

CFE FD Model Solutions

Fall 2014

1. 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:

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

Sources:

Dowd, Measuring Market Risk 2nd ed, Ch 6

Dowd, Measuring Market Risk 2nd ed, Ch 11

Huynh, Lai, Soumare, Wiley, Stochastic Simulation and Applications in Finance, Ch 14

Commentary on Question:

This question tests candidates' basic understanding of VaR, IVaR, CVaR, and the delVaR approach. The focus of this question is not the calculation. The question requires candidates to extend the concepts into a business decision making context. Candidates did well for parts a) and b) and not so well for part d).

Solution:

- (a) Describe incremental risks and component risks of a portfolio.

Commentary on Question:

Part a) asks the candidates to describe IVaR and CVaR and describe the benefits of risk decomposition. Most candidates did well on this retrieval part.

Incremental Risk: These are the changes in risk when some factor changes. The incremental VaR or IVaR is the change in VaR associated with the addition of the new position to our portfolio.

1. Continued

Component Risk: These are the component or constituent risks that make up a certain total risk. The portfolio VaR can be broken down into components, known as component VaRs or CVaRs, that tell us how much each position contributes to the overall portfolio VaR.

- (b) Calculate the 95% daily VaR associated with a portfolio of \$1,250 of Security A and \$3,375 of Security B. Show your work.

Commentary on Question:

Most candidates did well on this comprehension part. Common errors included confusing standard deviation with variance, not applying the square root to the co-variance matrix, and not applying their VaR calculation to the portfolio value.

Plugging $\mu=0$, $\sigma = 1$:

$$VaR = [(\omega_1, \omega_2)(1-\rho \quad \rho | 1) (\omega_1 \quad \omega_2)]^{(1/2)} * z_\alpha * P = [(\omega_1^2 + 2\rho\omega_1\omega_2 + \omega_2^2)]^{(1/2)} * z_\alpha * P$$

ω_1 and ω_2 are the relative shares of Security A and Security B, respectively. The standard normal percentile, z_α , is given in the question stem as 1.645. The total portfolio value is \$4,625.

$$VaR = \{((1250/(1250+3375))^2 + 2*0.5*1250/(1250+3375)*3375/(1250+3375)+(3375/(1250+3375))^2)\}^{0.5}*1.645*4625$$

$$VaR = 6,816.71$$

- (c)
- (i) Calculate the IVaR associated with adding \$10 of Security A to the portfolio using the delVaR approach. Show your work.
 - (ii) Interpret the result of (i) with regard to portfolio risk.
 - (iii) Describe the impact if the \$10 addition to the portfolio was of Security B instead of Security A.

Commentary on Question:

Candidates did not score well on this comprehension part. Some candidates did not remember the IVaR formula or had difficulty with partial derivatives. Candidates needed to recognize the impact from adding to security A is greater than adding to security B for credit.

1. Continued

(i) $IVaR = \partial VaR / \partial \omega_1 d\omega_1 + \partial VaR / \partial \omega_2 d\omega_2$

$$\partial VaR / \partial \omega_1 = 0.5 * (\omega_1^2 + 2\rho\omega_1\omega_2 + \omega_2^2)^{-0.5} * 2(\omega_1 + \rho\omega_2) * z_\alpha * P$$

The purchase of the additional amount of security A changes the relative position shares by

$$d\omega_1 = (1250+10)/(1250+3375+10) - 1250/(1250+3375) = 0.001574$$

$$d\omega_2 = 3375/(1250+3375+10) - 3375/(1250+3375) = -0.001574$$

Plugging all these into the equation above

$$IVaR = 5392.05 * 0.0015745 + 7344.0 * (-0.001574) = -3.0646$$

(ii) The IVaR from the new addition asset is negative so the overall portfolio VaR decreases due to the diversification effects within the portfolio.

(iii) The new relative position shares if we add \$10 to B instead of A.

$$d\omega_1 = 1250/(1250+3375+10) - 1250/(1250+3375) = -0.00058, \quad d\omega_2 = 0.00058$$

The IVaR is 1.132.

(d) Explain two reasons why an analysis of daily IVaR may not predict actual changes to portfolio VaR.

Commentary on Question:

Candidates scored poorly on this comprehension part. Most candidates did not understand that the first order Taylor series might not be a good approximation to the VaR of the new portfolio. Many candidates understood a large trade or number of small trades could cause the method to fail but were unable to explain why.

With very large trades the first order Taylor series might not give a good approximation for the VaR of the new portfolio, and in this case the resulting IVaR approximation might be poor.

For a large number of small trades accumulating during the day, the sum of daily trades will cause the intra-day portfolio to drift away from the start of day portfolio, and the VaR and delVaRs of the latter will be increasingly poor proxies for the VaR and delVaRs of the former. Inaccurate VaR and delVaR estimates can then lead to inaccurate IVaR estimates due to drift in the portfolio composition, even if individual trades are all small.

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:

- (1f) Apply real options analysis to recommend and evaluate firm decisions on capital utilization.
- (1g) Describe the methods of allocating risk capital.

Sources:

Jonathan Berk and Peter Demarzo, Corporate Finance, Third Edition, Ch 22

Capital Allocation in Financial Firms

Commentary on Question:

This question was testing the candidates' ability to evaluate the advantages and disadvantages of the option to purchase a project versus waiting. Candidates that performed well on this question were able to recognize that the decision to wait could change depending on certain assumptions: specifically the volatility of the future value of the franchise in this question. The last section of the question was meant to show that even if a project is not profitable on a stand-alone basis, it could be a good venture for a company because the value-maximizing amount of risk capital for diversified firms is less than the sum of the stand-alone capital requirements.

Solution:

- (a) Identify two advantages and two disadvantages of delaying the decision to buy a HypeD franchise for one year.

Commentary on Question:

Most candidates were able to identify the first item in both the advantages and disadvantages but struggled identifying a second advantage and disadvantage.

Advantages

- 1.) Can wait to gather additional or new information regarding the economy, consumer tastes and trends on the investment over the next year
- 2) The cost of opening the coffee shops a year from now is the same as now, so the present value of the cost declines if the decision is made to wait

Disadvantage

- 1) Give up any profits the project might generate in the next year
- 2) A competitor could use the delay to develop a competing product

2. Continued

- (b) Calculate the Net Present Value (NPV) of purchasing a franchise now. Show your work.

Current Value

$$1,000,000 / (0.15 - 0.055) = 10,526,316$$

NPV

$$10,526,316 - 10,000,000 = \mathbf{526,316}$$

- (c)
- (i) Calculate the value of the option to buy the franchise in one year. Show your work.
- (ii) Recommend whether Elbert should invest in the franchise now or delay the investment decision for a year. Support your recommendation.
- (iii) Explain whether your recommendation would change if the volatility of the franchise's value was 10% rather than 60%.

Commentary on Question:

Unsuccessful part (i) calculations either mis-calculated the current value of the asset or incorrectly used the standard normal table. About half of candidates did not recalculate the value of the call option in (iii), which was not required to answer the question. However, for credit they had to realize that a change in franchise value volatility from 60% to 10% would substantially reduce the value of the call and mean that there won't be enough information gained over the next year to warrant waiting to investment.

