

CFE FD Model Solutions

Spring 2015

1. 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.

Learning Outcomes:

- (2a) Evaluate how the legal form of an organization, corporate governance and/or compensation dynamics impact decision-making on projects or business activities.
- (2b) Describe the factors impacting short-term capital needs.
- (2e) Describe considerations for the risk borne by capital employed.
- (2g) Evaluate human behavioral biases in the decision making processes.

Sources:

Jonathan Berk and Peter Demarzo, Corporate Finance, Third Edition, Ch 2

F-115-14 McKinsey, Overcoming a Bias against Risks

Commentary on Question:

Commentary listed underneath question component.

Solution:

- (a) Evaluate the change in CW's liquidity from 2012 to 2013. Support your evaluation.

Commentary on Question:

Liquidity ratios were expected to support the analysis part of the question. Most candidates were able to identify the deterioration of the company's liquidity and received partial credit.

Quick ratio: ratio of cash and "near cash" assets (short-term investments and accounts receivable) to current liabilities.

2012 quick ratio = **0.528** = $(50+900) / (1000+300+500)$

2013 quick ratio = **0.353** = $(30+800) / (1200+500+650)$

1. Continued

Cash ratio: ratio of cash assets to current liabilities

2012 cash ratio = **0.028** = (50) / (1000+300+500)

2013 cash ratio = **0.013** = (30) / (1200+500+650)

The liquidity measures have deteriorated. The firm may have liquidity concerns that it is not able to generate positive cash from operating and investing activities

(b)

(i) Calculate the cash generated by CW from its operating activities in 2013. Show your work.

(ii) Calculate the change in CW's retained earnings from 2012 to 2013. Show your work.

Commentary on Question:

Candidates did poorly on this analysis question. Very few candidates received full credit for part (i). Many candidates did not recognize the change in accounts receivable and accounts payable. A common error was not to include depreciation. For part (ii), some candidates only calculated the retained earnings for 2013, but forgot to complete the change in retained earnings part.

(i) Calculate cash generated from 2013 operating activities.

Operating Activities

+200: Net income adjusted by all non-cash items related to operating activity

+160: Depreciation and amortization added back to net income

+100: Increase of accounts receivable deducted from net income

+200: Increase of accounts payable added back to net income

-200: Increase of inventory deducted from the net income

= **460**: Cash from operating activities

(ii) Calculate the change in retained earnings from 2012 to 2013.

Retained Earnings = Net Income - Dividends

Retained Earnings in 2012 = 190 - 0 = 190

Retained Earnings in 2013 = 200 - 100 = 100

The change in Retained Earnings from 2012 to 2013 = 100 - 190 = **-90**

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

1. Continued

Commentary on Question:

Candidates generally did well on this retrieval part of the question. A common error was to state the policy without any explanation. Three answers were needed for full credit.

Up the ante on risk projects

Ask managers for project ideas that are risky but have high potential returns. Require managers to submit each investment recommendation with a riskier version of the same project with more upside

Consider both the upside and downside

Executives should require that project plans include a range of scenarios or outcomes that include both failure and success.

Avoid overcompensating for risk

Managers should pay attention to the discount rates to evaluate projects. Higher discount rates for relatively small but frequent investment do not make sense once projects are pooled at a company level.

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.

Learning Outcomes:

- (1d) Assess whether the risky return from a new project or ongoing business is sufficient to employ investor capital
- (1e) Evaluate the return on employed capital using NPV, IRR and Payback period.
- (1g) Describe the methods of allocating risk capital.

Sources:

Corporate Finance 3rd edition, Chapter 7: Investment Decision Rules

F-101-13: Capital Allocation in Financial Firms

Commentary on Question:

Candidates generally did well on this question.

Solution:

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

Commentary on Question:

Most candidates did well on part (a). A common error was to recommend payback period as an alternative to IRR. Alternate solutions received full credit.

- (i) “Delayed Investments” - The IRR rule is only guaranteed to work for a stand-alone project if all of the project’s negative cash flows precede its positive cash flows.
“Multiple IRRs” – Sometimes multiple IRRs can exist, depending on projected cash flow patterns.
- (ii) Should incorporate NPV rule since it is the most accurate and reliable decision rule. Could incorporate a Profitability Index to help make investment decisions under resource constraints. Need to ensure that hurdle rates reflect risk premiums and costs of risk capital.

2. Continued

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

Commentary on Question:

Most candidates earned full credit for parts (i) and (ii). Nearly half of candidates gave incorrect answers for the qualitative statements and calculations for part (iii). A common mistake was to use an economic profit of 0 as the break-even point.

- (i) LLL (excl ULSG): $40 - 0.25 \cdot 100 = 15$ (profitable). ULSG: $5 - 0.25 \cdot 40 = -5$ (unprofitable)
 - (ii) Diversification across business units with imperfectly correlated profit streams can reduce a company's deadweight cost of risk capital. Can reduce required rates of return for investment projects. Can increase firm value. The value-maximizing amount of risk capital for diversified firms is less than the sum of the capital requirements for each of the businesses operated on a stand-alone basis.
 - (iii) LLL will be indifferent in its decision if its economic profits net of deadweight cost of capital remain unchanged after moving forward with the ULSG product. $45 - 0.25 \cdot x = 15 \rightarrow x = 120$, where x represents combined economic capital requirements after diversification effects. Diversified economic capital requirements need to be 20 less than the sum of stand-alone requirements in order for LLL to be indifferent in its investment decision.
- (c) Recommend whether or not LLL should proceed with the ULSG product offering. Justify your recommendation.

Commentary on Question:

Most candidates arrived at correct calculations along with right recommendation. An alternative solution of comparing total economic capital given ($100 + 15 = 115$) to the break-even point calculated in b(iii) also received full credit.

2. Continued

Total expected economic profits net of deadweight costs = $45 - 0.25 \cdot 115 = 16.25$.

The addition of the ULSG product results in an increase in net profits of 1.25, from 15 to 16.25, so the recommendation is to proceed.

3. 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.

Learning Outcomes:

- (1e) Evaluate the return on employed capital using NPV, IRR and Payback period.
- (1f) Apply real options analysis to recommend and evaluate firm decisions on capital utilization.

Sources:

Corporate Finance, Ch 18, Capital Budgeting with Valuation and Leverage

Corporate Finance, Ch 22, Real Options

Commentary on Question:

Most candidates arrived at correct answers by applying the correct WACC formulas and valuing the project and options. Some candidates mistakenly used the book value for WACC calculation and discounted incorrectly.

