their demand is sensitive to underwriter risk and the long term security of the company. Customer demand for an insurer's policies will fall with the insurer's rating; hence, the need for a good credit rating. Blue Jay Air has short-term commitments to its customers. Their customers are therefore less concerned about Blue Jay's credit rating.

There are also a number of reasons to believe that insurance customers act as though they are more risk averse than capital providers, such as Blue Jay's investors. The price of risk reduction for insurance is much higher relative to a portfolio of securities. Policyholders also may not be diversified with much of their wealth tied up in a single insurer because their costs to diversify are much higher than that of investors. Policyholder losses occur mainly when their wealth is low, so they can't risk an insurer not being able to pay out. There are also costs to the policyholder in dealing with an insurer failure. Insurance is also very capital intensive, requiring long term assets. Having a higher credit rating will allow an insurer to raise capital at a lower cost.

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:
(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:
N102 JP Morgan, Creating Value Through Best-In-Class Capital Allocation

N105 Graham & Harvey (Duke University), How Do CFOs Make Capital Budgeting and Capital Structure Decisions?

T102 Berk & Demarzo, Corporate Finance, 3rd Edition, Ch 18: Capital Budgeting and Valuation with Leverage

Commentary on Question:
This question tested the calculation and application of WACC. Candidates generally did okay but often forgot to fully explain the positives and negatives of equity financing for an acquisition.

Solution:
(a) Calculate the weighted average cost of capital for RPPC and Too Big Bank (Case Study Section 1.2.6). Show your work.

Commentary on Question:
Almost all candidates did well on this section.

$$r(wacc) = \frac{E}{D+E} * r(e) + \frac{D}{D+E} * r(d) * \left(1 - t(c)\right)$$

RPPC → 60%*14% + 40%*8%*(1-35%) = 10.48%

2. Continued

TooBigBank → 40%*12%+60%*3%*(1-35%) = 5.97%

(b) Assess which companies should pursue the acquisition under each funding framework by recalculating the WACC. Show your work.

Commentary on Question:
Generally strong performance though some candidates identified the better scenario instead of considering all 4 scenarios as standalone considerations.

$$r(e) = r(u) + \frac{D}{E} * (r(u) - r(d))$$

Scenario 1 for RPPC: Fund the purchase by issuing equity.
$$r(e) = 10\% + \frac{30}{70} * (10\% - 8\%) = 10.86\%$$
$$r(wacc) = 70\% * (10.86\%) + 30\% * 8\% * (1 - 35\%) = 9.16\%$$

Under this scenario RPPC should execute the transaction because r(wacc) is less than the expected return of 11% for the acquisition.

Scenario 2 for RPPC: Fund the purchase by issuing debt.
$$r(e) = 10\% + \frac{50}{50} * (10\% - 8\%) = 12\%$$
$$r(wacc) = 50\% * (12\%) + 50\% * 8\% * (1 - 35\%) = 8.6\%$$

Under this scenario RPPC should execute the transaction because r(wacc) is less than the expected return of 11% for the acquisition.

Scenario 1 for Too Big Bank: Fund the purchase by issuing equity.
$$r(e) = 10\% + \frac{50}{50} * (10\% - 3\%) = 17\%$$
$$r(wacc) = 50\% * (17\%) + 50\% * 3\% * (1 - 35\%) = 9.475\%$$

Under this scenario Too Big Bank should not execute the transaction because r(wacc) is greater the expected return of 6% for the acquisition.

Scenario 2 for Too Big Bank: Fund the purchase by issuing debt.
$$r(e) = 10\% + \frac{70}{30} * (10\% - 3\%) = 26.3\%$$
$$r(wacc) = 30\% * (26.3\%) + 70\% * 3\% * (1 - 35\%) = 9.265\%$$

Under this scenario Too Big Bank should not execute the transaction because r(wacc) is greater than 6%, its expected return for the acquisition.

2. **Continued**

(c)   Explain two factors for RPPC to consider if it decides to issue debt.

      Commentary on Question:
Many potential answers; generally well done by all candidates. Below are two POTENTIAL answers.

Increasing debt risks will put RPPC's credit rating at risk due to increased risk of financial distress.

RPPC's cost of debt is less expensive at 8% than its cost of equity of 14%, and the debt tax shield makes debt a more attractive option.

(d)   Explain two factors for RPPC to consider if it decides to issue equity.

      Commentary on Question:
Many potential answers; generally well done by all candidates. Below are two POTENTIAL answers.

Magnitude of equity under/overvaluation: RPPC could issue equity if it feels its stock is "overvalued", as this would gain it more funds to fund the acquisition.

Stock is RPPC's least risky source of funds. There is no obligation to repay stockholders like there is to repay debt holders on a periodic basis.

(e)   Explain how two of the capital allocation framework considerations can be assessed by Darwin Life in the acquisition of Rose.

      Commentary on Question:
Generally all candidates identified two benefits of the acquisition but did not mention the trade-offs that should be included in the considerations.

Competitive Advantage Period: Customers loyal to other RPPC brands might be newly attracted to Rose Health.
Competitive Advantage Period: Will Darwin's agents be able to learn the new Rose Health products?

Portfolio Fit: Health insurance diversifies the insurance risk exposure
Portfolio Fit: None of the current executives have prior health insurance experience.

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:
(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:
T105 Jonathan Berk and Peter Demarzo, Corporate Finance, 3rd Edition, Ch. 24

T110 Jonathan Berk and Peter Demarzo, Corporate Finance, 3rd Edition, Ch. 25

Commentary on Question:
This question tested candidates' knowledge of capital structure, specifically deciding whether to lease or purchase equipment, and in particular probed candidates to demonstrate nuanced understanding of lease and debt-related items in order to come to an appropriate conclusion.

Solution:
(a) Describe three reasons Blue Jay Air might choose to lease rather than purchase the new fleet.

Commentary on Question:
Most candidates were able to list at least a couple of reasons for leasing rather than purchasing, but did not adequately describe the reasons.

1. <u>Tax differentials</u>: Depreciation and interest payments often exceed lease payments. If the company leasing the planes to Blue Jay Air has a higher tax rate it can obtain the depreciation benefit and potentially pass on some of the savings to Blue Jay Air.
2. <u>Increased debt capacity / reduced distress costs</u>: Leased assets have higher priority in bankruptcy over senior debt and thus companies often get lower rates or higher borrowing capacity when leasing. Blue Jay Air currently has negative net equity, which means they may be near the limit of their debt capacity.
3. <u>Mitigating Debt Overhang</u>: Companies can invest in positive NPV projects while not giving existing debtholders claims to the leased assets in bankruptcy. The value of Blue Jay Air's liabilities is greater than its assets, indicating that debt overhang may be a problem.

3. Continued

(b) Propose two clauses that Blue Jay Air might want to include in a contract if it chooses to lease.

Commentary on Question:
Almost all candidates did well on this analysis question. The one mistake that occasionally occurred was not making sure the proposed clauses would be beneficial to Blue Jay Air.

1. <u>Right to Purchase fleet</u>: Blue Jay Air could negotiate the right to buy the planes at the end of the lease at either a specific price or at the fair market value (credit also for right to extend the lease at a certain price).
2. <u>Maintenance / Upgrade</u>: Obtain a bundled deal with supplier as planes are known for needing regular maintenance and potentially part upgrades.

