CFE FD Model Solutions
Spring 2018

1. **Learning Objectives:**
1. The candidate will understand how a business funds its activities with considerations for its business model, and the cost and constraints on the sources of capital, including other market frictions.

Learning Outcomes:
(1a) Identify and critique the available funding sources at different stages of a business's development.

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

Sources:
Corporate Finance, Berk, Chapter 8 Fundamentals of Capital Budgeting

Raising Capital - Sherman, Chapter 1 Capital Formation Strategies and Trends

Raising Capital - Sherman, Chapter 7 Commercial Lending

Raising Capital - Sherman, Chapter 11 Preparing for an Initial Public Offering

How do CFOs make Capital Budgeting & Structure Decisions (Duke University)

Creating Value through Capital Allocation (JP Morgan)

Case Study

Commentary on Question:
The goal of this question is for the candidate to demonstrate an understanding, identifying and critiquing the available funding sources as well as evaluating capital budgeting approaches for non-insurance organizations.

1. **Continued**

Solution:
(a)   Describe four concerns that may impact a commercial lender's willingness to make a loan to Frenz.

Commentary on Question:
Candidates scored well in general in this part. Any four of the list below received full credit. Candidates need to refer to Frenz's situation to receive full credit. General descriptions without referencing to the case study only receive partial credits.

(1) Additional debt could increase. Frenz's leverage ratio above the threshold mandated by the conglomerate. (Sign of credit risk)
(2) Frenz does not have a well-defined risk management program in place. There is still disagreement about which committee will oversee the program (No proper financial control in place)
(3) Frenz experienced recent reduction in market demand and significant investment loss which indicates poor business judgement and improper financial control. (Sign of poor business judgment in the past)

(4) The business has a low entry barrier thus competition can be fierce (What if business fails, can they repay the loan)
(5) Company does not have any trade credit agreements with suppliers thus Frenz could have difficult in maintain the quality of products. (Doesn't seem to have a strong strategy plan)
(6) Company is facing expansion which can be challenging and risky and may cause disruption to the ongoing business. (Growing too fast that may jeopardize the ability to repay)
(7) The company fails to exhibit an understanding of its business strategy and risk profile since the supply-demand economic model in place is simple and does not consider their operations and interrelationship with RPPC. (Fail to demonstrate that they have a clear understanding of the business)
(8) The oil price increases over recent year have eroded Frenz's profit margins which implies the company has poor risk management and financial control. (No proper financial control in place)

(b)   Explain why issuing equity may lead to negative market reactions according to the pecking-order model.

Commentary on Question:
Candidates are expected to touch on both the pecking order theory and negative market reactions to receive full credit. Most candidates scored well in this question.

1. Continued

In pecking-order theory:
- Issuing equity is considered very expensive, last resort
- Management should avoid issuing equity when the company is undervalued

- Investors thus rationally interpret most management decisions to raise equity as a sign that the firm is overvalued – at least based on management view of the future and a potential stock price reduction.
- Equity issuing will cause the existing shareholders to experience dilution of value.

(c) Considering the Vietombia project (Case Study, Section 4.2.3 & Section 4.3 – Exhibit 5b):

(i) Calculate the project payback period.

(ii) Calculate the net present value of the project.

(iii) Explain why this project's cost of capital is higher than Frenz's cost of capital. Support your answer.

(iv) Justify the use of the net present value criterion instead of the payback period to evaluate the Vietombia project.

Commentary on Question:
Most candidates did well in the calculation parts. For part iii, candidates need to give reasons for why the Vietombia project is risker than Frenz overall. Candidates are expected to discuss the particular situation of the project based on case study information to gain full credit. For part iv. Candidates need to discuss both shortcomings of payback period and why NPV is more appropriate to gain full points.

(i) NPV = -100 + 10 / r, where r = 20%, NPV = -50 M

(ii) Payback period =-100 / 10 =10 year

(iii) Vietombia project faces unique risks in addition to the risks shown in CS Exhibit 2 for Frenz. A few are listed below. The additional risk of Vietombia project suggest it should have higher cost of capital to account for the higher level of risk
Political Risk: Weak law, government corruption, change in political party may lead to an unstable economy in Vietombia.

1. **Continued**

> Regulatory Risk: Banking system and risk management practice is still under development. The company's rights and investment may not be well protected.
> Reputation Risk: The use of cheaper coffee beans may affect customers' perception of the quality of Frenz's products.
> Currency Risk: The pegging system is beyond the control of Frenz. Political and financial changes in the neighboring countries may lead to unfavorable currency impact to Vietombia.

(iv) The payback period is within the company requirement, but the payback criterion is not a good decision-making tool since it ignores:
- the time value of money
- the value of cash flows beyond the cutoff date
- the cutoff is usually arbitrary

For NPV calculation, the 20% is higher than RPPC CoC to account for the additional risk in the project. But, the additional risk is not accounted for using payback period method.