- (i) Current Value of Asset without 1mm free cash flow => $10,526,316 - (1,000,000 / 1.15) = 9,656,751$

$$\text{PV of cost in 1 year} = 10,000,000 / 1.045 = 9,569,378$$

$$d1 = [\ln(9,656,751 / 9,569,378)] / 0.6 + (0.6 / 2) = 0.315148$$

$$d2 = d1 - 0.6 = -0.2849$$

$$\text{Value of Call Option} = [9,656,781 * N(d1)] - [9,569,378 * N(d2)] = \mathbf{2,310,919}$$

- (ii) NPV of purchase today is \$526,316. NPV of waiting is \$2,310,919, so waiting would be recommended. This is driven by the volatility of the value of the franchise. More information can be gained over the next year that justifies the loss of the 1mm cash flow from purchasing today.

2. Continued

- (iii) 10% Volatility
 $d1 = [\ln(9,656,751 / 9,569,378)] / 0.1 + (0.1 / 2) = 0.14089$
 $d2 = d1 - 0.1 = 0.0409$
Value of Call Option = $[9,656,781 * N(d1)] - [9,569,378 * N(d2)] =$
\$428,613

Recommendation

The recommendation would change because the value of the call option (\$429K) is now lower than the NPV of the purchase (\$526K). With the lower volatility in the franchise's value, you won't gain enough information over the next year to justify the cost of waiting.

- (d) Calculate Elbert's estimated first-year profits after deadweight costs for each of the following:
- (i) HypeD franchise as stand-alone
 - (ii) StarcheD franchise as stand-alone

Deadweight Cost of Capital = Risk Capital * Deadweight Cost
Profits - Deadweight Cost of Capital = Profits after Deadweight

- (i) Coffee Shop – Alone
 $10,000,000 * 0.15 = 1,500,000$ is the deadweight cost of capital
 $2,000,000 - 1,500,000 =$ **\$500,000**
 - (ii) StarcheD – Alone
 $10,000,000 * 0.15 = 1,500,000$
 $1,000,000 - 1,500,000 =$ **\$-500,000**
- (e) Recommend whether Elbert should invest in the StarcheD franchise. Justify your recommendation.

Commentary on Question:

Candidates that struggled with this question either based their answer solely on the value of StarcheD as a stand-alone business and ignored the diversification benefits or did not sufficiently justify their recommendation.

Combined franchise profits

$10,000,000 * (2 ^ 0.5) = 14,142,136$
 $14,142,136 * 0.15 = 2,121,320$
 $3,000,000 - 2,121,320 = 878,680$

2. Continued

Recommendation: Invest in StarcheD

On a stand-alone basis, net of deadweight costs, the coffee shop business is profitable and StarcheD is not. However, the combination of the two businesses makes \$878,680 (\$378,680 more than just the coffee shop alone) after deadweight costs. Therefore, the additional purchase of the StarcheD business is a good decision. The amount of risk capital is less than the sum of the capital requirements for each of the businesses operating as stand-alone businesses.

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.
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:

- (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.
- (1c) Interpret financial reinsurance and securitization as a form of capital funding.
- (1e) Evaluate the return on employed capital using NPV, IRR and Payback period.
- (2c) Recommend an optimal capital structure and how to implement it for a given business or strategy.

Sources:

Dynamic Financial Condition Analysis Handbook Ch 8

Jonathan Berk and Peter Demarzo, Corporate Finance, Third Edition, Ch 18

Jonathan Berk and Peter Demarzo, Corporate Finance, Third Edition, Ch 24

The Three Steps to Raising Capital and Why Most Companies Fail Miserably

Commentary on Question:

Students generally performed well on this analysis question. In particular, most had a good mastery of the use of WACC to evaluate NPV and the need for a different WACC for the Harp project.

Solution:

- (a) Contrast how TC should tailor its business plan to potential providers of debt financing versus equity financing.

3. Continued

Commentary on Question:

A common error was to contrast the effects of debt and equity financing on the firm instead of contrasting how TC should tailor its business plan to potential providers of financing.

To providers of debt financing:

- Emphasize the credit-worthiness of the firm, highlighting the ability of the firm to pay the interest on debt on time and regularly

To providers of equity financing:

- Emphasize the growth potential, high returns, and abilities to increase dividends or firm value (share price)

- (b) Recommend which insurer TC should purchase. Justify your recommendation.

Commentary on Question:

Common mistakes in this analysis question were ignoring the value of the interest tax shield in the WACC calculation or failing to subtract cash (which is negative debt) from the debt in making the calculation.

For Piano:

$$D = 205 - 30 = 175; E = 425; r_E = 10\%; r_D = 6\%; \tau = 35\%$$

$$\begin{aligned} \text{WACC} &= [E/(E+D)]*r_E + [D/(E+D)]*r_D*(1-\tau) \\ &= (425/600)*0.1 + (175/600)*0.06*0.65 = 8.22\% \end{aligned}$$

$$\begin{aligned} \text{NPV} &= \text{FCF}/(\text{WACC} - \text{growth rate}) - \text{initial investment} \\ &= 4/(0.0822 - 0.05) - 80 = 124.19 - 80 = 44.19 \end{aligned}$$

For Harp:

$$r_E = 12\%; r_D = 8\%$$

$$\text{WACC} = (425/600)*0.12 + (175/600)*0.08*0.65 = 10.02\%$$

$$\text{NPV} = 8/(0.1002 - 0.04) - 80 = 132.96 - 80 = 52.96$$

Because the NPV of the Harp project is higher than the NPV for the Piano project, TC should purchase the Harp insurer.

- (c) Calculate the amount of debt that must be used to fund the purchase recommended in part (b) to maintain TC's debt-equity ratio.

Commentary on Question:

Most common mistakes were to use the Debt/Equity ratio for determining the debt (instead of Debt/Value) or applying the ratio to the purchase price instead of the value of the project. Full credit was given for candidates who used the Debt-Equity ratio, and then applied it correctly to the resulting equity.

3. Continued

To maintain constant debt-equity ratio,

$$V_{\text{Harp}} = 132.96 \text{ (from part (b))}$$
$$\text{Debt/Value} = 175/600 = 0.2917$$
$$132.96 * 0.2917 = 38.78$$

Fund \$38.78 million of the project with debt.

- (d) Explain how each of the following provisions would impact TC's bond issue:
- (i) Restrictive covenants
 - (ii) Convertibility
 - (iii) Call provisions

Commentary on Question:

A full credit answer had to address the effect of each provision on TC's cost of debt: bond yield or price or an equivalent.

Covenants: Bond covenants are restrictive clauses that limit the issuer from taking actions that affect its ability to repay the bonds. The stronger the covenants in the bond contract, the lower the interest rate required by investors who buy the bond. Reduction in borrowing cost can outweigh loss of flexibility.

Convertibility: Lower yield compared to regular bond because it gives the bond holder an embedded warrant. The additional option has positive value, so a convertible bond is worth more than an otherwise identical non-convertible bond.