(c) State one advantage and one disadvantage for Blue Jay Air for each of options I – IV.

Commentary on Question:
This question tested candidates' understanding of different types of debt, and overall most did pretty well.

<u>Private Placement</u>
Advantage: Avoid the cost of registration, thus less costly to issue.
Disadvantage: Less liquid than public debt, may not be as attractive to investors.

<u>Callable Bond</u>
Advantage: Blue Jay can refinance at a lower rate when rates go down, reducing its borrowing cost.
Disadvantage: Blue Jay must issue at a higher yield than similar non-callable bond.

<u>Convertible Bond</u>
Advantage: Blue Jay can issue at lower interest rate than non-convertible bond.
Disadvantage: If the price of the firm were to rise, the investor will convert the bond into stock and Blue Jay will have to issue new shares of stock, thereby diluting the current shareholders' share of growth.

<u>Secured Debt</u>
Advantage: Blue Jay can issue debt at a lower interest rate by reducing investor's concern of not being paid back in case of bankruptcy.
Disadvantage: Loss of cash flow from the collateral.

3. Continued

(d) Calculate the free cash flows over the next five years under both the lease and purchase options.

Commentary on Question:
Responses varied widely on this analysis question. Common mistakes included not taking into account tax savings of depreciation, failing to account for capital gains tax upon selling the fleet and various cashflow timing mismatches.

Cash Flow Items

$m		0	1	2	3	4	5
Buy							
	Capital Expenditure	($1,750.0)					
	Expected Revenue		$270.0	$270.0	$270.0	$270.0	$270.0
	Depreciation Tax Shield (@35%)		$35.0	$35.0	$35.0	$35.0	$35.0
	Maintenance Expenses		($62.0)	($62.0)	($62.0)	($62.0)	($62.0)
	Taxes (@35%)		($72.8)	($72.8)	($72.8)	($72.8)	($72.8)
	Sale						$1,400.0
	Capital Gains Tax on Fleet						($52.5)
	Free Cash Flow	($1,750.0)	$170.2	$170.2	$170.2	$170.2	$1,517.7
Lease							
	Expected Revenue		$270.0	$270.0	$270.0	$270.0	$270.0
	Lease Payments	($100)	($100)	($100)	($100)	($100)	
	Maintenance Expenses		($60.0)	($60.0)	($60.0)	($60.0)	($60.0)
	Taxes (@35%)		($38.5)	($38.5)	($38.5)	($38.5)	($73.5)
	Free Cash Flow	($65)	$71.5	$71.5	$71.5	$71.5	$136.5

3.   Continued

(e)

    (i)   Calculate the after-tax cost of debt.

    (ii)   Assess the appropriateness of using the after-tax cost of debt to discount the incremental future cash flows between the lease and purchase options.

Commentary on Question:
Almost all candidates got the first part of this analysis question, although many struggled with the second part in assessing the appropriateness of using the after-tax cost of debt.

    (i)   After-tax discount rate = RPPC Expected Return on Debt * (1 - Tax Rate) = 8% * (1 - 35%) = 5.2%

    (ii)   No matter whether Blue Jay Air chooses to lease or purchase, they will be agreeing to pay fixed obligations in the future, which is similar to taking out a loan. The interest rate on that loan will be the cost of debt, but interest payments are deductible so the effective rate would be the after-tax cost of debt.

(f)   Evaluate whether Blue Jay Air should lease or purchase the international plane fleet. Justify your recommendation.

Commentary on Question:
Most candidates understood that the difference in free cashflows between leasing and purchasing is what needed to be compared here, although some struggled to come to the correct answer even after doing the comparison.

		Year					
$m		0	1	2	3	4	5
Lease vs. Buy							
	FCF Lease	$ (65.0)	$ 71.5	$ 71.5	$ 71.5	$ 71.5	$ 136.5
	FCF Buy	$ (1,750.0)	$ 170.2	$ 170.2	$ 170.2	$ 170.2	$ 1,517.7
	Lease - Buy	$ 1,685.0	$ (98.7)	$ (98.7)	$ (98.7)	$ (98.7)	$ (1,381.2)

Based on the comparison of free cash flows, leasing is equivalent to taking out a loan of $1,685m upfront and paying back $98.7m at the end of years 1-4 and $1,381.2m at the end of year 5.

3. **Continued**

Using the discount rate of 5.2% calculated in part (c), the PV of the incremental CFs at the end of years 1-5 is only $1,420m which means that by choosing to lease, Blue Jay Air is essentially taking out a "loan" of $1,685m while only needing to pay back a present value of $1,420m.

Therefore, Blue Jay Air should elect to <u>lease</u> the new international plane fleet.

4. **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.

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

Learning Outcomes:

(2c) Design a risk management plan to optimize the risk reward trade off of employed capital.

(3c) Assess the results of a given application of stochastic modelling and calibration processes.

Sources:
T115Jonathan Berk and Peter Demarzo, Corporate Finance, Third Edition, Ch 30 Risk Management

Commentary on Question:
This question tested candidates' understanding of duration matching, asset-liability management, and portfolio construction. Many candidates performed well on this question, and in particular the first two sections that were more calculation-intensive. Candidates did not score as well on the third and fourth sections, where they were asked to apply the duration formulae to construct a portfolio and to critique a company's ALM practices. Common mistakes included buying additional assets instead of rebalancing the portfolio for the third section and not providing sufficient rationale for the critique in the fourth.

Solution:

(a) Calculate the duration of Darwin Life's shareholders' equity as of year-end 2014 (Case Study Section 7.8 – Exhibit 2). Show your work.

   Commentary on Question:
   Most candidates scored well on this part of the question. Some candidates used the book value of assets instead of the market value, resulting in incorrect values for both the market value of asset and the market value of equity. There was a discrepancy between the scale of the assets in the Case Study and the liabilities described in the question. Candidates received credit for treating the liabilities either as millions or billions, as long as the calculations were performed correctly.

4. Continued

$$Duration_{Equity} = Duration_{Assets} \left({MV_{Assets}}/{MV_{Equity}} \right) -$$
$$Duration_{Liab.} \left({MV_{Liab.}}/{MV_{Equity}} \right)$$

$$Duration_{Liab.} = 7.2 \qquad MV_{Liab.} = 9,500,000$$

To calculate the market value of assets, we must adjust the book value by the market-to-book ratios (found in the Case Study, Exhibit 2).

$$MV_{Assets} = BV_{Cash} * MV2BV_{Cash} + BV_{Bonds} * MV2BV_{Bonds} + BV_{Mort.} * MV2BV_{Mort.}$$
$$= 1,022,230 * 1 + 6,133,380 * 1.08 + 3,066,690 * 1.04$$
$$= 10,835,638$$

$Duration_{Assets}$

$$= \frac{(Duration_{Cash} * MV_{Cash} + Duration_{Bonds} * MV_{Bonds} + Duration_{Mort.} * MV_{Mort.})}{MV_{Assets}}$$

$$= {(0 + 10 * 6,133,380 * 1.08 + 6 * 3,066,690 * 1.04)}/{10,835,638} = 7.88$$

$$MV_{Equity} = MV_{Assets} - MV_{Liab.} = 10,835,638 - 9,500,000 = 1,335,638$$

$$Duration_{Equity} = 7.88 * \left({10,835,638}/{1,335,638} \right) - 7.2 * \left({9,500,000}/{1,335,638} \right)$$
$$= 12.72$$

(b)   Calculate the market value of shareholders' equity as of year-end 2014 in this scenario using the duration analysis from part (a).