Solution:

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

Commentary on Question:

A common mistake was to use book values instead of market values. Partial credit was given for the correct WACC formula and calculation, and also for using net-of-cash debt values.

$$\begin{aligned} r_{WACC} &= E/(E+D) \times r_E + D/(E+D) \times r_D \times (1 - \text{marginal tax rate}) \\ &= 80/(80+20) \times 12\% + 20/(80+20) \times 5\% \times (1-35\%) = 10.25\% \end{aligned}$$

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

Commentary on Question:

Most candidates provided correct formula and calculations, while some candidates did not increase year-two FCF of \$10M by 2% for FCF(3) and did not subtract the initial investment or discount time value.

$$\begin{aligned} \text{Terminal value for FCF year 3+ (@the end of year 2) is:} \\ \text{FCF(3)} / (\text{WACC} - g) &= 10 \times (1+2\%) / (10.25\% - 2\%) = \$123.64\text{m} \\ \text{Value of the project} &= \text{PV of FCFs discounted at WACC} \\ &= -30 + 5/(1+10.25\%) + (10+123.64)/(1+10.25\%)^2 = \$84.48 \text{ million} \end{aligned}$$

3. Continued

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

Commentary on Question:

Nearly half of candidates used the correct formula for equity cost of capital which lead to the right WACC calculation. Some candidates didn't correctly calculate r_u based on the 2 comparables given. If r_U is based on only one of the comparables with a reason given, full credit was awarded.

Calculate the unlevered cost of capital for the two comparable companies:

$$\text{Comparable 1: } r_U = E/(E+D) * r_E + D/(E+D) * r_D = (1-50\%)*15.5\% + 50\%*7.5\% = 11.5\%$$

$$\text{Comparable 2: } r_U = E/(E+D) * r_E + D/(E+D) * r_D = (1-20\%)*13\% + 20\%*6.5\% = 11.7\%$$

Take the average of the two, the unlevered cost of capital is: $r_U = 11.6\%$

$$\text{Equity cost of capital } r_E = r_U + D/E*(r_U - r_D) \\ = 11.6\% + 2 * (11.6\% - 5\%) = 24.8\%$$

$$r_{WACC} = E/(E+D) * r_E + D/(E+D) * r_D * (1 - \text{marginal tax rate}) \\ = (1 - 66.67\%) * 24.8\% + 66.67\% * (5\%) * (1 - 35\%) = 10.43\%$$

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

Commentary on Question:

Most candidates received full credit for part (i). When calculating the NPV of the expansion option, common errors included incorrect discounting and using WACC instead of the risk free rate in discounting.

The board member's comment is incorrect since it ignores the option for future expansion if it turns out to be a success.

$$\text{NPV (tripling if successful)} = \text{Incremental FCF (1)} / r - \text{Additional Investment} = \\ 400 / 0.03 - 4000 = 9,333.33 \text{ million}$$

$$\text{PV(Expansion option)} = \text{NPV (tripling if successful)} * p / (1 + r) = 9333.33 * \\ 30\% / 1.03 = 2,718.45 \text{ million}$$

3. Continued

NPV (without expansion option) = $FCF(1) / r * p - \text{Initial Investment} = 200 / 0.03$
 $* 30\% - 2500 = -500$ million

Value of the Projection = NPV (without expansion option) + PV(Expansion
option) = $-500 + 2718.45 = \$2,218.45$ million or \$2.22 billion

4. 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) Explain the mathematical foundation of stochastic simulation.
- (3c) Recommend the use of techniques to reduce the computational demand when applying stochastic methodology.

Sources:

Huynh Ch 7, Introduction to Random Processes

Dowd Ch 8, Monte Carlo Simulation Methods

Dowd Ch 9, Applications of Stochastic Risk Measurement Techniques

Commentary on Question:

Most candidates did well on part (a) and (d). Most candidates struggled with the discrete-formula of geometric Brownian motion for the terminal stock price on part (b) and assessing shortcomings in the fixed-income portfolio modeling process on part (c).

Solution:

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

Commentary on Question:

Full credit was awarded for identification by elimination with proper reasoning. Figure 2 is log function and Figures 3 and 4 are SIN/COS functions.

Figure #1 represents S&P return.
Figure #1 exhibits a random process.

- (b) Calculate the terminal stock price.

Commentary on Question:

Most candidates didn't correctly apply the geometric Brownian motion formula to solve for μ and σ . Partial credit was given for calculating $S(t)$ even if used the wrong μ and σ .

Rewrite the equation $S(t+\Delta t) = S(t) \cdot (1 + \mu \cdot \Delta t + \sigma \cdot \phi \cdot \sqrt{\Delta t})$, then

$$S(1) = S(0) \cdot (1 + \mu + 0.1168 \cdot \sigma)$$

$$S(2) = S(1) \cdot (1 + \mu + 0.4779 \cdot \sigma)$$

Solve for $\mu=0$ and $\sigma=0.25$.

$$\text{Then } S(t) = S(t-1) \cdot (1 + \mu + 0.2440 \cdot \sigma), S(t) = 1.1006$$

4. Continued

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

Commentary on Question:

Most candidates performed poorly on part (c). Some candidates identified Brownian motion as inappropriate. Very few mentioned that term structure is needed.

1. Identification: Brownian process is not the best choice for fixed income [or interest rate] process.
Assessment: Interest rates are usually modeled as mean reverting.
Assessment: Cox-Ingersoll-Ross process is a better [or popular] option.
2. Identification: Need information about the spot rate term structure.
Assessment: The portfolio consists of various coupon-paying bonds. Need to model the term structure.
3. Geometric Brownian Motion is not a Martingale process; normal Brownian motion is. (Step 1)
4. Starting spot rate should be the same for all paths, not varying by simulation. (Step 3)

- (d)

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

Commentary on Question:

Most candidates suggested the correct variance reduction techniques with supporting explanations.

- (i) Project I: Recommend Control Variate Technique.
Project II: Recommend Importance Sampling Technique.
- (ii) Control Variates - used to price a derivative with no analytical solution where there exists some similar derivative that has a closed-form solution. The control variate estimate of the European call price is $f_A = f_A^{\text{MCS}} - f_B^{\text{MCS}} + f_B$.

Importance Sampling - Sample only from the paths where the option ends up in the money. If F is the distribution function for the underlying and p is the probability of the option ending up in the money, work with $G=F/p$.

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 will understand how to critique the appropriateness of advanced risk assessment methods for a given situation.

Learning Outcomes:

- (3g) Explain the benefits and limitations of Value-at-Risk, Incremental Value-at-Risk, Component Value-at-Risk, and Expected Shortfall as tail risk measures.

Pricing

- (4a) Apply and interpret the results of equilibrium pricing and no-arbitrage pricing theory to risk valuation.

Sources:

Artzner, Application of Coherent Risk Measures

Panjer, Ch 5, No-Arbitrage Pricing Theory

Commentary on Question:

Commentary listed underneath question component.

Solution:

- (a) Calculate the VaR(95) and CTE(95) at the end of the year for each of the four investments: A, B, C, and D.

Commentary on Question:

Many candidates received full credit for this question. Full credit was granted for alternative answers that used relative VaR and relative CTE.

VaR(95):

Investment A VaR(95): **0**

Investment B VaR(95): **50**

Investment C VaR(95): **10**

Investment D VaR(95): **0**

CTE(95):

Investment A CTE(95): $100 * 4\% / 5\% = 80$

Loss distribution of Investment B:

0, with probability $0.96^2 = 0.9216$

200, with probability $0.04^2 = 0.0016$

100, with probability $1 - 0.9216 - 0.0016 = 0.0768$

Investment B CTE(95) = $((0.05 - 0.0016) * 50 + 0.0016 * 100) / 0.05 = 51.6$

5. Continued

Investment C CTE(95): **10**

Investment D CTE(95): $300 * 0.2\% / 5\% = 12$

- (b) Contrast the use of VaR and CTE for evaluating the following:
- (i) Risk concentration for Investments A and B.
 - (ii) Tail risk for Investments C and D.