Callable bond: its yield is higher than a regular bond. The issuer has an option to call the bond back (repay early), leaving the investor with the interest rate risk. So, a callable bond is less attractive and needs a higher yield.

- (e)
- (i) Assess the consultant's suggestion. Support your assessment.
 - (ii) Assess the CEO's suggestion. Support your assessment.

3. Continued

Commentary on Question:

Generally candidates did not perform very well on this knowledge utilization part. Most made overly broad statements regarding converting future cash flows into present value, instead of specifically addressing the appropriateness of securitization for enhancing statutory surplus. Regarding debt, most candidates did not acknowledge that without a holding company structure, the cash raised by issuing debt would be offset by a liability.

Note: an alternative solution, with robust support, that outlined the use of an off-balance-sheet SPV was accepted.

- (i) The consultant's suggestion is not valid. Securitization has limited applicability for surplus enhancement and high set-up costs. The security issue will be difficult. These arrangements are more suitable for liquidity enhancement.
- (ii) The CEO's suggestion is not valid. Debt, with the exception of subordinated debt in Canada, does not improve the surplus of the issuing company, as the liability will offset the cash raised on the statutory balance sheet.

To increase statutory surplus, the debt could be issued by a holding company, which then accepts surplus notes or equity from the operating company for cash.

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.
- (3f) Explain the differences and implications of the use of P-measure and Q-measure for risk assessment.

Sources:

Panjer, Harry, et. al, Financial Economics with application to Investments, Insurance and Pension, Ch 4

Panjer, Harry, et. al, Financial Economics with application to Investments, Insurance and Pension, Ch 5

Huynh, Lai, Soumare, Wiley, Stochastic Simulation and Applications in Finance, Ch 9 (background)

Commentary on Question:

Very few candidates received full credit for this question. Most candidates received some credit for part (c), but did very poorly on parts (a) and (b).

Solution:

- (a) Calculate current market prices of the three securities, A, B, and C.

Commentary on Question:

Candidates did very poorly on this comprehension part. A common mistake was to omit the marginal rate of substitution (MRS) and only multiply prices at time 1 by the probability of each state.

$$\begin{aligned}\text{Price} &= \sum p(\omega) u'(C^1(\omega)) / u'(c^0) X(\omega) \\ &= EP [ZX(\omega)] \\ &= EP [MRS(\omega)X(\omega)]\end{aligned}$$

$$\begin{aligned}\text{Market Price of Security A} &= (1/3)(.9)(2) + (1/6)(.9)(5) + (1/2)(.95)(6) \\ &= 4.2\end{aligned}$$

$$\begin{aligned}\text{Market Price of Security B} &= (1/3)(.9)(8) + (1/6)(.9)(7) + (1/2)(.95)(9) \\ &= 7.725\end{aligned}$$

$$\begin{aligned}\text{Market Price of Security C} &= (1/3)(.9)(10) + (1/6)(.9)(2) + (1/2)(.95)(5) \\ &= 5.675\end{aligned}$$

4. Continued

- (b) Assume there is a complete market of one-period Arrow-Debreu securities.
- (i) State the definition of an Arrow-Debreu security.
 - (ii) Calculate prices for the three Arrow-Debreu securities, ψ_{ω} .
 - (iii) Calculate the one-period risk-free rate for CG.

Commentary on Question:

Most candidates did not know how to solve part (ii) by multiplying the probability and the MRS. Many candidates attempted to solve part (ii) using matrix algebra but did not use the correct matrices or simpler formula.

Very few candidates provided a complete solution for part (iii). Most candidates attempted this part, but did not use the correct formula for the risk-free rate.

- (i) An Arrow-Debreu security is one that pays 1 in a given state and 0 in all other future states of the world.
 - (ii) $\psi_{\omega} = p(\omega) u'(C^*(\omega)) / u'(c^*) = p(\omega) \text{MRS}(\omega)$
 $\psi_{\omega 1} = (1/3)(.9) = .30$
 $\psi_{\omega 2} = (1/6)(.9) = .15$
 $\psi_{\omega 3} = (1/2)(.95) = .475$
 - (iii) The risk free rate pays 1 in all states, hence
 $1 / (1+i) = EP [\text{MRS}(\omega) \cdot 1] = \sum_{\omega} \psi_{\omega} = 0.925$
 $(1+i) = 1.0810811$
 $i = 8.1\%$
- (c) Critique the regulator's proposal.

Commentary on Question:

In general, candidates disagreed with the regulator's proposal. However, very few candidates provided a complete justification. In order to receive full credit, candidates were expected to state that the proposal was incorrect, indicate why risk neutral scenarios were inappropriate for solvency testing, and propose that real world scenarios should be used instead. Most candidates did not mention that risk neutral scenarios should be derived and not prescribed.

Candidates who did not provide a clear critique did not receive credit.

4. Continued

Regulator's proposal is incorrect.

Risk-neutral probabilities are synthetic constructs that can replicate market prices or valuation, but will not give realistic probabilities.

No-arbitrage approach is not appropriate for solvency projections and VaR calculations.

Should use equilibrium approach instead of no-arbitrage approach for solvency testing.

Risk-neutral probabilities are derived from observed rates and prices and should not be set by a regulator.

5. 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.
- (3b) Assess the appropriateness of a given stochastic simulation technique to quantify various market risk exposures.

Sources:

Huynh, Lai, Soumare, Wiley, Stochastic Simulation and Applications in Finance, Ch 4

Dowd, Measuring Market Risk 2nd ed, Ch 8

Dowd, Measuring Market Risk 2nd ed, Ch 9

Commentary on Question:

This question uses multiple sources to test the mathematical foundation of stochastic simulation and appropriateness of simulation techniques.

In general, candidates scored well on all parts of this question.

Solution:

- (a) Identify an advantage and disadvantage of using Monte Carlo simulation to model the funds in Lucky Tom's portfolio.

Commentary on Question:

Cognitive Level: Comprehension

In general, candidates scored well on this part. Equivalent wording and any other acceptable answers received credits.

ADV: MCS can handle complex and/or heterogeneous instruments/investments

DISADV: MCS works forward in time, cannot handle early exercise well

- (b)
- (i) Determine the missing values for L :

$$L = \begin{bmatrix} 0.400 & 0.000 & 0.000 \\ 0.180 & ? & ? \\ -0.200 & 0.025 & ? \end{bmatrix}$$

- (ii) Verify L is the lower triangular square-root matrix of A .

5. Continued

Commentary on Question:

Cognitive Level: Comprehension

Candidates scored well in this part.

To get full credit in (i), candidates need to correctly calculate all the missing values in matrix L

To get full credit in (ii), candidates need to set up and/or described correctly how to derive the starting A matrix.

- (i) Determine Missing Values of L Matrix

Determine L(2,2)

$$L(2,2) = \text{SQRT}[A(2,2) - L(2,1)^2] = \text{SQRT}[0.09 - 0.18^2] = 0.24$$

Determine L(2,3)

L(2,3) = 0 since L matrix is lower triangular.