Commentary on Question:
Many candidates scored well on this section. Candidates could either calculate the change in the market value of equity directly or calculate the changes in both the market value of assets and the market value of liabilities. Some candidates incorrectly used the book value of assets in the calculations for this question.

The scenario described is an up 120 bps parallel shift above an initial 3% flat yield curve. Using Macaulay durations, we can approximate the percent change in equity value using the following formula:

$$Percent\ Change\ in\ Equity = -Duration_{Equity} * \frac{\varepsilon}{1+r} = -12.72 * \frac{1.2\%}{1+.03}$$
$$= -14.819\%$$

$$MV_{Equity*} = MV_{Equity} * (1 + Percent\ Change\ in\ Equity)$$
$$= 1,335,638 * (1 - .14819) = 1,137,710$$

4. Continued

(c) Construct a compliant UL asset portfolio using Asset A and/or Asset B. Show your work.

Commentary on Question:
Candidates scored moderately well on this part of the question. This section required that candidates calculate the durations of assets A and B, identify that the ALM policy required the asset portfolio to be rebalanced, and determine the amount of the current portfolio that needed to be sold in order to purchase asset B and lengthen the asset portfolio. Many candidates did not rebalance the portfolio by selling assets in the current portfolio and buying asset B, but rather bought additional assets.

The current duration mismatch is .7 years, outside the tolerance of .5, therefore the asset portfolio needs to be rebalanced so that the new effective duration is equal to the liability duration.

The duration of Asset A is 8 years, which is below the current asset duration of 8.4. and therefore, not useful in lengthening the asset portfolio. To calculate Asset B's duration, we will use the following equation:

$$Duration = \frac{\sum PV(Cashflow_t) * t}{Price}$$

Asset B has coupons of $15 at years 5 and 10, with a coupon and principal payment of $115 at year 15. Thus, the duration is

$$Duration = \frac{15 * 1.03^{-5} * 5 + 15 * 1.03^{-10} * 10 + 115 * 1.03^{-15} * 15}{15 * 1.03^{-5} + 15 * 1.03^{-10} + 115 * 1.03^{-15}} = 13.11$$

Asset B can be used to extend the duration of the current portfolio, and we need to find the amount to exchange to fund the purchases.

$$Amount\ to\ Exchange = \frac{Change\ in\ Portfolio\ Duration * Portfolio\ Value}{Difference\ in\ Asset\ Duration}$$

To change the portfolio duration by .7 years using an asset that has duration 4.71 years (13.11 – 8.4) longer than the portfolio duration, we need to exchange

$$\frac{0.7 * \$1,929,200}{4.71} = \$286,804.5$$

4. **Continued**

(d)   Critique Darwin Life's method of asset-liability management.

Commentary on Question:
Candidates scored moderately well on this part. Some candidates did not provide sufficient justification for the points of their critique. Candidates did not need to mention all the points below to receive full credit, but did need to demonstrate a thorough understanding of Darwin's current approach and potential areas for improvement.

Darwin Life manages duration only and ignores convexity, an approach that could lead to surplus volatility and frequent rebalancing if interest rates move by large amounts, particularly since the durations are compared only semi-annually.

Duration matching only protects against parallel interest rate movements, leaving Darwin exposed to uneven movements in the yield curve. Darwin could improve their risk management by managing key-rate duration gaps.

Duration matching does not mitigate the credit spread risk faced by Darwin, a risk that could affect the assets and liabilities differently.

By rebalancing so that the effective durations of the assets and liabilities are equal, Darwin would incur more transaction costs than just rebalancing to move the asset duration inside the acceptable range. By measuring the duration quarterly and updating asset purchases accordingly, these transaction costs could be significantly decreased.

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

Learning Outcomes:
(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.

(5d)   Interpret stress-testing and back-testing results.

Sources:
T135-5 Dowd, Measuring Market Risk 2nd ed, Ch 15

T136-5 Dowd, Measuring Market Risk 2nd ed, Ch 16

Commentary on Question:
*This question tested the comprehension of the general principals and guidelines of model
risk management and backtesting using Big Ben Bank from the Case Study as an
example.*

Solution:
(a)   Describe the type of each risk model used by Big Ben Bank (Case Study Section
        6.1.3).

        Commentary on Question:
        *Most candidates were able to list and describe the types of models used by Big
        Ben Bank. Partial credit was given for just listing the model types.*

        - Mortgage Prepayment: Statistical model. This model attempts to capture the
          relationship between variables using some sort of statistical best fit, with the
          emphasis usually on the correlation between them rather than any attempt at a
          causal explanation.
        - Black Scholes: Fundamental model. This model is a formal system tying
          outputs to inputs based on assumptions about dynamic processes,
          interrelationships between variables, etc. This model attempts to explain
          cause and effect.
        - Bond price model: Descriptive model. This model is a short-cut to the
          fundamental model. It is more superficial, but often more intuitive and easier
          to work with. It is a simplified approach to explain cause and effect.

5. Continued

(b)   Critique your boss's statement.

Commentary on Question:
Most candidates were only able to offer one or two valid responses to the boss. Full credit was given to responses that adequately explained the expectations of a model and what model risk is.

A model is only a representation of something, and it should never be mistaken for what it represents. It is a highly simplified structure that we should not expect to give a perfect answer. We should expect some degree of error from a model, and we can think of this risk of error as a form of model risk.

(c)

(i)   Describe four guidelines risk managers use to manage model risk.

(ii)   Identify one good practice and one poor practice from RPPC's model risk framework (Case Study Section 1.3.10). Justify your choices.

Commentary on Question:
Most candidates were able to list and describe at least two guidelines for part (i). Full credit was given for a description of four guidelines. For part (ii), many candidates were able to fully justify their responses, while some identified a good and bad practice without adequate justification.

Part (i): Examples of acceptable guidelines:
- Be aware of model risk. Be aware of the limitations, strengths, weaknesses, and applications of the models. Make sure that the model is used for its correct purpose.
- Identify, evaluate and check key assumptions. Explicitly set out the key assumptions and evaluate the dependency of the model results on these assumptions.
- Test models against known problems. Check a model on simple problems to which one already knows the answer.
- Choose the simplest reasonable model for the task at hand. Avoid any unnecessary complexity.
- Evaluate model adequacy using back tests and stress tests.
- Estimate model risk quantitatively, where feasible.
- Don't ignore small problems. Small discrepancies are often good warning signals of larger problems that will manifest themselves later if they are not sorted out.

5. Continued

- Plot results and use non-parametric statistics. Graphical outputs can be extremely revealing, and simple histograms or plots often expose errors that might otherwise be very hard to detect.
- Re-evaluate models periodically. Recalibrate and re-estimate on a regular basis to update the models.

Part (ii):
Below are examples of Good Practices:
- Standards for vetting models. This helps to avoid common model errors.
- Documentation of a model before it is used for decision making. This helps to reduce model error.
- Production of stress testing and back testing results. This helps to ensure model fit.
- Documented limitations on the use of the model. This helps to ensure the model is used appropriately.