Commentary on Question:

Few candidates were able to step back from the results and compare the risks behind each pair of investments versus what VaR and CTE conveyed.

Investments A & B:

The two investments are identical, except that Investment A invests in one bond while Investment B invests in two identical and independent bonds. Investment A has higher concentration risk.

VaR suggests Investment A is less risky, and that diversification increases risk. CTE correctly points out that Investment A is riskier. VaR does not address risk concentration properly.

Investment C & D:

The two investments have the same PV. However, Investment D has extreme loss at its tail. Investment D is at least as risky as investment C because of its magnitude of loss.

VaR suggests that there is no risk for investment D, which is incorrect. VaR tells us the maximum loss at 95% confidence, but it does not provide any information beyond the 95% confidence level. Investment D has an extreme loss that VaR isn't able to measure. CTE is able to capture the tail risk of Investment D.

- (c) Critique the student's statement. Support your critique.

Commentary on Question:

Many candidates were able to identify the fact that insurance risk and default risk are two different risks that can't be hedged by each other. There are other problems with the student's statement. However, few candidates could identify the problems other than the basis difference described above.

- For an instrument to perfectly offset a liability, the instrument has to be the liability itself or its derivative. Default of Investment A is mostly likely, if not totally, independent to the insurance liability.

5. Continued

- Interest rate derived from market price of Investment A reflects credit risk, liquidity margin, buy-sell spreads and other margins of Investment A, which may not be suitable to discount the insurance liability. Selection of interest rate for an insurance liability should reflect its risk and purpose.
- No-arbitrage pricing theory requires investments to be available in the market so that a replicating portfolio can be constructed. Liability of life insurance contract is likely not to be available in the market. So, this method won't work.
- The timing of the insurance liability payment is unknown, unlike the known payoff period of ZCB.

6. 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) Assess the appropriateness of a given stochastic simulation technique to quantify various market risk exposures.
- (3e) Interpret the results of a given application of stochastic modeling and the impact of the chosen calibration process used.
- (3g) Explain the benefits and limitations of Value-at-Risk, Incremental Value-at-Risk, Component Value-at-Risk, and Expected Shortfall as tail risk measures.

Sources:

Dowd, Ch. 2, Measures of Financial Risk

Dowd, Ch. 4, Non-parametric Approaches

Dowd, Ch. 16, Model Risk

Huynh, Ch. 14, Risk Management and VaR

Hardy, Ch. 3, Maximum Likelihood Estimation for Stock Return Models

Commentary on Question:

Commentary listed underneath question component.

Solution:

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

Commentary on Question:

Very few candidates identified that ROSY is a spectral risk measure. Credit was awarded for alternative answers that correctly referred to ROSY as a linear combination or sum of coherent risk measures.

The weights given to higher losses are weakly increasing (the applied weights are 0 for $0 < p < 0.9$, 5 for $0.9 < p < 0.98$, and 30 for $0.98 < p < 1$).

ROSY is a spectral risk measure and thus coherent since all spectral risk measures are coherent.

6. Continued

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

Commentary on Question:

Candidates generally performed well in this section. In section (ii), a common error was to discuss advantages and disadvantages of ROSY, which was not what the question is asking. Correct alternative answers received full credit.

$$\text{CTE}(90\%) = (550 + 485 + 434 + 408 + 403 + 367 + 327 + 266 + 265 + 249)/10 = 375.4$$

$$\text{CTE}(98\%) = (550 + 485)/2 = 517.5$$

$$\text{ROSY} = (\text{CTE}(90\%) + \text{CTE}(98\%))/2 = (375.4 + 517.5)/2 = 446$$

Advantages:

- Simple to implement in spreadsheet
- Simple to explain to town council

Disadvantages :

- Does not allow for more extreme events than those observed (black swans)
- Subject to ghost effects in the future as top 10 snowfall events fall outside 100-year sample period

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

Commentary on Question:

Many candidates were able to calculate ROSY using the delta-normal approach. However, candidates did not perform well in part (ii). For part (ii), candidates who received full credit were able to use data provided by the question to support their reasoning.

$$(i) \quad \text{CTE}(90\%) = 99 + 112 * 1.755 = 295.56$$

$$\text{CTE}(98\%) = 99 + 112 * 2.421 = 370.15$$

$$\text{ROSY} = (\text{CTE}(90\%) + \text{CTE}(98\%))/2 = (295.56 + 370.15)/2 = 332.86$$

6. Continued

- (ii) 5% of historical observations are above 370, the model average of the worst 2%.

The data exhibits a fatter tail than a normal distribution can provide. Using the delta-normal method will underestimate the risk measures of fat-tailed distributions.

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

Commentary on Question:

Candidates generally performed well on part (d).

- (i) $l(\lambda) = \text{Sum from } i = 1 \text{ to } 100 \text{ of } \log f(x(i))$
 $= \text{Sum from } i = 1 \text{ to } 100 \text{ of } \log \lambda e^{-\lambda x(i)}$
 $= \text{Sum from } i = 1 \text{ to } 100 \text{ of } [(\log \lambda) - \lambda x(i)]$
 $= 100 \log \lambda - 9900\lambda$ (since average of $x(i)$ is 99)
 $l'(\lambda) = 100/\lambda - 9900$
Setting $l'(\lambda)$ to 0 yields parameter estimate $\lambda^* = 100/9900 = 1/99$
- (ii) $\text{CTE}(90\%) = (1 - \log(1 - 0.9))(1/(1/99)) = 99(1 - \log(0.1)) = 327.3$
 $\text{CTE}(98\%) = (1 - \log(1 - 0.98))(1/(1/99)) = 99(1 - \log(0.02)) = 486.8$
 $\text{ROSY} = (\text{CTE}(90\%) + \text{CTE}(98\%))/2 = (327.3 + 486.8)/2 = 407$
- (e) Explain why using the mixed exponential distribution will cause ROSY to increase compared to the result from (d)(ii).

Commentary on Question:

Few candidates realized that by randomizing one of the parameters of a distribution, overall variability increased.

Introducing a mixing variable increases the uncertainty and widens the probability distribution. This will cause the CTE calculations to produce higher results and ROSY to increase.

6. Continued

- (f) Describe the directional impact moving from 100 years to 50 years of calibration has on ROSY for each of the following approaches. Justify each answer.
- (i) The non-parametric approach in (b)
 - (ii) The exponential parametric approach in (d)
 - (iii) The mixed exponential parametric approach in (e)

Commentary on Question:

Most candidates did well on part (i) and (ii) but poorly on part (iii). However, most candidates thought ROSY would decrease for the mixed exponential model, which was not correct.