Determine L(3,3)

$$L(3,3) = \text{SQRT}[A(3,3) - L(3,1)^2 - L(3,2)^2] = \text{SQRT}[0.25 - (-0.20)^2 - 0.025^2] = 0.4576$$

- (ii) Verify L is the Lower Triangular Square Root Matrix of A

Matrix L times Matrix L^T will equal the original Matrix A since L is the square root matrix of A.

Matrix Multiplication:

.4000 .0000 .0000		.4000 .1800 -.200		.1600 .0720 -.080
.1800 .2400 .0000	times	.0000 .2400 .0250	equals	.0720 .0900 -.030
-.200 .0250 .4576		.0000 .0000 .4576		-.080 -.030 .2500

- (c) Calculate the first three correlated values, for the Monte Carlo simulation using the first three Gaussian values.

Commentary on Question:

Cognitive Level: Analysis

Candidates scored well on this part of the question.

No penalty if incorrect values from (b) were correctly used.

.4000 .0000 .0000		0.90		
.1800 .2400 .0000	times	-1.10	equals	0.36, -.102, -.116
-.200 .0250 .4576		0.20		

5. Continued

- (d)
- (i) Describe the two processes, I and II, above.
 - (ii) Recommend a process, I or II above or geometric Brownian motion, as the most appropriate for each of Lucky Tom's investments.

Commentary on Question:

Cognitive Level: Analysis

Most candidates received full or partial credits in part (i). No credit was given for conflicting statements.

Candidates didn't score well in part (ii). Many candidates recommended one process for the whole portfolio rather than one process for each investment within the portfolio. Only partial credit was given to these candidates.

- (i) Describe Random Processes
Process I: $dx = \eta E(\bar{x} - x)dt + \sigma E dz + dqE$
 - Called the Ornstein-Uhlenbeck process with jumps.
 - \bar{u} is the long term average.
 - Shows occasional spikes and strong mean reversion.
- (ii) Process II: $dr = k(\mu - r)dt + \sigma\sqrt{r} dz$
 - μ here is long term average.
 - σ is the annualized volatility.
 - k is the speed the process reverts to the mean.
 - It has three characteristics of interest rates: stochastic, mean reverting, and positive.

6. 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:

- (3a) Explain the mathematical foundation of stochastic simulation.
- (3d) Assess the strengths and weaknesses of the calibration techniques for a given stochastic model.
- (4d) Recommend when to use Markov Chain Models to evaluate risk.

Sources:

Dardis, Layering Your Own Views into a Stochastic Simulation, SOA Risks & Rewards, August 2013

Norris and Gossmiller, Hidden Markov Models and You, SOA Forecasting and Futurism, July 2013

Huynh, Lai, Soumare, Wiley, Stochastic Simulation and Applications in Finance, Ch 8

Commentary on Question:

This question tests the concept of entropy and using Markov models to determine probable outcomes.

Solution:

- (a) For Station A:
 - (i) Estimate the high temperature for two days from today.
 - (ii) Identify the type of stochastic process its daily high temperature forecast assumes.

Commentary on Question:

Cognitive level: Retrieval

In general, candidates scored well on this part of the question.

- (i) Yesterday was 72 and tomorrow will be 72 and two days from today will also be 72.
- (ii) Martingale.
Linear model, no distribution is specified

6. Continued

- (b) For Station W:
- (i) Describe the type of model its daily high temperature forecast assumes.
 - (ii) Briefly discuss what other parameters might be necessary to make an estimate.
 - (iii) Suggest a model distribution for temperatures within the various daily states. Defend your suggestion.

Commentary on Question:

Cognitive level: Comprehension

Candidates generally performed poorly on this part. Most candidates struggled with part (ii). Very few candidates received full credit. To receive full credit for part (b), candidates needed to:

Successfully identify hidden Markov model,

Mention at least 2 parameters in (ii), and

Defend their answer in part (iii) in order to receive credit. Reasonable and well-supported alternative answers to part (iii) were accepted for credit.

- (i) Model is an example of a Hidden Markov Model. There are several states of nature, a transition matrix and conditional probabilities
 - (ii) Other parameters needed:
Distribution of temperatures within a typical cold, temperate, hot state
Some way to determine which state (cold, temperate or hot) that you are currently in
Weights to determine conditional probabilities to move from one state to the next
 - (iii) Poisson works well. Poisson is "memory less".
- (c)
- (i) Calculate the maximum entropy for this set of observations.
 - (ii) Estimate the monthly average temperature using maximum entropy.

Commentary on Question:

Cognitive level: Comprehension

Candidates generally scored well on this part. Some candidates described in words when entropy is maximized but didn't calculate the value; only partial credit was given in this situation.

6. Continued

- (i) Entropy $S = - \sum w_i \ln w_i$
Entropy maximized when equal weighting is given to all observations
So weights are 1/5 or 20% or 0.2
Therefore $S = 1.609$
- (ii) Estimate is simply $(67 + 80 + 75 + 86 + 77) / 5 = 77$ degrees
- (d)
 - (i) Calculate minimum entropy for the set of observations, not including Station F.
 - (ii) Estimate the monthly average temperature using minimum entropy.

Commentary on Question:

Cognitive level: Comprehension

Some candidates described in words when entropy is minimized but didn't calculate the value; only partial credit was given in this situation.

- (i) Entropy $S = - \sum w_i \ln w_i$
Entropy is minimized when one scenario/observation is given a weight of one and the remainder a weight of zero
Therefore $S = 0$
- (ii) Temperature Estimate: 67 assuming 100% weight on Station A
- (e)
 - (i) Develop an estimate of the monthly average temperature by weighting multiple stations' observations to match your own view of tomorrow's high temperature with entropy of at least 0.94.
 - (ii) Explain why the entropy methodology cannot be used to refine your estimate of the monthly average temperature if your own view is that tomorrow's high temperature will be 69.

Commentary on Question:

Cognitive level: Knowledge Utilization

Candidates performed well in (ii). For part (i), almost all candidates stopped at suggesting a distribution that meets the criteria but didn't proceed to complete the calculation of monthly temperature estimate.

6. Continued

- (i) Estimate that weightings of 20% Station A, 60% Station C and 20% Station N to match your tomorrow view $20\% (72) + 60\% (75) + 20\% (73) = 74$

$$\text{Entropy } S = - \sum w_i \ln w_i = -.2 * \ln (.2) - .6 * \ln(.6) - .2 * \ln(.2) = 0.95 > 0.94$$

Using those weightings, develop a monthly temperature estimate $20\% (67) + 60\% (80) + 20\% (86) = 78.6$

- (ii) Your own view target falls outside the range of observations

Entropy methodology will not work where target is outside of all of the original scenarios/observations. Entropy weightings may not be negative.

7. Learning Objectives:

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

Learning Outcomes:

(4c) Evaluate the limitations of modeling dependences in risk variables.

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

Sources:

Huynh, Lai, Soumare, Wiley, Stochastic Simulation and Applications in Finance, Ch 15

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

Commentary on Question:

Very few candidates received full credit for this question.

Solution:

- (a) Critique the CRO's statement. Justify your critique.