Below are examples of Poor Practices:
- There are too many models. This may result in excessive complexity.
- It is suggested (but not required) that a model be reviewed and signed-off before implementation. This could lead to bad models moving into production.
- Economic Capital model results are not integrated with conglomerate level results. This could lead to poor decisions on projects to fund.

(d) Determine whether the model is valid for each portfolio by conducting one-sided frequency tests. Show your work.

Commentary on Question:
Most candidates did poorly on this question. Many candidates only received partial credit for determining the validity of the model correctly but failing to show the proper work to reach that conclusion.

For Portfolio A
  $N = 200$, $p = 0.05$, $x = 5$
  H0: $p = 0.05$;
  H1: $p < 0.05$ (since $p = 5/200 < 0.05$)
  Prob$(x \leq 5) = 0.06 > 0.05$
  So, accept the null hypothesis. Pass the model as acceptable.

5. **Continued**

For Portfolio B
N=200, P= 0.05, x =16
H0: p = 0.05
H1: p > 0.05 (since p =16/200 > 0.05)
Prob(x ≥16) =1-0.96 = 0.04 < 0.05
So, reject the null hypothesis. Reject the model as credible.

(e)

(i)   Identify a limitation of the validation test used above.

(ii)   Recommend an alternative test.

Commentary on Question:
Many candidates could have improved their responses by recognizing that the size of losses in a tail event is valuable information.

Part (i)
The test focuses exclusively on the frequency of exceedances and throws away information about the size. Information about the sizes of exceedances is more reliable.

Part (ii)
Back tests based on tests of distribution equality should be used to compare predicted distributions across the whole profit/loss spectrum, or at least along the spectrum of tail losses.

6.   **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 should understand how and when to apply various advance techniques to evaluate risk or uncertainty in any business enterprise especially non-insurance organizations.

Learning Outcomes:
(1b)   Evaluate capital budgeting approaches and structure policy for insurance and non-insurance organizations.

(4c)   Apply Applied Information Economics (AIE) concepts to Enterprise Risk Management (ERM).

Sources:
T101 Jonathan Berk and Peter Demarzo, Corporate Finance, 3rd Edition, Ch. 8

T103 Jonathan Berk and Peter Demarzo, Corporate Finance, 3rd Edition, Ch. 22

T131 Hubbard, How to Measure Anything, Ch. 10

Commentary on Question:
This question tested a candidate's ability to understand and quantify the value of real options, specifically the option to abandon a particular investment, given projected cash flows.

Solution:
(a)   Describe the three types of real options that occur in capital budgeting.

Commentary on Question:
Most candidates did very well on this question. For full credit, candidates had to provide an explanation for each option rather than just listing the name.

Option to wait/delay: Allows a company to delay making an investment decision so they can obtain more information about the return, and choose the right time to invest.
Option to abandon: Allows a company to walk away and drop a project if the investment returns are suffering.
Option to expand: Allows a company to increase its investment in the project if the investment returns are acceptable.

6. Continued

(b) Evaluate the decision made to invest in the project based on NPV analysis. Show your work.

Commentary on Question:
Most candidates did very well on this question. Candidates that realized that the NPV was equivalent to $4000 payments at the end of each year saved time. Some candidates forgot to comment on the company's decision to commit to the project.

Expected cash flow at the end of each year = 0.5*2000 + 0.5*6000 = $4000
NPV should be calculated for the 3-year projection period based on WACC:
$NPV = -10000 + 4000/1.14 + 4000/(1.14)^2 + 4000/(1.14)^3$
NPV = -$713.47
The company's decision to commit was poor since the NPV is negative. If given the same choice, the company should not invest.

(c) Determine the salvage value at the end of the first year that will set the value of the option to abandon to be zero. Show your work.

Commentary on Question:
Candidates struggled on this section for two common reasons. Some candidates misread the question and didn't realize that the two potential outcomes were either cash flows of $6000 for each of the three years, or a cash flow of $2000 and then the salvage value at time 1. More commonly, candidates failed to set the weighted average of these outcomes equal to the NPV without the option from part (b) since the objective was to make the value of the option equal to 0.

NPV with option to abandon must equal the NPV without the option (-$713.47) if the option is to have no value.

If the project is a success, with probability 0.5, the NPV of the project will be:
$NPV = -10000 + 6000/1.14 + 6000/(1.14)^2 + 6000/(1.14)^3 = 3929.80
If the project fails, with probability 0.5, the NPV of the project will be:
$NPV = -10000 + 2000/1.14 + S/1.14$; where S = salvage value

$0.5*3929.80 + 0.5*(-10000 + 2000/1.14 + S/1.14) = -713.47$
S = $3294

ALTERNATIVELY: The salvage value is equal to the present value at time 1 of cash flows that are no longer realized in the case of a failure:
$S = 2000/1.14 + 2000/(1.14)^2 = 3293.32

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6. **Continued**

(d) Calculate the probability that your company's first project was a success. Show your work.

Commentary on Question:
Candidates did reasonably well on this application of Bayes Theorem, however some failed to connect the probability of success from the start of the question as being 0.5. If candidates provided the two conditional probability formulas that were needed, they received most of the points.

I = the event of investing in the second project
S = the first project was a success
S'= the first project was not a success

Pr(I) = Pr(S)*Pr(I|S) + Pr(S')*Pr(I|S')
Pr(I) = 0.5*0.7 + 0.5*0.2 = 0.45 or 45%

Pr(S|I) = Pr(S)*Pr(I|S)/(Pr(I))
Pr(S|I) = 0.5*0.7/0.45 = 0.35/0.45 = 0.7778 or 77.78%

Therefore, there's a 77.78% chance the first project was a success.

7.　**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:

(2b)　Recommend an optimal capital structure and how to implement it for a given business strategy.

Sources:

IO2-CFEFD-T109-16 Jonathan Berk and Peter Demarzo, Corporate Finance, Third Edition, Ch 17: Payout Policy

IO2-CFEFD-N106-16 Pagano, The Modigliani-Miller Theorems: A Cornerstone of Finance

IO2-CFEFD-N107-16 Villamil (University of Illinois), The Modigliani-Miller Theorem

Commentary on Question:

Candidate should demonstrate mastery of dividend policy and be able to identify agency costs. In general, candidates did well on all parts of this question.

Solution:

(a)　Describe two agency costs of retaining cash.

Commentary on Question:

Candidates did well on this part. Full credit was granted if the candidate provided two of the agency costs listed below.

Managers may use the funds inefficiently by continuing money-losing projects, paying excessive executive perks, or over-paying for acquisitions.

Unions, the government, or other entities may take advantage of the firm's "deep pockets"

Due to debt overhang problem, some of the value of retained cash will benefit the debt holders and not the equity holders if firm is highly levered.

(b)

(i)　Calculate Tulip's share price following implementation of each payout strategy.

(ii)　Determine which payout strategy is optimal in the perfect capital market conditions of Modigliani-Miller.

7. **Continued**

Commentary on Question:
Candidates scored well on this part. Full credit was granted to candidates who calculated correct share prices under each payout strategy and realized investors would be indifferent to the payout strategy under Modigliani-Miller.