- (i) Non-parametric approach:
ROSY will decrease
 $ROSY = (485 + 367 + 327 + 266 + 265)/2 + 485/2 = 413.5 < 446$
 - (ii) Exponential approach:
ROSY will decrease
ROSY is proportional to the average, which decreases from 99 to 97
 - (iii) Mixed exponential approach:
ROSY will increase
Smaller data set for calibration will increase parameter estimation error and lead to wider mixed distribution
- (g) Recommend an approach, of the three in (f), that Tybee should adopt to calculate ROSY. Justify your recommendation.

Commentary on Question:

Candidates performed well on this question. Correct alternative answers other than non-parametric methods (provided below) were awarded credit. Candidates were expected to give sufficient justification to receive full credit.

Recommend: Non-parametric justifications

It is easy to explain to the town council, unlike the other two.

It is simple to put into a spreadsheet and update without actuary's help, unlike mixed exponential approach.

It produces a higher result than exponential, a politically savvy result.

6. Continued

- (h) Recommend an approach that would likely provide a better fit to the historical pattern of snowfall than any of the three in (f). Justify your recommendation.

Commentary on Question:

In general, candidates performed poorly on this question. Many candidates recommended a method to project snowfall pattern, while the question asked for an approach to fit historical data.

Recommend: A regime-switching model:

High and low snowfalls appear to happen in batches, and a regime-switching model may provide a better fit for high and low snowfall periods.

7. 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) Explain the mathematical foundation of stochastic simulation.
- (5a) Evaluate the methods and processes for measuring and monitoring market risk positions.
- (5b) Describe the types of models and the sources of model risk.
- (5e) Interpret the results of back-testing.

Sources:

Dowd, Measuring Market Risk 2nd ed, Ch 6

Dowd, Measuring Market Risk 2nd ed, Ch 7

Commentary on Question:

Commentary listed underneath question component.

Solution:

- (a) List one advantage and one disadvantage of constructing a parametric model of daily profit/loss using each of the following distributions:
 - (i) Normal
 - (ii) t with 5 degrees of freedom
 - (iii) Levy with $\alpha = 1.5$

Commentary on Question:

In general, candidates did well on this part. No credit was given for stating the t -distribution is a complicated distribution. Candidates only need to state one advantage and one disadvantage to receive full credit.

Advantages of normal distribution:
Requires only two independent parameters

Disadvantages of normal distribution:
Most financial returns have excessive kurtosis/fatter than normal tails

7. Continued

Advantages of t distribution:

Accommodates excess kurtosis through the choice of the degrees of freedom

Disadvantages of t distribution:

Fails to limit maximum possible losses

Advantages of Levy distribution:

Accommodates fat tails of financial return data

Disadvantages of Levy distribution:

Variance of non-normal Levy is infinite, widespread evidence on financial returns suggests they are finite

- (b) Recommend a type of distribution from (a) to fit data with a mean of 3, variance of 4, and kurtosis of 5. Justify your answer.

Commentary on Question:

This is a comprehension question. Most candidates were able to justify why the normal distribution was not appropriate. Few candidates correctly identified the infinite variance when Levy has alpha less than 2.

Recommend the use of the t distribution over the normal and Levy.

A kurtosis of 5 means that there is a presence of excess kurtosis in the sample data. This suggests that a distribution with fat tails should be utilized. This eliminates the normal distribution due to its limited kurtosis.

The presence of a finite variance of 4 suggests that the Levy distribution would be inappropriate. With an alpha less than 2, the distribution would yield an infinite variance. This would not yield an appropriate fit.

- (c) Calculate the following. Show your work.
- (i) Expected daily portfolio return
 - (ii) Five-day portfolio VaR(95)

Commentary on Question:

In general, candidates did not do well on (i). Most candidates did not multiply by portfolio value to get the expected portfolio return. Most candidates received only partial credit for part (ii) because they did not perform the covariance matrix math or the VaR section, or both, correctly.

7. Continued

- (i) $E[\text{return}] = w \times m \times P$, where
 w = weighting between assets (i.e. 25% and 75%)
 m = expected return of assets (i.e. 0.10% and 0.25%)
 P = value of portfolio (i.e. \$1000)

$$E[\text{return}] = |0.25 \ 0.75| \times |0.001 \ 0.0025| \times \$1000$$
$$E[\text{return}] = 0.002125 \times \$1000 = \mathbf{\$2.13}$$

- (ii) $\text{VaR}(h, \alpha) = [-h \times \mathbf{w} \times \mu + \text{SQRT}(h) \times \text{SQRT}(\mathbf{w} \times \Sigma \times \mathbf{w}^T) \times z_\alpha] \times P$,
where
 h = holding period in days (i.e. 5)
 \mathbf{w} = weighting between assets (i.e. 25% and 75%)
 \mathbf{w}^T = weighting between assets, transposed
 μ = expected return of assets (i.e. 0.10% and 0.25%)
 z_α = standard normal for 95% confidence interval (i.e. 1.645)
 P = value of portfolio (i.e. \$1000)

$$\mathbf{w} \times \Sigma \times \mathbf{w}^T = |0.25 \ 0.75| \times \begin{Bmatrix} 0.002 & 0.001 \\ 0.001 & 0.005 \end{Bmatrix} \times |0.25 \ 0.75|^T$$

$$\mathbf{w} \times \Sigma \times \mathbf{w}^T = 0.0033125$$

From (i), $\mathbf{w} \times \mu = 0.002125$

$$\text{VaR}(h, \alpha) = [-h \times \mathbf{w} \times \mu + \text{SQRT}(h) \times \text{SQRT}(\mathbf{w} \times \Sigma \times \mathbf{w}^T) \times z_\alpha] \times P$$
$$\text{VaR}(h, \alpha) = [-5 \times 0.002125 + 2.236067 \times 0.057554 \times 1.645] \times 1000$$
$$\text{VaR}(h, \alpha) = \mathbf{\$201.08}$$

- (d) Describe four possible reasons for the ineffectiveness of this approach.

Commentary on Question:

The section focused on utilizing knowledge of embedded model risks. Few candidates received full credit. Some candidates mentioned the shortcoming of variance-covariance matrix and the sampling error from the data. Four answers were needed for full credit.

- 1) The method of moments is likely providing an inferior fit and thus introducing model risk to the VaR calculation.
- 2) The underlying assets might not be multi-variate normal. This could introduce error if the wrong distribution was chosen.

7. Continued

- 3) Variance-covariance matrix might be inferior to copula approaches; or covariance variance might be misestimated.
 - 4) Sampling error. Covariance or variance on the underlying asset is higher than the underlying data.
- (e) Recommend two ways to improve the forecast of extreme losses.

Commentary on Question:

This is a knowledge utilization question. Most candidates were awarded partial credit. Few received the full credit. Partial credit was awarded for recommending CTE. Two correct answers were needed for full credit.

- 1) Use a copula approach to estimate the dependence structure from the joint distribution functions, instead of using a variance-covariance matrix. This is a more fundamentally valid approach.
- 2) Utilize extreme value theory and fit the distribution to tail values above the 95% confidence interval. This will focus on providing a quality fit in the upper tail of the distribution which is the focus of how this is being used.