Commentary on Question:

Most candidates did not realize that the third principal component represents convexity. Candidates who answered the question assuming the second principal component related to convexity received partial credit, provided their understanding of the use of principal component analysis in explaining variation was clearly demonstrated.

Candidates who did not provide a clear critique of the CRO's statement or candidates who simply stated convexity is important without referring to the results of the principal component analysis did not receive credit.

Agree: convexity is not important in explaining the variation in treasury yields

<u>Principal Component</u>	<u>Eigen Value</u>	<u>Proportion of Variation</u>	<u>Cumulative proportion of variation</u>
1	2.4765	96.7%	96.7%
2	0.0664	2.6%	99.3%
3	0.0123	0.5%	99.8%
Sum of all eigen values	2.5600		

7. Continued

The first two principal components representing the trend and tilt of the yield curve explain over 99% of the variation in yields.

The third principal component representing convexity explains only an incremental 0.5% of variation in yields.

- (b) Describe three methods that can be used to derive discount factors beyond 30 years.

Commentary on Question:

Alternative names for the Static Control Method were accepted and received full credit.

Simple monopole method:

Assume a single constant forward rate for all durations greater than 30

Simple dipole method:

Assume a single constant forward rate equal to the last observed rate (30 year rate) for all durations greater than 30

Static Control Method:

Use a total return approach for cash flows beyond 30 years

Derive the marginal cost yield curve from the model

- (c) Recommend a method from your answer to (b) to derive discount factors in this scenario. Support your recommendation.

Commentary on Question:

Most candidates did not receive full credit for this part. In order to receive full credit, the answer must be tied to the prolonged low rate scenario presented in the question and also state why the recommended method is superior to other methods listed in part (b) for this particular scenario.

Alternative recommendations were accepted as long as candidates clearly stated how the method can be used in a low rate environment.

Recommend Simple Dipole Model

Model holds rates constant beyond year 30 at the 30 year rate

This method best reflects the low rates in the future

Simple monopole model would take losses while interest rates remain below assumed rate level.

7. Continued

Static Control Model will require higher allocations to the total return component with an increased total return hurdle rate. Total return component would become unmanageable in a prolonged low rate environment. Key parameters in the model will need to be adjusted resulting in an increase in the liability value for which an appropriate amount of economic capital should be held.

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:

- (3b) Assess the appropriateness of a given stochastic simulation technique to quantify various market risk exposures.
- (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.
- (5a) Evaluate the methods and processes for measuring and monitoring market risk positions.

Sources:

Dowd, Measuring Market Risk 2nd ed, Ch 4

Commentary on Question:

The goal of this question is to show understanding of non-parametric methods through the calculation of risk measures and the interpretation of the results. Candidates were also asked to support a recommendation to use parametric methods. Candidates performed well on part a) but not on part e)

Solution:

- (a) List 2 advantages and 2 disadvantages of non-parametric methods.

Advantages

Can accommodate fat tails, skewness and other non-normal features
Easy to produce confidence intervals for non-parametric VaR and ES

Disadvantages

Extreme losses unlikely to recur in sample period can dominate estimates
In general, no allowance for events that might occur but didn't in sample period

- (b) Calculate the 95% VaR and 95% expected shortfall (ES) based on the histogram.

Commentary on Question:

Part b) requires the candidate to interpret a histogram in order to calculate VaR and ES. Most candidates did not understand this comprehension question. For example, if a candidate misinterpreted the histogram in the wrong direction, Profit/Loss versus Loss/Profit, some credit was lost.

8. Continued

There are 500 losses.

95% is the highest 25 losses of the 500 losses

The 26th loss occurs at 150, so $\text{VaR}(95) = 150$

ES(95) is the average of the highest 25 losses

$(20 \cdot 200 + 5 \cdot 150) / 25 = 190$, so $\text{ES}(95) = 190$

- (c) Explain how to improve the results in (b) using the following:
- (i) Bootstrapped historical simulation.
 - (ii) Weighted historical simulation.

Commentary on Question:

Candidates did well on this comprehension part of the question. Some candidates did well in explaining the methods but did not explain how the methods improve the results and were given only partial credit.

- (i) Improvements from Bootstrapping
More accurate than raw estimate because the new sample size is much larger than original
New sample is useful for gauging precision of estimate based on raw data
Enables us to calculate a confidence interval for any parameter we estimate
 - (ii) Improvements from Weighted Historical Simulation
Reduces distortions caused by events not likely to recur
Helps reduce ghost-effect
Allows obtaining VaR and ES estimates that can exceed maximum loss in historical data set
- (d)
- (i) Describe the impact of ignoring the change in volatility.
 - (ii) Explain how to correct for the change in volatility.

Commentary on Question:

Candidates did well on this analysis part of the question.

- (i) Data from the older period will understate the changes we expect to see tomorrow, thus historical returns will underestimate tomorrow's risks.

8. Continued

- (ii) Explain how to correct:
Adjust historical returns to reflect how volatility tomorrow is believed to have changed from its past values.
Use volatility weighting on the historic returns, grossing up the data in the old set 2 times, and calculate the HS P/L using these data points, then estimate the VaR or ES in the same familiar way.
- (e) Recommend a better approach for calculating risk measures for RWC's subsidiary. Justify your recommendation.

Commentary on Question:

Candidates did not score well on this knowledge utilization part of the question. Few recognized the parametric approach as the right solution. Some candidates recommended a semi-parametric approach and partial credit was given if the recommendation was well-supported. Most candidates were not able to relate their recommendation to RWC's specific situation.

RWC should use a Parametric Approach

Reasons

Emerging Market - Non-parametric need time series data on all current positions, not generally available in emerging markets

Lots of Recent Fluctuation - large one-off events can cloud non-parametric estimation

Expect future one-off volatile events - non-parametric approaches based on underlying assumption that near future like recent past

9. 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:

- (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

Sources:

Jonathan Berk and Peter Demarzo, Corporate Finance, Third Edition, Ch 18

Case Study

Commentary on Question:

This question tests the ability of the candidate to incorporate information from the case study into a scenario comparing two different funding strategies for a project.

Candidates that performed well on this question were able to use information provided in the case study to successfully support their answers. Some candidates struggled with ensuring their answers were specifically related to information provided in the case study.

Solution:

- (a) Describe the Weighted Average Cost of Capital (WACC) method to value a project.

Commentary on Question:

Most candidates did not discuss the applicability of WACC (#2) in their responses.

- The WACC method takes the interest tax shield into account by using the after-tax cost of capital as the discount rate: $R(\text{wacc}) = E / (E+D) * R(E) + D / (E+D) * R(D) * (1-\text{marginal corporate tax rate})$.
- Applicability of WACC: The firms' cost of capital is equal to the WACC if the market risk of the project is similar to the average market risk of the firms' investment.
- The key steps in WACC are: Determine the free cash flow of the project.
- Compute the weighted average cost of capital using formula above the value of the project is the free cash flow of the project discounted by using the WACC.

9. Continued

- (b) Explain whether the WACC method is appropriate for evaluating the project.

Commentary on Question:

Many candidates did not adequately support their assessment of the WACC method's suitability for the valuation of the project.