(i)   Dividend payout:
With 10M shares outstanding, Tulip is expected to pay
$30M / 10M = $3M in dividends
Post-dividend share price = pre-dividend price – dividend amount
= $25 - $3 = $22

Share repurchase:
The stock price remains the same. The market value of assets falls when a company pays out cash to repurchase shares, but the number of shares outstanding also falls. The two changes offset each other, leaving the share price unchanged.
Post-repurchase share price = $25

(ii)   In perfect capital markets, investors are indifferent between the firm distributing funds via dividends or share repurchases. By investing dividends or selling shares, they can replicate either payout method on their own.

(c)

(i)   Determine which payout strategy Butch would prefer. Support your answer.

(ii)   Determine which payout strategy Butch would prefer if his dividend tax rate is the same as his capital gains tax rate. Support your answer.

Commentary on Question:
Candidates scored well on part (i) of this question. Full credit was granted to candidates who clearly pointed out the correct strategy and supported the answer with fully developed reasoning.

(i)   Share repurchase – Since the dividend tax rate is greater than the capital gains tax rate, Butch will prefer share repurchases to dividends. When the tax rate on dividends exceeds the tax rate on capital gains, shareholders pay lower taxes if the firm repurchases shares rather than pays dividends.

Alternative answer: Dividend payout - "bird in the hand fallacy" states that investors prefer current dividends to future ones.

7. Continued

    (ii)   Although tax rates are the same for both payout strategies, there is still a tax advantage for share repurchases over dividends for long-term investors because capital gains taxes are deferred until the asset is sold.

(d)   Describe how Tulip's management, acting in the interests of its long-term shareholders, would use its proposed $30 million payout to signal this information to the market.

Commentary on Question:
Candidates scored very well on this part.

Repurchase shares at current market price.
If managers are acting in the interest of long-term shareholders and are attempting to maximize the firm's future share price, they will be more likely to repurchase shares if they believe the stock to be undervalued.
Repurchasing shares when managers perceive the stock to be undervalued is a positive NPV investment for these shareholders.

(e)

    (i)   Calculate Tulip's new share price.

    (ii)   Calculate the amount gained by Tulip's remaining shareholders due to the share repurchase.

Commentary on Question:
Most candidates scored reasonably well on this part. A common mistake was incorrectly calculating the total asset value after new information. No points were deducted if an incorrect share price calculated in step (i) was used in a later step, as long as the methodology was correct.

(i)

	Before repurchase	After repurchase	After new information
Cash	30M	0	0
Other Assets	10M*$25 - 30M =220M	220M	$270M - 30M= 240M
Number of Shares	10M	10M - 30M/$25 = 8.8M	8.8M
Share price	$25	$25	**$27.3**

    (ii)   The amount gained by Tulip's remaining shareholders due to the share repurchase is $240M- $220M = $20M or ($27.3 - $25)*8.8M=20M

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

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

Learning Outcomes:
(3a) Assess the appropriateness of a given stochastic technique to quantify market and non-market risk exposures.

(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.

(3e) Explain what risk exposures are or are not identified with a given risk metric, assess implications, and recommend further action.

(5a) Evaluate the methods and processes for measuring and monitoring market risk positions.

Sources:
CFEFD-T117-16: Kemp, Market Consistency, Ch 4

CFEFD-T122-16: Korn, Monte Carlo Methods and Models in Finance and Insurance, Ch 5, Sections 5.1-5.6 (background), 5.7-5.9, 5.11, 5.14-5.19

CFEFD-N116-16: Heavy Models, Light Models, and Proxy Models

Commentary on Question:
The goal of this question was to test candidates' understanding of derivative pricing theory. Successful candidates provided explanations that fully answered the questions rather than simply listing key words.

Solution:
(a) Describe four hedging parameters (i.e. Greeks) that provide information on the sensitivity of the portfolio.

   Commentary on Question:
   Successful candidates provided both the name and the definition of four hedging parameters.

8. Continued

Delta - the rate of change of the option price with respect to the price of the underlying asset

Gamma/Convexity - the rate of change of delta with respect to the price of the underlying asset

Vega - the rate of change of the option price with respect to the price volatility of the underlying asset

Rho - the rate of change of the option price with respect to the risk-free rate

Lambda - the rate of change of the option price with respect to the dividend yield

Theta - the rate of change of the option price with respect to time

(b)

(i) Describe two major assumptions of geometric Brownian motion that violate actual stock price dynamics.

(ii) Explain why practitioners still use the Black-Scholes framework given the limitations noted in part (i).

Commentary on Question:
Successful candidates described how the major geometric Brownian motion assumptions violate actual stock price dynamics

(i) Assumption that stock price growth is log-normally distributed: One can verify that the normality of stock prices is violated by performing statistical tests.

Assumption of time-independence: Volatility is assumed to be constant over time, but in reality, volatility often fluctuates between highs and lows.

(ii) There is an analytical solution for the Black-Scholes formula which makes it convenient to calculate the theoretical price of an option.

The option price can be expressed as a function of volatility, which enhances the comparison of options across various strike prices and terms.

(c) Describe two methods of valuing path-dependent options.

Commentary on Question:
Successful candidates named the valuation method and briefly described how it is applied.

Lattice technique - place a minimum value of the option at each lattice point and discount the values utilizing risk neutral rates and probabilities.

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8.   **Continued**

Monte Carlo simulation - define a risk-neutral probability distribution, calculate the PV of the option pay-off for each sample path, and estimate the value of derivative by averaging the PVs over the entire sample.

(d)   Compare and contrast the methods to calculate VaR for standard European options and path-dependent options.

Commentary on Question:
Successful candidates described the similarities and differences between the VaR calculation methods for the two option types.

For a standard European option:
- To calculate VaR, one must know the payoff distribution at option expiry.
- Simulate the stock price at option expiry under real world scenarios to obtain the payoff distribution. (Standard European options have analytical solutions if geometric Brownian motion is the underlying stock price dynamic, so simulation is not needed.)

For a path-dependent option:
- Simulate the stock price not only at option expiry, but also at each possible exercise point using either a nested approach or least-squares Monte Carlo.
- Define the strategy for option exercise.

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:
(3a)   Assess the appropriateness of a given stochastic technique to quantify market and non-market risk exposures.

(3b)   Recommend the use of techniques that balance the reduction of computational demand versus model accuracy when applying stochastic methodology.

Sources:
T120 - Monte Carlo Methods and Models in Finance and Insurance, Chapter 3: The Monte Carlo Method: Basic Principles

T122 - Monte Carlo Methods and Models in Finance and Insurance, Chapter 5: Simulating Financial Models: Continuous Paths

Commentary on Question:
Candidates generally did well on this question. In order to receive full credit, the candidate had to demonstrate an understanding of the concepts by fully describing methods and techniques rather than just identifying them.

Solution:
(a)
(i)   Identify one advantage and one disadvantage of using the Constant Elasticity of Variance (CEV) model rather than the Black-Scholes model.

(ii)   List the steps required to price a European put option using the CEV model and Monte Carlo simulation.

Commentary on Question:
Candidates generally did well on this question. Full marks in part ii) required candidates to clearly demonstrate that the CEV model is used to simulate the stock price.

(i)   Advantage: CEV models provide a better approximation of the shape of the observed implied volatility curve than the Black-Scholes model.

Disadvantage: CEV models may not always have an easy closed form solution (e.g. $\alpha = 0.5$), but Black Scholes always does.