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.

Learning Outcomes:

- (1a) Describe the steps to procuring capital funding (treasury function).
- (1b) Assess the various features and implications of various sources of capital funding and recommend the optimal approach for funding.
- (1d) Assess whether the risky return from a new project or ongoing business is sufficient to employ investor capital
- (1e) Evaluate the return on employed capital using NPV, IRR and Payback period.
- (1f) Apply real options analysis to recommend and evaluate firm decisions on capital utilization.

Sources:

Berk, Ch 22, Real Options

Berk, Ch 23, Raising Equity Capital

Commentary on Question:

This question tested candidates understanding of decision tree analysis, valuing companies, evaluating real options, and understanding the IPO process. Many candidates understood the concepts of the question but failed to calculate the values correctly.

Solution:

- (a) Calculate the value of CEC.

Commentary on Question:

Candidates generally performed well on this comprehension section. Successful candidates recognized that the CEC free cash flow needed to be increased by 8% in the present value calculation.

Last year's Free Cash Flow = 2.6M

Value of CEC = $50\% * 2.6M * (1.08) / (12\% - 8\%) = 35M$

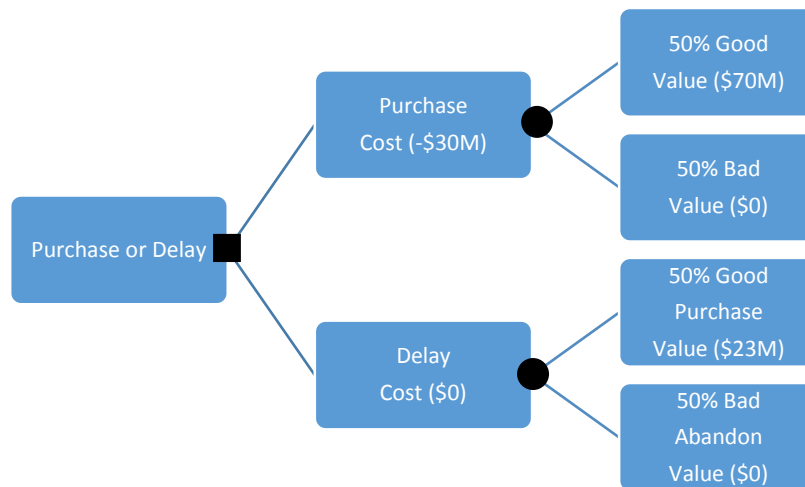
8. Continued

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

Commentary on Question:

Candidates generally performed poorly on this question. Successful candidates were able to diagram all decision and information nodes, which aided in setting up the value of the deal with the option.

- (i) *In order to get full credit, the candidates had to show a distinction between decision nodes and information nodes.*



- (ii) *A common error was attempting to subtract the first year's cash flow that was given up upon taking the option. Furthermore, some candidates did not complete this last step and stated that the value of the option was the value of the deal with the option.*

Value of the deal without the option = Value of CEC from part (a) minus the sale price: $\$35\text{M} - \$30\text{M} = \$5\text{M}$

The cash flows from CEC 1 year from now will be $\$2.6\text{M} \cdot 1.08^2$, so the value of CEC if purchased at time 2 and it hasn't gone bankrupt is:

$$(\$2.6\text{M} \cdot 1.08^2) / (12\% - 8\%) = \$75.816\text{M}$$

8. Continued

Value of the purchase discounted back to time zero and applying the 50% probability of bankruptcy:

$$(\$75.816 - \$50M) * 50\% = \$11.5M$$

Value of the deal with the option = \$11.5M

Value of the option is the value of the deal with the option minus the value of the deal without the option:

$$\$11.5M - \$5M = \$6.5M$$

- (iii) It is recommended to delay the investment decision because the expected present value with the option is \$11.5M compared to \$5M without the option. The option has positive value.

(c)

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

Commentary on Question:

Candidates generally performed well in identifying the costs and benefits of an IPO in this retrieval question. Candidates generally did not perform well in identifying how to value an IPO.

Candidates were not given credit for reasons other than the first two of costs, benefits, and methods. Explanations were not required.

Costs:

- Loss of control
- Increased regulation, such as by the SEC

Benefits:

- Increased liquidity, especially for the original owners, who are able to get some of their invested money out of the company
- Better access to capital

Many candidates mistakenly listed ways to execute or launch an IPO, not how to value one. While the answers they gave were true, they were not what the question was asking.

Ways to Value:

Present value of future cash flows
Examine comparable companies

9. 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.

Learning Outcomes:

- (2e) Describe considerations for the risk borne by capital employed.
- (2f) Design a risk management plan to optimize the risk reward trade off of capital employed.
- (2g) Evaluate human behavioral biases in the decision making processes

Sources:

Berk Ch 29, Corporate Governance

Berk Ch 30, Risk Management

F-116-14, High Risks of Short Term Management

Commentary on Question:

Commentary listed underneath question component.

Solution:

- (a) Critique the appropriateness of the discount rate used to value the VFPP.

Commentary on Question:

Most candidates recognized the VFPP is riskier but few identified the size of the project could also affect the discount rate.

Discount rate seems appropriate given size and riskiness of the project.

Riskiness: Although there are 20 other projects being undertaken this year, this project is in risky Vietombia, which may mean the project-based WACC would go up and this is a significant project relative to the other projects.

Size: This project is significantly larger than the other projects and has the potential to cause financial distress.

- (b) Describe three factors that investors should look for that would commonly be found in companies with a long-term horizon.

Commentary on Question:

Candidates did not perform well on this retrieval question.

9. Continued

Terminology Used on Earnings Calls - Companies with long-term time horizons generally use language such as "long-term" or "years" on their conference calls if they truly are investing long-term.

Lower than Average Volatility of Earnings/Stock Returns - Long-term companies generally have a lower than average volatility of earnings and stock returns

Lower Estimated Cost of Equity Capital - Because long-term investing companies are perceived as less risky, they generally have a lower equity cost of capital

- (c)
- (i) Demonstrate how the Vietombia bank can execute a currency hedge using a cash-and-carry strategy. Show your work.
 - (ii) Contrast the advantages of hedging using a forward contract versus a cash-and-carry strategy for the Vietombia bank.

Commentary on Question:

Most candidates could answer the major components of the cash-and-carry strategy – borrow, exchange, invest, and repay. Some candidates did not use the correct borrowing amount to accurately hedge the bank's exposure. A common error was to borrow \$10m instead of $\$10m / 1.01\% = \$9.9m$.

A common error in part (ii) was not linking the advantages of a forward contract to the Vietombia bank.

- (i) In one year, the bank will provide $\$10,000,000 * 0.717 = 7,170,000$ R in exchange for US dollars.

Borrow dollars today at the US Interest Rate. The bank can borrow $\$10,000,000/1.01 = \$9,900,990.10$ and repay this in one year with the money from the exchange.