- For using WACC, we will need to assume constant debt to equity ratio and assume the project's market risk is similar to the risk of remaining of firm's investment.
 - This project has different risk profile from RPPC's. This project may also have different leverage than the company overall under above two funding strategies.
 - When we relax the assumption of a constant debt-equity ratio, the equity cost of capital and WACC for a project will change over time as the debt-equity ratio changes. As a result, the WACC method is difficult to implement.
- (c) Recommend the preferred funding approach from strategies I and II based solely on project value. Show your work.

Commentary on Question:

Some candidates did not calculate the actual project value as the question requested but stopped at the levered value.

Strategy I

Unlevered Cost of Capital of Omega Airlines $R(U) = E / (E+D) * R(E) + D / (E+D) * R(D)$

$$= 35\% * 12\% + 65\% * 10\% = 10.7\%$$

$$\text{Unlevered Value } V(U) = \text{FCF} / R(U) = 15\text{m} / 10.7\% = \$140.19\text{m}$$

$$\text{Levered Value } V(L) = V(U) + \text{PV}(\text{Interest Tax Shield}) = 140.19\text{m} * (1 + 0.3 * 0.35) = \$154.91 \text{ m}$$

$$\text{Project Value} = V(L) - 50 = \mathbf{\$104.91\text{m}}$$

Strategy II

$R(U) = 10.7\%$, $\text{FCF} = 15\text{m}$, $\text{Debt} = 100\text{m}$

$R(\text{wacc}) = R(U) * [1 - \text{marginal corporate tax rate} * \text{Debt} / (\text{FCF} / R(U) + \text{marginal corporate tax rate} * \text{Debt})]$

$$= 10.7\% * (1 - 35\% * 100\text{m} / (15\text{m} / 10.7\% + 35\% * 100\text{m})) = 8.56\%$$

$$V(L) = 15 / 0.0856 = \$175.23 \text{ m}$$

$$\text{project value} = \$175.23 - 50 = \mathbf{\$125.23}$$

9. Continued

Strategy II (Alternate)

Unlevered Value $V(U) = FCF / R(U) = 15m / 10.7\% = 140.19m$

Levered Value $V(L) = V(U) + \text{marginal corporate tax rate} * \text{Debt} = 140.19m + 35\% * 100m = 175.19m$

Project Value $= \$175.19 - 50 = \mathbf{\$125.19m}$

Recommend II: Increase debt by \$100 m because it has higher project value.

- (d) Identify risks specific to Blue Jay Air of choosing a funding approach based solely on the calculated project value.

Commentary on Question:

Candidates were successful in realizing that the company is already extremely leveraged. Beyond that, candidates struggled tying their responses back to the information contained in the case study. Specifically, candidates did not realize that the tax shield is only useful if tax losses can be carried forward and future profitability is expected. Furthermore, most candidates did not reference the fact that Blue Jay Air has had losses the last 2 to 3 years.

- Optimal leverage depends on project and firm characteristics. Project with safer cash flows can support more debt. We need to do more analysis on the characteristics of the project cash flow.
- Blue Jay Air is already highly leveraged with negative shareholder equity. It is under stress and likely will not be able to increase debt by any amount.
- In the last 3 years Blue Jay Air made losses in 2 out of 3 years.
- The tax shield is only useful if tax losses can be carried forward and outlook of future profitability is high.

10. 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:

- (2b) Describe the factors impacting short-term capital needs.
- (2c) Recommend an optimal capital structure and how to implement it for a given business or strategy.
- (2g) Evaluate human behavioral biases in the decision making processes.

Sources:

Jonathan Berk and Peter Demarzo, Corporate Finance, Third Edition, Ch 26

Jonathan Berk and Peter Demarzo, Corporate Finance, Third Edition, Ch 27

Behavioral Biases and Corporate Decision Making on Investing Abroad

Case Study

Commentary on Question:

This question tested candidates' understanding of working capital management and short-term financial planning. Successful candidates calculated financial metrics and understood differences between trade credit and commercial paper financing and their effects on a company's balance sheet.

Solution:

- (a) Assess Frenz's operational performance relative to its competition using the following metrics. Show your work.
 - (i) Net working capital
 - (ii) Operating cycle
 - (iii) Cash conversion cycle

10. Continued

Commentary on Question:

Candidates did moderately well on this question. Many candidates were able to calculate working capital and the cash conversion cycle. Fewer were able to calculate the operating cycle. Successful candidates were able to recall the formulas for these basic operational performance metrics. An assessment of Frenz's ranking versus the industry was required for full credit.

(i) $WC = \text{Current Assets} - \text{Current Liabilities}$
 $WC = 423 - 175 = 248$ (million)

Frenz is ranked in the 3rd quartile in the industry, which is below average performance.

(ii) $OPC = \text{Accounts Receivable} / \text{Avg. Daily Sales} + \text{Inventory} / \text{Avg. Daily COGS}$
 $OPC = 60 / (1166 / 365) + 96 / (495 / 365) = 89.6$ (days)

Frenz is ranked in the 3rd quartile in the industry, which is below average performance.

(iii) $CCC = \text{Accounts Receivable} / \text{Avg. Daily Sales} + \text{Inventory} / \text{Avg. Daily COGS} - \text{Accounts Payable} / \text{Avg. Daily COGS}$
 $CCC = 60 / (1166 / 365) + 96 / (495 / 365) - 24 / (495 / 365) = 71.9$ (days)

Frenz is ranked in the 4th quartile in the industry, which is among the worst industry performers.

- (b) Complete the following table.

Commentary on Question:

Candidates' performance varied widely. Successful candidates correctly adjusted the formulas for working capital and the cash conversion cycle for the new capital management strategy.

An alternative solution which recognized that the traditional CCC definition may miss the use of commercial paper as part of its cash cycle because short-term debt is not included in accounts payable received full credit.

10. Continued

90-day Commercial Paper (4% discount to face)

$$3 \text{ month interest cost} = 100/96 - 1 = 4.17\%$$

$$\text{EAC} = 1.0417^4 - 1 = 17.7\%$$

Assuming Frenz issues enough commercial paper to finance the entire inventory,

New WC = Current Assets - Current Liabilities - Commercial Paper Balance

$$\text{New WC} = 423 - 175 - 96 = 152 \text{ (million)}$$

CCC remains unchanged

2/10, Net 40, Supplier Trade Credit

Assuming Frenz plans to wait to the last day to pay suppliers,

$$30\text{-day interest cost} = 2 / 98 = 2.041\%$$

$$\text{EAC} = 1.02041^{(365 / 30)} - 1 = 27.9\%$$

New APD = 40 (days)

$$\text{New Accounts Payable} = \text{New APD} * \text{Avg. Daily COGS} = 40 * (495 / 365) = 54.2 \text{ (million)}$$

New WC = WC - Change in AP

$$\text{New WC} = 423 - 175 - (54.2 - 24) = 217.8 \text{ (million)}$$

$$\text{New CCC} = 60 / (1166 / 365) + 96 / (495 / 365) - 40 = 49.6 \text{ (days)}$$

- (c)
- (i) Contrast the two potential strategies.
 - (ii) Recommend which capital management strategy Frenz should implement. Support your recommendation.