9. **Continued**

      (ii)   Let *B* be the option payoff, *K* be the strike price of the put option, *S* be the stock price and *r* be the discount rate

           For i = 1 to N

           Step 1: Simulate the CEV stock price paths $S^{(i)}(t)$, $t \in [0,T]$
           Step 2: Determine the option payoffs $B(i) = \max\{K - S^{(i)}(T), 0\}$
           Step 3: Calculate a Monte Carlo estimate $1/N * e^{-rT} * \text{sum}(B(i), i=1\ldots N)$
           for the option price

(b)   Critique your intern's statement.

    Commentary on Question:
    Most candidates did well on this question. The candidate had to clearly demonstrate the relationship between the number of runs and accuracy of the Monte Carlo estimator to receive full credit.

    The intern is incorrect. The Monte Carlo estimator is defined as:

$$\bar{X}_N := \frac{1}{N}\sum_{i=1}^{N} X_i, N \in \mathbb{N}$$
$$E(\bar{X}_N) = \mu$$

    The variance of the Monte Carlo estimator is then equal to:

$$Var(\bar{X}_N - \mu) = Var(\bar{X}_N) = \frac{1}{N^2}\sum_{i=1}^{N} Var(X_i) = \frac{\sigma^2}{N}$$

    Therefore, the accuracy improves at a rate proportional to $1/\sqrt{N}$. As a result, four times the number of runs would be required to double the accuracy.

(c)   Describe three variance reduction methods that can be used to improve the speed of convergence of a simulation.

    Commentary on Question:
    Most candidates did well on this question. Full marks were given for clearly explaining three variance reduction techniques. Below is a sample answer that describes three variance reduction techniques.

    Antithetic Variates: This method reduces variance by introducing symmetry. For each random number u in the simulation, create another random number 1-u. If f(u) and f(1-u) have negative covariance, variance will be reduced.

9. Continued

Control Variate: This method involves introducing a random variable Y which is close to X and for which we can compute E(Y) exactly. The relation E(X) = E(X-Y) + E(Y) motivates the following control variate Monte Carlo estimator:

$$\bar{X}_Y = \frac{1}{N}\sum_{i=1}^{N}(X_i - Y_i) + E(Y)$$

As a result,

$$Var(\bar{X}_Y) = \frac{1}{N}Var(X - Y) = \frac{1}{N}(Var(X) + Var(Y) - 2Cov(X,Y))$$

The variance will be reduced if Var(X) ≥ Var (X − Y). The amount of reduction of Var(X) is given by 2Cov(X,Y) − Var(Y).

Importance Sampling: Find a distribution that assigns a high probability to those values that are important for computing the quantity of our interest, E(g(X)).

(d)   Identify two reasons why the CEV and Black-Scholes models are not suitable for modeling interest rates.

Commentary on Question:
Candidates were generally able to identify two reasons. Below is a sample answer.

CEV and Black-Scholes are stock price models which are not suitable for modeling interest rates for the following reasons:

1. Stock prices generally increase with time, whereas interest rates tend to move around some specific level (mean reversion).

2. Interest rates are not traded, only derivatives on the interest rate are traded.

(e)

   (i)   Describe three approaches to interest rate modeling.

   (ii)   Provide an example for each interest rate modeling approach.

Commentary on Question:
Most candidates were able to identify three approaches to interest rate modelling, but many failed to clearly describe each approach in i). A common mistake in part ii) was to associate an interest model with the incorrect interest rate approach.

9. **Continued**

(i)

1. The short rate approach in which the evolution of the interest rate for loans that only last an infinitesimal time span is modelled.
2. The forward rate approach in which the evolution of the whole interest rate curve over time is modelled.
3. The market model approach in which the evolution of a finite set of simple market interest rates is modelled.

(ii)   An example of the Short Rate Approach is the Vasicek Model.
         An example of the Forward Rate Approach is the Ho-Lee Model.
         An example of the Market Model is the LIBOR Market Model.

10. **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.

Sources:
IO3-CFEFD-T121-16 Korn, Monte Carlo Methods and Models in Finance and Insurance, Section 4.4.3

IO3-CFEFD-T123-16 Korn, Monte Carlo Methods and Models in Finance and Insurance, Ch 8

IO3-CFEFD-N114-16 Ferrara & Nezzamoddini, Interest Rate Swap – Exposed

IO3-CFEFD-N116-16 Heavy Models, Light Models, and Proxy Models

Commentary on Question:
Overall, candidates did not do very well on this question. One of the key learning objectives for the exam is to apply stochastic techniques to uncertain financial outcomes. Candidates struggled most with part c, but performed relatively well on part d.

Solution:
(a) Explain whether to use real world or risk neutral scenarios for each of Step 1 and Step 3 of the EC framework.

   Commentary on Question:
   Most candidates understand the differences between real world measure and risk neutral measure, but only some were able to correctly apply the concepts to the specific EC framework presented in the question and explain the reasons.

   In step 1) of the EC framework, a real world measure is more appropriate because a real-world distribution of the liability values at year 1 is needed to calculate the EC.
   In step 3) of the EC framework, a risk neutral model is appropriate because we are valuing the liabilities in this step, and only arbitrage-free scenarios can be used to calculate market value.

10. Continued

(b)   Calculate the S&P 500 index for $T = 1/4$, 1/2 and 3/4 using the Brownian Bridge. Show your work.

Commentary on Question:
Most candidates recognized how Brownian Bridge can be used to simulate the required values, but struggled to turn the given z values from a standard normal into the required W(t) values. A few candidates did not use Brownian Bridge at all, but tried to use the geometric Brownian motion to model the movement of the index, which did not receive credit.

$B(t) \sim N(a + t/T \, (b-a), \sigma^2(t - t^2/T))$ (according to proposition 4.22 of Korn)

$B(1/4) \sim N(2000 + 0.25 * 50, 1600 * [1/4 - (1/4)^2])$
$B(1/4) \sim N(2012.5, 300)$
$(B(1/4) - 2012.5)/\text{sqrt}(300) \sim N(0, 1)$
Substituting the first z value, we have
$(B(1/4) - 2012.5)/\text{sqrt}(300) = 0.24$
$B(1/4) = 2016.8$

$B(1/2) \sim N(2000 + 0.5 * 50, 1600 * [1/2 - (1/2)^2])$
$B(1/2) \sim N(2025, 400)$
$(B(1/2) - 2025)/20 \sim N(0, 1)$
Substituting the second z value, we have
$(B(1/2) - 2025)/20 = -0.3$
$B(1/2) = 2019.0$

$B(3/4) \sim N(2000 + 0.75 * 50, 1600 * [3/4 - (3/4)^2])$
$B(3/4) \sim N(2037.5, 300)$
$(B(3/4) - 2037.5)/\text{sqrt}(300) \sim N(0, 1)$
Substituting the third z value, we have
$(B(3/4) - 2037.5)/\text{sqrt}(300) = 0.5$
$B(3/4) = 2046.16$

The above calculation involves simulation from time 0 to time 1. Candidates can also work backwards from time 1 to time 0. The z values can be used in any order.

(c)   Calculate $r_{0,0}$, $r_{1,0}$, $r_{1,1}$ and $r_{1,2}$ in Tree A derived from the B-K model, by matching the two observed bond prices. Use $x = 0.84$ as the solution to the equation $x^{1.682} + 4x + x^{0.595} = 5$. Show your work.