Convert the dollars to Rubiaceae at today's spot rate, which results in $\$9,900,990 * 0.70 \text{ R}/\$ = 6,930,693.07 \text{ R}$

Invest the Rubiaceae at the current Rubiaceae interest rate, to get the necessary money = $6,930,693.07 \text{ R} * 1.03453 = 7,170,000 \text{ R}$

In one year, the bank will have the Rubiaceae needed to give to Frenz to pay VFPP, and the bank will receive $\$10,000,000$, which will be used to pay back the original loan.

9. Continued

- (ii) Vietombia is not a large bank with a stable currency so it would likely be unable to execute a cash-and-carry at lower transaction costs. Cash-and-carry is easier for large banks which can borrow easily and have low costs. Forward contracts are simpler and so would be better for Vietombia bank which may not have hedging experience. Cash-and-carry is more complex.

Forward contracts are better for firms that are not able to borrow easily in different currencies and may pay a higher interest rate if their credit quality is poor - Vietombia bank may fit in this category.

Dodd-Frank constraints, such as clearing expenses or margin/collateral requirements if U.S. counterparty.

10. 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.

Learning Outcomes:

- (1e) Evaluate the return on employed capital using NPV, IRR and Payback period.
- (2a) Evaluate how the legal form of an organization, corporate governance and/or compensation dynamics impact decision-making on projects or business activities.
- (2e) Describe considerations for the risk borne by capital employed.
- (2f) Design a risk management plan to optimize the risk reward trade off of capital employed.

Sources:

CFF-T114-14, Corporate Governance

CFF-T115-14, Risk Management

Commentary on Question:

This question tested candidates' ability to analyze corporate structures and governance, specifically with regards to vertically-structured companies, and identify and evaluate the downsides of these structures to certain stakeholders.

Solution:

- (a)
 - (i) Identify the strategy used by BJ Air when purchasing BJ Tire.
 - (ii) Describe the primary benefit to BJ Air of having BJ Tire as its sole supplier.
 - (iii) Explain whether BJ Air's strategy is beneficial to BJ Air's minority shareholders.

10. Continued

Commentary on Question:

Candidates were generally successful in identifying that the strategy was vertical integration, but many candidates failed to recognize that, based on Modigliani and Miller, firms do not add value by hedging risks that the investors can hedge for themselves. Blue Jay Air is attempting to hedge against commodity risk, but investors could purchase shares in a tire company themselves.

- (i) Blue Jay Air's purchase of Blue Jay Tire is a Vertical Integration purchase.
 - (ii) The primary benefit to Blue Jay Air is that purchasing Blue Jay Tire serves as a natural hedge against increasing costs of production. Because an increase in the price of the commodity (tires) raises Blue Jay Air's costs and Blue Tire's revenues, Blue Jay Air offsets its risk by merging.
 - (iii) This transaction would not be beneficial to someone who owns Blue Jay Air stock. According to Modigliani and Miller, firms add no value by doing something investors can do for themselves. Investors concerned about this commodity price risk can diversify by "vertically integrating" their portfolios and buying shares of both Blue Jay Air and Blue Jay Tire.
- (b)
- (i) Describe two capital structures that allow a shareholder to own less than 50% of a company and control over 50% of the voting rights.
 - (ii) Explain the primary advantage of these structures to the controlling shareholder.
 - (iii) Calculate the percent of any Seal-Tite dividends Ruiz will receive, ignoring taxes on dividends. Show your work.
 - (iv) Describe the primary concern a minority shareholder in Seal-Tite would have with this organizational structure.

Commentary on Question:

Candidates generally performed poorly on this question. Many candidates did not describe both capital structures. Many candidates did not deduce that the ability to "tunnel" profits would be the primary concern of minority shareholders.

10. Continued

- (i) Dual Class Shares - Dual class shares exists when a company has two classes of shares in which one has superior voting rights over the other.

Pyramid Structures - In a pyramid structure, a group creates a company in which it owns more than 50% of the shares and has a controlling interest. That company then purchases a controlling interest (50% or more) in another company.

- (ii) Dual Class Shares - The primary advantage is that it allows shareholder of the company to raise additional capital and acquire other companies without diluting their own control.

Pyramid Structures - Primary advantage is that the controlling shareholder has less ownership investment lower down in the pyramid but still remains in complete control of all companies in the pyramid.

- (iii) Ruiz will receive $0.37 * 0.35 * 0.80 = 10.36\%$ (without tax considerations)

- (iv) Primary concern would be that the structure creates a conflict of interest, where Ruiz has an incentive to try and move profits away from Seal-Tite and up to Blue Jay Air, so he receives a larger portion of the profits, which is known as tunneling. Ruiz could accomplish this by having Blue Jay Tire buy supplies from Seal-Tite at prices that are extremely favorable to BJT but that hurt Seal-Tite.

(c)

- (i) Describe the three main frictions that cause an insurance company's premium to be greater than the actuarially fair price.
- (ii) Calculate the premiums for Policy I and Policy II.

Commentary on Question:

While many candidates were able to identify the main frictions, some failed to provide adequate explanation to earn full credits. The model solution is more comprehensive than what is needed for full credit. Many candidates did not calculate reinsurance premiums correctly. Common errors were not discounting and applying incorrect discount rates.

- (i) Administrative and Overhead Costs of Insurance: The insurance company must sell, underwrite, price, and administer the insurance contracts, which requires personnel and physical resources. The costs of these expenses are generally passed along to the customer in the premium cost.

10. Continued

Adverse Selection: A person or a firm's desire to buy insurance may signal that they are an above-average risk. If people/firms have private information about how risky they are, insurance companies will ask to be compensated for this anticipated additional risk.

Moral Hazard (Agency Costs): A person may change their behavior as a result of having insurance. The increased likelihood of a claim due to changes in policyholder behavior may be factored into the cost of insurance.

- (ii) Use CAPM to calculate cost of capital:
 $r(l) = r(f) + \beta(l) * (r(mkt) - r(f))$
 $r(l) = 6\% + (-1.5) * (9.0\% - 6.0\%) = 1.5\%$

Premium = (Loss * Probability of Loss) / (1 + Cost of Capital) *
(Insurance Company Surcharge)

Policy 1: $[(\$30,000,000 * 0.03) / (1.015)] * 1.15 = \$1,020,000$

Policy 2: $[(\$60,000,000 * 0.035) / (1.015)] * 1.15 = \$2,379,000$

- (d) Determine which policy, if either, Seal-Tite should purchase assuming the following actual risks of loss due to fire:
- (i) 5.0%. Show your work.
- (ii) 4.5%. Show your work.

Commentary on Question:

Many candidates did not apply the NPV technique to evaluate the reinsurance contracts. Alternative methods that produced the correct answer were awarded full credit.

- (i) Formula: $NPV = - (\text{Premium}) + [(\text{Probability of Loss}) * (\text{Coverage})] / (1 + \text{Cost of Capital})$
 $NPV(\text{Policy 1}) = -\$1,019,704.43 + (0.05 * \$30,000,000) / (1.015) = \$458,128.08$
 $NPV(\text{Policy 2}) = -\$2,379,310.34 + (0.05 * \$60,000,000) / (1.015) = \$576,354.69$
With a 5% true risk of loss, select Policy 2, as it has a higher Net Present Value.