Commentary on Question:

Very few candidates did well on this question. Successful candidates contrasted the effects of each capital management strategy on Frenz's performance metrics.

- (i) Commercial paper has a lower interest cost than the trade credit and will reduce WC, but WC is a less meaningful benchmark because it is affected by the size of a company. Trade credit has a higher interest cost than commercial paper, but it will reduce WC and CCC significantly.

Commercial paper will have no effect on a traditional CCC metric. Trade credit: Frenz will increase its performance ranking into the second quartile for the WC and CCC metrics.

10. Continued

Commercial paper: Traditional CCC becomes less useful because it does not capture the financing of inventories with commercial paper. CCC is also a more meaningful benchmark than WC because it is not affected by the size of a company.

- (ii) Recommend trade credit because the strategy will improve Frenz's performance for WC and CCC. Commercial paper will have no effect on the CCC benchmark, and it forces the company to become reliant on short-term financing, which creates interest rate risk.
- (d) Describe the heuristic biases the CEO is relying upon.

Commentary on Question:

Successful candidates correctly identified and described at least two biases.

"I know this strategy will work because I've seen it work at other companies."

Overconfidence bias – a level of expressed confidence that is unsupported by the evidence.

"I'm confident we'll see immediate improvements in the industry benchmarks."

Optimism bias - tendency to be over-optimistic about the outcome of planned events.

11. Learning Objectives:

4. The candidate will understand how to critique the appropriateness of advanced risk assessment methods for a given situation.
5. The candidate will understand how to identify and recommend appropriate risk assessment and monitoring techniques for financial risk management.

Learning Outcomes:

- (4c) Evaluate the limitations of modeling dependences in risk variables.
- (4e) Assess when a copular based capital aggregation model is desired over a correlation matrix based approach.
- (5a) Evaluate the methods and processes for measuring and monitoring market risk positions.

Sources:

Dowd, Measuring Market Risk 2nd ed, Ch 5

Dowd, Measuring Market Risk 2nd ed, Ch 12

Dowd, Measuring Market Risk 2nd ed, Ch 6

Jonathan Berk and Peter Demarzo, Corporate Finance, Third Edition, Ch 1

Case Study

Commentary on Question:

This question included analysis, recall and comprehension components, testing candidates' ability to calculate basic statistics and recall conditions for applicability, and to identify appropriate methods for deriving earnings dependence of two different entities.

Solution:

- (a) Calculate the standard deviation of earnings for Blue Jay Tire. Show your work.

Commentary on Question:

This question required an assumption that was not provided in the question stem. As a result, all candidates received full credit for part (a).

$$\text{Var}(x) = 800 \text{ million}$$

11. Continued

- (b) Calculate the covariance of the earnings for Blue Jay Tire with the earnings of all of RPPC.

Commentary on Question:

Many candidates used an incorrect formula for covariance. Partial credit was given for correct formulas.

$$\text{cov}(x,y) = \beta_x \beta_v \sigma_x^2 + \varepsilon$$

ε is zero because BJT's firm-specific risk is zero

$$= (0.8) * (1) * 1,0002$$

800,000 million

- (c) Estimate the correlation of Blue Jay Tire's earnings with RPPC's earnings using the information you calculated in (a) and (b).

Commentary on Question:

Since the solution to part (c) depended on part (a), all candidates received half credit for part (c) to compensate for the inability to substitute an answer from (a). Further credit was awarded for correct use of the formula for correlation, regardless of what, if any, value was used from part (a).

$$\text{correlation}(x,y) = \text{cov}(x,y) / \sigma_x \sigma_v$$

$$= 800,000 / (800 * 1,000)$$

$$= 1 \text{ or } 100\%$$

- (d) Describe four caveats of estimating the correlation between earnings using the above methodology.

Commentary on Question:

Candidates performed well on part (d). The source contained several acceptable answers.

- Correlation estimates are often very volatile so you should use estimated amounts with great care
- It often takes a large number of observations to detect any changes in correlations so the risk of using incorrect data is increased, and once detected it may be too late to respond
- Correlations can appear stable in normal market conditions but change in a stressed environment. Cannot assume assumptions will hold in abnormal markets or in tails of the distribution

11. Continued

- Correlation is defined under limited conditions so you must verify those conditions do indeed exist

(e)

- (i) Evaluate your work in light of her concern.
- (ii) Propose an alternate methodology for deriving the earnings dependence of a subsidiary with the larger RPPC organization.

Commentary on Question:

Candidates did not perform well on part (e).

It is true that the methodology used above does depend on similar and well-behaved elliptical distributions. It is still good for rough estimates and quick “rule of thumb” analysis.

A more robust methodology would be to use copulas to determine correlation/dependence. This methodology does not depend on the underlying distributions, and is able to integrate disjoint marginal distributions into a single multivariate distribution for risk estimation. However, copulas are not easy to use.

12. Learning Objectives:

4. The candidate will understand how to critique the appropriateness of advanced risk assessment methods for a given situation.
5. The candidate will understand how to identify and recommend appropriate risk assessment and monitoring techniques for financial risk management.

Learning Outcomes:

- (4f) Assess approaches to quantify risks when there is limited data.
- (5a) Evaluate the methods and processes for measuring and monitoring market risk positions.
- (5c) Assess the methods and process for quantifying and managing model risk within a financial institution.
- (5d) Design an appropriate stress-testing process and evaluate its limitations for a given risk position.

Sources:

Dowd, Measuring Market Risk 2nd ed, Ch 13

Case Study

Ali Samad-Khan, Modern Operational Risk Management

Solution:

- (a) Critique your colleague's statement.

Commentary on Question:

Many candidates assumed that VaR and CTE were only model based, while stress testing was not model based, which is not always true. Many candidates remarked that stress testing was good as a supplementary measure. Several alternative answers could receive full credit.

My colleague's statement is not completely correct. VaR gives us the maximum likely loss at a certain probability, but gives us no idea of the amount of loss we might suffer if we experience a loss in excess of VaR.

Scenario testing is a complement to VaR and CTE; each highlights what the other might miss.

Stress Tests are coherent risk measures. VaR is not.

12. Continued

- (b) Describe the three main forms of scenarios used in stress testing.

Commentary on Question:

Many candidates wrote answers describing types of stylized scenarios, namely mechanical and factor-push. Full credit answers had to describe the three main types of scenarios listed below.

1. Stylized scenarios: a simulated movement in one or more major interest rates, exchange rates, stock prices or commodity prices. Can be moderate or extreme. Movements expressed in terms of absolute changes, percentage changes, or in standard deviation units.

2. Actual historical events: Historical scenarios can be based on relatively moderate market changes, which presumably have a reasonable chance of repeating themselves, or more extreme market changes, which are much less likely but more significant if they do. Can also be based on bootstrap exercises from historical data.

3. Hypothetical one-off events: Scenarios can come from plausible hypothetical scenarios that have no direct historical precedents. Scenarios are not replays of past historical events but can be similar to past events.