10. Continued

Commentary on Question:
Candidates struggled with this part. Few candidates realized that the interest rates should be solved by using the given bond prices, and a few were able to solve for $r_{0,0}$. Most candidates did not know how to convert tree A into tree B, and could not set up the correct equation to solve. A common mistake was to equate the expected value of the time 1 rates to the time 0 rate, which is incorrect.

To find the value of $r_{0,0}$, simply match the bond price at time 1:
$0.96 = \exp(-r_{0,0})$
Thus, $r_{0,0} = 4.08\%$

To find the 1-year forward bond price, we need to solve the following equation:
$P = \text{sum} (1/6 * P(\text{up}) + 4/6 * P(\text{mid}) + 1/6 * P(\text{down}))$
The relationship between x and r can be converted to: $r = \exp(x + g(t))$
Then, values $r_{1,0}, r_{1,1}, r_{1,2}$ can be written as:

$r_{1,2} = \exp[0.52 + g(t)]$
$r_{1,1} = \exp[g(t)]$
$r_{1,0} = \exp[-0.52 + g(t)]$

We need to find the value of $g(t)$ that matches the bond price at time 2.

$P(\text{up}) = \exp\{-\exp[0.52 + g(t)]\} = \exp(-1.682Y)$
$P(\text{mid}) = \exp\{-\exp[g(t)]\} = \exp(-Y)$
$P(\text{down}) = \exp\{-\exp[-0.52 + g(t)]\} = \exp(-0.595Y)$

where $Y = \exp[g(t)]$

$0.8 = 0.96*[1/6*P(\text{up}) + 4/6*P(\text{mid}) + 1/6*P(\text{down})]$
$5 = \exp(-1.682Y) + 4 * \exp(-Y) + \exp(-0.595Y)$
Thus $\exp(-Y) = 0.84$
$Y = 0.174$
$r_{1,2} = 1.682 * 0.174 = 0.293$
$r_{1,1} = 0.174$
$r_{1,0} = 0.595 * 0.174 = 0.104$

Note: points were awarded if the interest rates were treated as annual effective.

(d)

    (i)   Evaluate the appropriateness of each graph as the fitting space for Step 2 of the EC framework.

    (ii)   Recommend the most appropriate fitting points for fitting the spaces in Step 2 of the EC framework.

10. Continued

Commentary on Question:
Candidates did relatively well in this part. Most candidates were able to describe the characteristics of the first three graphs and evaluate their appropriateness, although some candidates did not make the right choice between I and II (incorrectly picked randomness as the more important criteria over an even coverage of the fitting space to ensure a good fit). However, very few candidates were able to recognize the importance of graph IV and correctly explain why it's not appropriate specifically for LSMC.

I. is randomly generated. It has points more concentrated in some areas, and some areas do not have enough points. It's not appropriate since we may be missing fitting points in some areas, which is especially concerning in the extreme scenarios, where we are the most interested for the EC framework.

II. is pseudo random, evenly distributed across the entire fitting space, and ensures that we have a good fit in all regions of the fitting space.

III. is generated from a normal distribution for both risk factors. It'll give results to a weighted least square fit, which gives more weight to the fitting points towards the mean of the distribution, and leads to sub-optimal fit in the extreme scenarios.

IV. is the intersections of the roots of the 2nd order Legendre polynomial. Using these 4 points is a precise interpolation instead of a regression. This would work if the 4 fitting points are valued rigorously through the original heavy model to produce accurate results. But for LSMC, since each fitting point is very inaccurate (using only 2 scenarios to value each fitting point), the process is dependent upon the use of a large number of fitting points, so that the inaccuracies "average out" to produce an accurate proxy function.

The recommended fitting points are those in graph II.

(e) Recommend a change to the calibration method to improve the fit of the proxy model. Justify your recommendation.

Commentary on Question:
Candidates performed satisfactorily on this part. As the question is quite open, many candidates were able to describe some way in which the fit can be potentially improved in the tails.

10. Continued

Many reasonable answers received points, including:
- Since the CEO is concerned with the fit in the extreme scenarios, use more fitting points in the tail region in order to improve the fit there.
- Include higher order terms involving the two risk factors in the proxy model to better capture the behavior of the heavy model in the tail.
- Use more intuitive proxy models such as replicating portfolios, which are expected to behave broadly sensibly outside of their "reliable range".

11.

Learning Objectives:

4. The candidate should 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:

(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.

(5c) Design and evaluate stress-testing and back-testing processes.

Sources:

CFEFD-T128-16 Hubbard, How to Measure Anything, Ch 7

CFEFD-T134-16 Dowd, Measuring Market Risk 2nd ed, Ch 13

Commentary on Question:
Candidates generally performed satisfactorily on this question. Most candidates fell short on part b. Candidates generally performed well on the other sections.

Solution:

(a) List the three reasons why information has value to a business.

Commentary on Question:
This question is a simple retrieval question, in which most candidates performed well.

- Information reduces uncertainty about decisions that have economic consequences.
- Information affects the behavior of others, which has economic consequences.
- Information sometimes has its own market value.

(b) Recommend whether or not to proceed with the consultant's proposal. Show your work.

Commentary on Question:
Candidates performed poorly on this question. Most candidates did not use all the information provided in the question to arrive at the correct solution. For example, most did not use the EVPI and EOLF to calculate the bond sold at a 90% confidence level.

11. Continued

EVPI = (EOLF/1000) * (Opportunity Loss per Unit) * (Best Bound - Worst Bound)

Let X = Worst Bound
EOLF = 23
Opportunity Loss per Unit = $500
EVPI = $125,000

$125,000 = (23/1000) * ($500) * (1.5 X - X)
X = Worst Bound = 21,739 bonds sold
Best Bound = Worst Bound * 1.5 = 21,739 * 1.5 = 32,609 bonds sold

Administrative cost = $150,000
Capital raised from bond offering is between (21,739 * $500 - $150,000) and (32,609 * $500 - $150,000)
Capital raised from bond offering is ~10.7 million to ~16.2 million (with 90% certainty).

Recommend NOT proceeding with consultant's plan because the capital range falls short of the $16.5 million needed to purchase the new technologies.

(c)

    (i)   Identify four relevant considerations in developing a stress test for this situation based solely on the information provided above.

    (ii)   Design an appropriate stress test.

    (iii)   Justify the type of stress test and the rationale of the design in (ii).

Commentary on Question:
Candidates performed satisfactorily on this question. Candidates often considered only the model aspects of stress tests but not any other considerations in developing a stress test. Most candidates recommended an appropriate stress test.

    (i)
- The type of event (viability is contingent on the success of the bond offering)
- The type of risk involved (market demand for the company's debt)
- The country or region (company is a multi-national retailer)
- The stress test methodology (scenario analysis)
- The model assumptions (various possibilities, including probability of successful bond offering, certainty level, etc.)
- The instruments concerned (the use of bonds)
- The level of the test (business unit / balloon division level)

11. Continued

(ii) and (iii):

<u>Type of stress test:</u>

Scenario (or 'what if') analysis, evaluating the impact of specified scenario(s). Emphasis on specifying a scenario and working out its ramifications.

<u>Stress test:</u>

Look at similar (actual) historical events, such as success of past company bond offerings or results from other companies. Consider how the consultant calibrated to a 90% certainty level. Choose the least successful bond offering scenario for stress test, e.g. what if bond offering is at or near the lowest level in the past; what if bond issuing cost is at historical high; what if credit rating hits historical low, etc.