10. Continued

(ii) Formula: $NPV = -(\text{Premium}) + [(\text{Probability of Loss}) * (\text{Coverage})] / (1 + \text{Cost of Capital})$

$$NPV(\text{Policy 1}) = -\$1,019,704.43 + (0.045 * \$30,000,000) / (1.015) = \$310,344.83$$

$$NPV(\text{Policy 2}) = -\$2,379,310.34 + (0.045 * \$60,000,000) / (1.015) = \$280,788.18$$

With a 4.5% true risk of loss, select Policy 1, as it has a higher Net Present Value.

11. Learning Objectives:

4. The candidate will understand how to critique the appropriateness of advanced risk assessment methods for a given situation.

Learning Outcomes:

- (4f) Assess approaches to quantify risks when there is limited data.

Sources:

F-118-14, Modern Operational Risk Management

Recognizing When Black Swans Aren't

Commentary on Question:

Commentary listed underneath question component.

Solution:

- (a) Contrast the traditional and modern approaches to operational risk management.

Commentary on Question:

This comprehension question asked candidates to identify differences between the two main risk management frameworks, traditional and modern. Most candidates did well on this part, although some did not identify more than one or two differences.

Traditional Risk Management:

- Begins with risk identification process
- Focus is on high probability / high impact losses
- Treats risks as if there is only one bad outcome
- Requires a tactical solution

Modern Risk Management:

- Evaluates risk in terms of risk / reward
- Focus is on low probability / high impact losses
- Uses actuarial methods to look at the probability and severity of potential outcomes
- Is related to strategic issues

- (b) Describe the three elements of a “Black Swan” event, according to Nassim Taleb, the author of *The Black Swan*.

Commentary on Question:

Candidates were expected to list and give a brief description of the three elements that constitute a “Black Swan”. Most candidates were able to correctly identify at least two elements for this retrieval question.

11. Continued

1. Outlier - The event is beyond the realm of regular expectations
 2. Extreme Impact - Result of the event has a large influence on the process being observed
 3. Retrospective Predictability - In spite of being an outlier, we are able to come up with an explanation after the fact for why it should have been predicted
- (c) Defend the statement: “A Black Swan event is relative to knowledge.”

Commentary on Question:

Most candidates were able to explain at least one reason for why a “Black Swan” is relative to knowledge.

An event can only be a “Black Swan” if it is not part of one’s expectations. Therefore, if you know or are aware that something is possible, it cannot be a “Black Swan”. The inability to predict outliers is at the heart of the definition of a “Black Swan” and knowledge of the possibility of a certain potential event makes us able to prospectively predict that event.

- (d) Explain four improvements to Brown’s reserving model that could help to move rare events from “Black Swans” to “Large-Scale, Large-Impact Rare Events.”

Commentary on Question:

This analysis question tested candidates’ ability to understand how models can be improved and apply it to a specific example from the case study. Many candidates did not suggest model improvements or tie them back to the case study.

1. Better statistics and research will help make events conceivable that would otherwise be inconceivable. Every effort should be made to continuously obtain the most robust and up-to-date solar panel data.
2. Pull apart the “black box” to truly understand what is going on instead of blindly accepting results. The valuation model is based on the travel insurance reserve engine and should be thoroughly understood and appropriately updated or changed before being used.
3. Determine how and why a given change or accomplishment is likely to occur. It is important to consider why all changes to the model are being implemented while the model is in development.
4. Overlay results with common sense and experience. The model currently only uses a limited number of risk factors and the parameters have been roughly estimated. By analyzing model results and determining if they make sense we can often detect if risk factors or parameters are off.

Other answers also received credit provided they were clear model improvements and could be tied to the case study.

11. Continued

- (e) Support the plaintiff's attorney's statement that, "Although the failure of the Blue Jay Tire was catastrophic for the Franklin family, it was definitely not a 'Black Swan' event."

Commentary on Question:

This part of the question asked candidates to explain why a specific event that occurred in the case study was not a "Black Swan". Most candidates were able to identify at least one reason to support the attorney's statement.

1. It was prospectively predictable - Deserts are hot and long trips at fast speeds are not uncommon.
 2. It was not really outside the realm of regular expectations - The head engineer wrote a memo noting defects in the tires' manufacturing and safety issues were mentioned by Paul Gosling as well.
 3. This event is subject to risk reduction - Tire failure is not a random or unknown event and the likelihood of occurrence can be reduced with better manufacturing and testing processes.
- (f) Explain why a traditional operational risk approach would have been unlikely to mitigate the circumstances leading to the Smallville, Arizona, Tire Explosion Case.

Commentary on Question:

Most candidates did well on this knowledge utilization question.

Traditional operational risk management focuses on high probability / high impact events. The tire explosion was a low probability event and thus would have received a low rating measure under the Traditional approach.

12. 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) Describe the types of models and the sources of model risk.
- (5c) Assess the methods and process for quantifying and managing model risk within a financial institution.

Sources:

Dowd Ch 2, Measures of Financial Risk

Huynh Ch 14, Risk Management and VaR

Commentary on Question:

Commentary listed underneath question component.

Solution:

- (a)
 - (i) Describe four characteristics that cause model risk for Darwin.
 - (ii) Evaluate Darwin's exposure to each characteristic.

Commentary on Question:

Candidates did poorly on this section. Most were able to describe and evaluate two or three characteristics, but very few were able to provide complete answers for four characteristics of model risk. Common mistakes included providing redundant answers (such as including both data and parameter errors) and not giving enough detail to be considered a complete evaluation of Darwin's exposure. A full credit solution included descriptions of four characteristics, along with an evaluation of whether or not Darwin was exposed to this risk and why.

1. Complexity – A model with a large number of inputs and complicated formulas can lead to complexity risk. Darwin is not at risk because the company only models rho and delta hedges on its IVA business.
2. Transparency – The more accessible the model, the more management can rely on the results. Darwin has a high level of transparency risk because only Tim Jones and his small team are responsible for the hedging model, which is isolated from the rest of the organization.

12. Continued

3. Misspecification – A model with missing risk factors is subject to misspecification modeling risk. Darwin is potentially at risk since it does not model higher-order Greeks like vega and gamma. The company should test these risks for materiality.
 4. Application – A model may be correct but is misused for a particular purpose. Darwin has some application model risk because even though they may be comfortable that the hedge model is correct, they do not rebalance their hedges as often as they could, which could lead to basis risk in the hedge model.
- (b) Evaluate the potential impact on shareholder value from Darwin's individual variable annuity (IVA) business due to the following market risks:
- (i) Rho
 - (ii) Delta
 - (iii) Vega
 - (iv) Gamma

Commentary on Question:

This knowledge utilization question required candidates to simultaneously describe a risk and its impact to Darwin. Most candidates were able to correctly determine what impact the Greeks would have on shareholder value provided a given movement. Complete answers included a description of what portion of Darwin's business was at risk for each Greek.