- (c)
- (i) Propose a stress test specific to Big Ben for each of the four risks. Support your proposals.
 - (ii) Identify the form of scenario from your answer to (b) used in each proposed stress test in (c)(i).

Commentary on Question:

Many well-supported alternative answers received credit. Several candidates were unable to make the stress tests specific to Big Ben and its risks, which was an important aspect of the question.

Many candidates were able to successfully identify a stress test for a Regulatory Risk and a Sovereign Risk. Strategic Risks and Operational Risks seemed more difficult for candidates to devise appropriate stress tests because they were unable to provide a specific risk to be tested.

As long as the candidate was able to identify an appropriate stress test and name the type: stylized, historical, or hypothetical they were able to get full credit for part (ii).

12. Continued

The model solution shows an example of a full credit answer, but other stress tests would also be acceptable.

I. Sovereign

The Balance Sheet has 50% of assets in foreign bonds. A *stylized stress test* could be a sudden change in exchange rates, downgrade of foreign bonds, or a change in the classification of these bonds for capital purposes.

II. Strategic

A recent drop in AUM followed by a sudden increase in redemption caused a change in the Strategic approach. A *historical stress test* could be to repeat this exact situation of an AUM drop as an actual historical event.

III. Operational

The revised strategy to integrate wealth management and insurance offerings could be tested in relation to the systems. A *hypothetical one-off event stress test* could be to assume systems are down for some time, and measure profitability, productivity, and reputation exposure / loss over the period.

IV. Regulatory

Changes to Basel III Capital Adequacy result in increased capital requirements for Big Ben. This would be a *hypothetical one-off event stress test*.

- (d) Recommend two strategies to mitigate each of the following:
- (i) Operational Risk
 - (ii) Sovereign Risk

Commentary on Question:

Operational risk mitigations tended to be more general than those for Sovereign risk. Many gave examples of “establish controls”, “have an oversight function”, or “create a risk management culture”. Candidates that scored better had more specific mitigations to the risk at hand.

(i) Operational Risk

Traditional and Commercial banking are predominately online instead of physical branches - the risk is cyber-attacks, hacking, and information security. A mitigation could be to add additional security or other data protection strategies. Another option would be to purchase data protection from a vendor.

12. Continued

(ii) **Sovereign Risk**

The Balance Sheet has 50% of assets in foreign bonds. Possible mitigations to this exchange rate (and potential credit exposure are the following):

- Foreign interest rate / currency futures, swaps, securitization of expected cash flows, etc.
- Diversification of foreign assets, reducing holdings in Government X.

13. 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:

- (2d) Evaluate the capital efficiency of using reinsurance or securitizations for a given risk.

Sources:

Trainer & Cummins, Securitization, Insurance, and Reinsurance

Commentary on Question:

This question tested candidates' understanding of the reinsurance market and insurance-linked securitization alternatives. Successful candidates understood how reinsurance transactions are assessed using a mean-variance diversification model, why normality assumptions might not be appropriate, the benefits of securitization, and how a reinsurance company securitizes risk. Candidate performance was poor.

Solution:

- (a) Identify three characteristics of an efficient reinsurance market.

Commentary on Question:

Many candidates were able to identify one characteristic correctly. Few obtained full credit. Inexact wording of correct answers, if reasonable, received credit.

Large Reinsurers

Reasonable small variances

Premium charges close to the expected value of loss

- (b)
 - (i) Recommend which quote Telfair should accept using the CRO's criteria. Justify your recommendation.
 - (ii) Evaluate the appropriateness of the CRO's assumptions. Support your evaluation.

Commentary on Question:

Candidates' performance on this part varied widely. Some candidates were able to obtain full credit for part (i) or (ii).

For part (i), many candidates did not calculate the probability of ruin but instead made a recommendation based on the given data without a calculation. Partial credit was given to these candidates for reasonable answers.

For part (ii), some candidates misunderstood the question by criticizing the CRO's decision criteria instead of the CRO's normality assumption.

13. Continued

- (i) For all reinsurers: $E(\text{loss})$ is 100 and σ_{loss} is 400.

For Reinsurer X: $P = 147.87$, $r_c = 10\%$, $\text{sqrt}(\sigma_{ij}) = \text{sqrt}(0.15) \times 400 = 154.92$. All values given.

Substituting into the general formula and solving for $z\varepsilon$: $147.87 = 100 + 10\% \times z\varepsilon \times 154.92$, implies $z\varepsilon = 3.09$.

Using the standard normal c.d.f. (given), $z\varepsilon$ of 3.09 implies a probability of ruin, ε , of 0.1%.

For Reinsurer Y: The implied probability of ruin is 1.0%.

For Reinsurer Z: The implied probability of ruin is 5.0%.

Recommend Reinsurer X because it has the lowest implied probability of ruin by far.

- (ii) CRO's assumption is not appropriate. Because risks in the real world are not normally distributed but are highly skewed. The cost of capital for reinsurers is likely to deviate from levels implied by capital market theory to reflect skewness and the stress that the riskiest reinsurance policies place on capital and solvency. Reinsurer utility, agency costs, regulatory costs and accounting rules are ignored by assuming normal distribution to measure insolvency.

(c)

- (i) Briefly describe the cause of the underwriting cycle.
- (ii) Describe three ways an insurance securitization can resolve reinsurance market inefficiencies.
- (iii) Summarize the steps Telfair would take to issue insurance-linked cat bonds as a substitute for buying reinsurance.

Commentary on Question:

Candidate did poorly on part (i). Most candidates did not describe the cause of underwriting cycle correctly or simply described a completely different economic cycle such as the business cycle or an interest rate cycle.

Candidates had average performance on part (ii). Most candidates were able to describe one or two ways that securitization can resolve reinsurance market inefficiencies. Few could describe three for full credit.

Candidates did well on part (iii), Many candidates were able to write down key steps involving an SPV and describe the impact of insured claims.

13. Continued

- (i) Reinsurers that face relatively high costs of external funds and hold relatively low internal capital will have higher prices than firms with lower costs of capital and higher internal funds. Prices are inversely related to the amount of capital held by firms. Risk aversion declines as capital increases.
- (ii) Risks correlated within the reinsurance market may be uncorrelated with other risks in the economy. This allows reduction in the covariability loading in reinsurance premiums.

Equity capital of reinsurers is small compared total volume of traded capital market securities. It is more efficient to transfer risks in larger market.

Securitized financial instruments can reduce or eliminate the credit/counterparty risk inherent in reinsurance agreements.

- (iii) Telfair initiates issuance of insurance-linked bonds.

Telfair establishes a special purpose vehicle (SPV), a free-standing entity off balance sheet.

SPV raises funds by issuing bonds to investors.

Funds raised with the bond issue by the SPV are held in a trust and invested in safe securities.

SPV enters a reinsurance transaction with Telfair or SPV reinsures Telfair's excess claims.

Reinsurance agreement allows for release of funds from SPV on occurrence of cat event.

Investors receive a higher yield on bonds for taking on risk of loss of bond principal.

Bond premium is paid indirectly by Telfair in return for reinsurance coverage.