<u>Rationale:</u>

Scenario analysis that is based on historical events is plausible and easy to understand.

Other answers are also acceptable, as long as they are reasonable and relevant.

12. **Learning Objectives:**

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

Learning Outcomes:

(4b) Evaluate the use of cost of capital frameworks for micro and macro level risk assessment.

Sources:

CFEFD-N118-16 Manistre, Down but not Out: A Cost of Capital Approach to Fair Value Risk Margins

CFEFD- N120-16 CRO Forum, Market Cost of Capital Approach to Market Value Margins

Commentary on Question:
Stronger candidate responses went beyond generic answers and considered the attributes of Daisy in their remarks.

Solution:

(a) Describe the Market Cost of Capital approach.

Commentary on Question:
Candidate should demonstrate awareness that this approach is a market consistent way to view the balance sheet, while also addressing how to account for non-hedgeable risks.

The Market Cost of Capital views both assets and liabilities on a market consistent basis. The market value of liabilities (MVL) includes the present value of liability cash flows as well as a margin for non-hedgeable risks. Capital calculated using this approach is sufficient to run off the business.

MVA = MVL + SCR

(b) Outline a response to address the CIO's concerns.

Commentary on Question:
Candidates should emphasize why the MCoC approach is simpler, clearer, widely used, and easily adaptable in responding to the CIO's concerns.

The MCoC approach is simpler to implement and does not require stochastic on stochastic calculations. MCoC is also easier for small companies, like Daisy to adopt because simplifying assumptions can be used. The standard SCR approach which is used in many companies can be leveraged as well. MCoC has been used industry-wide for many years and passes the "use test."

12. Continued

(c)

    (i)   Explain the three-step process Daisy would use to model the capital required for non-hedgeable risks.

    (ii)   Explain the circularity problem when estimating non-hedgeable parameter risk.

    (iii)   Recommend a method Daisy can use to address the circularity problem.

Commentary on Question:
Very few candidates were able to identify the 3 steps for part (i). Full credit was given for part (ii) if a reasonable explanation was given as to how assumption uncertainty leads to additional reserves, which in turn can also be incorrect. Candidates received credit for generally describing short cut methods or describing a specific method in part (iii), but most candidates did not provide a specific method.

    (i)
- Develop a best estimate model appropriate for Daisy.
- Hold a static margin for a contagion risk (the risk that current experience is different from the best estimate).
- Add a dynamic margin for parameter risk (the risk that the best estimate is wrong).

    (ii)   The initial reserve is calculated based on uncertain assumptions. Then another reserve is calculated based on a shocked assumption, which could also be wrong. This would require another reserve calculation, and would go on indefinitely.

    (iii)   Daisy can use the simple mean method. This method avoids stochastic on stochastic calculations by assuming the shock to the chosen parameter evolves at a certain rate to an ultimate level. Valuation scenarios then are based on the shocked parameter and scaled risk loading.

(d)

    (i)   Calculate the mortality risk margin at year 0.

    (ii)   Calculate the capital for the mortality risk margin at year 0.

Commentary on Question:
Candidates needed to use the prospective method for (i). An incorrect margin calculation in (i) was not a bar to receiving credit for (ii) if expressed correctly.

12. Continued

    (i) $M_t(1+i) = (1-q)M_{t+1} + \pi[V_1-V_0-(1-\alpha)M_t]$
                 $M_0*1.04 = (1-.00157)*.98 + .06*[91.25-83-.5*M_0]$
                 $M_0 = [(1-.00157)*.98 + .06*(91.25-83)]/1.07$
                 $M_0 = 1.38$

    (ii)   Capital $= V_1-V_0-(1-\alpha)M$
                 Capital $= 91.25 - 83.00 - (1-0.5)(1.38) = 7.56$

13. **Learning Objectives:**

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

Learning Outcomes:

(4c) Apply Applied Information Economics (AIE) concepts to Enterprise Risk Management (ERM).

Sources:

CFEFD-T129-16 Hubbard, How to Measure Anything, Ch 8

CFEFD-T130-16 Hubbard, How to Measure Anything, Ch 9

Commentary on Question:

The key to this question was for the candidate to understand the teachings of the Hubbard text. You don't need infinite observations and you should think about what is appropriate before just applying some methodology.

Solution:

(a) Discuss characteristics of sample data that warrant the use of the t-distribution versus the normal distribution in calculating confidence intervals.

Commentary on Question:

Most candidates did well on part (a) by identifying issues of sample size.

The t-distribution should be used when sample sizes are low (n<30), and the normal distribution should be used when sample sizes are high (n>30). Both distributions should only be applied to normally-distributed population samples.

(b) Calculate the 90% confidence interval.

Commentary on Question:

In general, candidates calculated the mean correctly. Common errors included incorrectly calculating the standard error, or using the wrong t-factor or normal factor. Some candidates would have benefited from performing a reasonableness check on their responses.

Mean = (2+9+7+8+6+7+3+10)/8 = 6.5

Sample Variance = $((2-6.5)^2 + (9-6.5)^2 + (7-6.5)^2 + (8-6.5)^2 + (6-6.5)^2 + (7-6.5)^2 + (3-6.5)^2 + (10-6.5)^2) / (8 - 1) = 7.7143$

Standard Error = $(7.71/8)^{1/2} = 0.982$

13. Continued

Using the t-score of 1.89 from the table provided, the answer is then
6.5 +/- 1.89*0.982 = [4.6, 8.4].

(c) Approximate the 90% confidence interval for sick days using the Mathless approach and the sample data above.

Commentary on Question:
Most candidates did well on part (c).

With a given sample size of 8, the mathless approach would approximate with the 2nd highest and 2nd lowest values for a 90% confidence interval, which would be (3, 9).

(d)

(i) Describe differences between using the t-distribution and the Mathless approach for determining confidence intervals.

(ii) Describe a common drawback shared by using the t-distribution, normal distribution, and the Mathless approach for determining confidence intervals.

Commentary on Question:
Most candidates did well on part (i), but not on part (ii). Some stated that sample size is an issue with all approaches, but did not go further to explain that prior knowledge about sick days experience is ignored.

Part (i) had several appropriate responses that candidate could have mentioned, including:

I. Mathless approach estimates the "median" of the population, while t-distribution estimates the "mean".
II. The Mathless approach, since it estimates the median, completely avoids the problem of nonconverging estimates, i.e. it works in cases which might be problematic for the t-distribution method, such as when the population follows a power law.
III. The Mathless approach always provides possible values of the median, while it's possible that the lower bound may be a nonsensical negative value under the t-distribution method.
IV. T-distribution method is parametric and Mathless approach is nonparametric.

13. Continued

The drawback of using either the t-distribution or Mathless approach is that both ignore any prior knowledge about the incidence of sick days. Both approaches rely only on the sample data, which could lead to incorrect or non-intuitive results.

(e) Recommend which method works best among normal distribution, t-distribution and the Mathless approach. Support your recommendation.

Commentary on Question:
Some candidates said a normal distribution would be best, which is not appropriate given the low sample size. Most candidates merely stated their recommendation with adequate explanation or justification.

Mathless approach would be the best option because the data is a non-converging sample. The 90% confidence interval for the estimate of the average health claim cost does not necessarily get narrower as sample size increases.