- (i) Interest rate risk – A decrease in interest rates will increase the present value of guarantees attached to the IVAs, which will decrease shareholder value because of an increase in capital. A 50% rho hedge does not completely eliminate interest rate risk.
- (ii) Equity risk – A decrease in equity values will increase Darwin's exposure to the IVA's guarantees even with a 90% delta hedge. This will cause an increase in capital which will lower shareholder value.
- (iii) Volatility risk – An increase in volatility will increase hedging costs and can put the IVA guarantees in the money. Between increased costs and higher capital requirements, shareholder value would be lowered from adverse vega movement.

12. Continued

- (iv) Gamma risk – Equities are delta hedged, but gamma is unhedged. Since hedge effectiveness is only evaluated quarterly the delta hedge alone may not cover significant swings in equity values, which would cause a decrease in shareholder value due to an increase in capital requirements.
- (c) Critique the statement made by Mr. Jones from the perspective of:
 - (i) Darwin's IVA business
 - (ii) RPPC's Risk Management Framework

Commentary on Question:

This knowledge utilization question required candidates to critique a statement on the use and results of stress testing from differing viewpoints of the business unit and ERM program overall. Most candidates were able to come up with at least one valid critique of Mr. Jones' statement from both Darwin's and RPPC's perspectives.

- (i) Reduced exposure to interest rate risk in the IVA business will decrease volatility in the business' earnings, making them more predictable. However, the increased hedge may lower earnings because of the increased hedging costs required by the increased hedge amount.
- (ii) Increased rho hedging can reduce earnings volatility and bring the IVA line within the risk tolerance of the overall ERM program. However, this may be an overhedge if RPPC is doing a macro hedge or depending on multi-line diversification to mitigate rho risk across the company as a whole.
- (d) Recommend three improvements to RPPC's Risk Management Framework.

Commentary on Question:

Recommendations without the proper support or that weren't related to the case study did not receive full credit. Candidates generally did well on this knowledge utilization question.

1. Integrate the market assumption-setting process across the various business lines. This creates transparency for management (instead of just the hedge team understanding the assumptions), consistency, and provides a view of the overall ERM impact of a change in assumptions.

12. Continued

2. Implement dynamic policyholder behavior assumptions. Because of the static assumption, the ERM program may be under-protected as policyholder behavior may change during adverse market scenarios for several products (IVA, ULSG, etc.).
3. Perform more frequent stress tests and include hypothetical scenarios rather than focusing so much on historical events.

Other improvements received full credit provided they were applicable to the case study and were improvements for RPPC as a whole, not just Darwin.

13. Learning Objectives:

4. The candidate will understand how to critique the appropriateness of advanced risk assessment methods for a given situation.

Learning Outcomes:

- (4b) Evaluate the risk margin as a cost of risk capital within a risk valuation framework.

Sources:

F-107-13, A Market Cost of Capital Approach to Market Value Margins

Commentary on Question:

Commentary listed underneath question component.

Solution:

- (a) Define the following terms:
 - (i) Market consistent value of liabilities (MVL)
 - (ii) Solvency capital requirement (SCR)
 - (iii) Market value margin (MVM)

Commentary on Question:

Most candidates were able to properly define the market consistent value of liabilities and market value margin in this retrieval question. Most candidates were not able to define the solvency capital requirement. While most candidates were able to partially describe the SCR, they often did not provide the two necessary key pieces of its definition. Some candidates also confused SCR with MCR.

- (i) Market Consistent Value of Liabilities:
MVL is the market consistent value at which the liabilities could be transferred to a willing, rational, diversified counterparty in an arm's length transaction under normal business conditions.

Exact wording was not required. Credit was awarded for correct equivalent wording.

- (ii) Solvency Capital Requirement:
The SCR at time 0 is set at the 99.5% Value at Risk for non-hedgeable risk types for a one year period.

13. Continued

(iii) Market Value Margin

MVM is the cost of risk. It is a risk margin in addition to the expected present value of cash flows required to manage the business on an ongoing basis.

(b)

(i) List the five components of MVL.

(ii) Identify which components of MVL may be valued using available market prices.

Commentary on Question:

Overall, candidates did well on this retrieval section. A majority of candidates did not answer that the MVL is made up of the MVM for hedgeable and non-hedgeable financial and non-financial risks. Most candidates left off “MVM” for these 4 components and were not awarded full credit.

(i) Five components of MVL:

- Present value of expected future cash flows or the best estimate liability
- MVM for hedgeable financial risks
- MVM for hedgeable non-financial risks
- MVM for non-hedgeable financial risks
- MVM for non-hedgeable non-financial risks

(ii) May be valued with market prices:

- Present value of expected future cash flows or the best estimate liability
- MVM for hedgeable financial risks
- MVM for hedgeable non-financial risks

(c) Calculate the time 0 MVL for Wright’s term insurance business. Show your work.

Commentary on Question:

Few candidates were awarded full credit on this comprehension question. Most received significant partial credit. The most common errors were not discounting the present value of the cost of capital charges correctly, including the premiums in the present value of benefits calculation, and not recognizing that the SCR was a percentage of the present value of benefits (15%) and calculating its different values at each time step.

13. Continued

Time step (end of year)	0	1	2	3	4
Premium	50,000	0	0	0	0
Claims & Expenses	0	15,000	15,000	15,000	0
PV of Benefits (at 3%)	42,429	28,702	14,563	0	0
SCR (= 15% * PV of Benefits)	6,364	4,305	2,184	0	0
Capital Charge at the end of year (=10%*beginning of the year SCR)	0	636	431	218	0
MVM (sum of PV of CoC at 3%)	1,224				

$$\text{MVL} = \text{PV of Benefits} + \text{MVM} = 42,429 + 1,224 = 43,653$$

- (d) Explain the impact the following scenarios will have on MVM:
- (i) Increased expected mortality
 - (ii) Increased operational risk
 - (iii) Greater asset-liability mismatch
 - (iv) Lower corporate income tax rate

Commentary on Question:

Candidates did well on parts (i) and (ii) of this analysis question, but not on parts (iii) and (iv). Full credit answers contained the correct reasoning as well as correct impacts.

- (i) Impact: MVM will increase.
Explanation: increased mortality is non-hedgeable risk.
- (ii) Impact: MVM will increase.
Explanation: Operational risk is non-hedgeable risk.
- (iii) Impact: MVM will not change.
Explanation: Asset liability mismatching is hedgeable risk.
- (iv) Impact: MVM will not change.
Explanation: MVM is calculated on a pre-tax basis.

13. Continued

- (e) Recommend whether Wright should vary MCoC by risk in its economic capital calculation. Support your recommendation.

Commentary on Question:

Few candidates were able to get full credit for this analysis question. Most candidates were awarded partial credit. In order to get full credit, the candidate had to provide two reasons to support their recommendation. Since either recommendation, to vary MCoC or not, is supported in the source, simply stating a recommendation without support did not earn any credit. Well-reasoned support was necessary for credit.

Recommend to not vary MCoC by risk:

I recommend Wright not vary the MCoC by risk. They should not do this because the CRO forum suggests that in most cases, the MCoC should not vary by risk type or business. Any difference in risk should be reflected in the SCR. Also, they suggest the cost of capital for non-hedgeable risks be reviewed periodically.