(d) Evaluate the Vietombia project's impact to Frenz's existing business in terms of:

(i) Synergies

(ii) Cannibalization

Commentary on Question:
Candidates received partial points for defining synergy and cannibalization. Candidates are expected to tie to the case study to receive full credit.

Synergies:
Vietombia project complements Frenz's existing business and help it manages its supply chain risk, it provides synergies to the business.

Cost Reduction. Frenz has greater control over pricing with the exclusive supply of high quality coffee beans.
Knowledge: Frenz can get the talent and knowledge in the Vietombia coffee bean production.

1. **Continued**

Cannibalization:
Market cannibalization is the negative impact of a company's new product on the sales performance of its existing and related products.

The introduction of new coffee bean may intrude on the existing market for other products, such as tea, fruit drinks, rather than expanding company's market base. If customers realize the new bean is not as superior as those from Costa Rica, it may lead to reduction in coffee sales and other products.

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

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

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

Sources:
Trainer & Cummins, Securitization, Insurance, and Reinsurance

Commentary on Question:
Commentary listed underneath question component.

Solution:
(a)
   (i)   Calculate the minimum per policy capital requirement for 2018. Show your work.

   (ii)   Critique this methodology for determining capital for Darwin's term block.

   Commentary on Question:
   Most candidates did not recognize that the standard deviation would reduce as a result of the aggregation of the number of policies for part i.

   (i)   Standard deviation for a single product is 300. Because risks are independent and identically distributed, the variance of the block is equal to # of policies multiplied by variance per policy. With a 1% threshold for loss, the z term is 2.33. From the case study, the total number of policies is 210,000.

          $1.52 = 2.33*300/(210,000\text{^}0.5)$

   (ii)   Resulting capital amount for Darwin's term block may be excessive because US reserve requirements for term life may already exceed the risks involved. If risks are not statistically independent, more capital will be required and premium capital charge will be higher

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2. **Continued**

(b)   Identify advantages and disadvantages of reinsurance as the mechanism of risk transfer in the insurance industry.

Commentary on Question:
Below are sample answers, other reasonable responses also received credit.

Advantages:
Reinsurer may have assumptions experience not available to the company
Diversification benefits from aggregation of policies

Disadvantages:
Reinsurance contracts held on the balance sheet are opaque to securities markets, making it difficult for equity holders to evaluate the firm, and creating information asymmetries, which increase cost of capital
Market begins to crumble when faced with very large, highly skewed risks whose realizations could create major shocks to the reinsurer capital base

(c)   Explain the steps Darwin should follow to use securitization.

Commentary on Question:
Candidates in general had to recognize that the SPV was a separate entity and recognize that investors received payments in exchange for the risk of the principal being called upon a catastrophic event.

Darwin will first have to establish a special purpose vehicle (SPV).
An SPV will be a free-standing entity that is off Darwin's balance sheet
The SPV will raise capital by issuing bonds to investors
The funds raised by the SPV will be held in trust in safe securities such as government bonds
Darwin and the SPV will enter in to a reinsurance agreement where the SPV promises to release funds to Darwin upon the occurrence of mortality hitting a preset threshold
In exchange for taking on the risk of possibly losing the bond principal the investors will receive a premium. This premium will be paid by Darwin to the SPV in return for the reinsurance coverage.

(d)   Recommend whether Darwin should reinsure or securitize the ULSG block as a method of transferring risk to reduce capital requirements. Justify your recommendation.

Commentary on Question:
Either answer was acceptable and received credit if adequately defended

2. **Continued**

Securitization:
Securitization is an appropriate method to transfer ULSG risks to capital markets due to the following reasons:

The ULSG block will come under AXXX regulations, which may require Darwin Life to hold reserves that far exceed the risks involved in these policies.

Securitization will allow Darwin Life to work around inefficiencies created by prudential regulation, particularly if the regulatory reserve requirements appear to be excessive relative to internal models.

Securitization, if properly structured, can also eliminate credit risk inherent in reinsurance policies.
Non-independent risks will increase the premium required by the reinsurer due to not being able to fully diversify the risks

Reinsurance:
Reinsurance is an appropriate method to transfer ULSG risks to capital markets due to the following reasons:

Risks are numerous, statistically independent and maximum probable losses are relatively small. For this type of risk reinsurance works better.

(e) Recommend two products within the RPPC family, other than ULSG, that would be good candidates for securitization. Support your recommendation.

Commentary on Question:
Other examples other than the ones below included lines subject to skewed or catastrophic risks (such as the marine insurance product).

Big Ben Bank can securitize its long-term loans. Big Ben has the expertise.
Loans can be packaged into high quality, high yield, and long duration investment to satisfy investor needs and also transfer underlying risk from balance sheet.

Darwin can securitize its term life block. US regulations may require Darwin to hold reserves in excess of the risk involved. Securitization will allow Darwin to work around the prudence in the reserve requirement.

3. **Learning Objectives:**
1. The candidate will understand how a business funds its activities with considerations for its business model, and the cost and constraints on the sources of capital, including other market frictions.

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

Learning Outcomes:
(1a) Identify and critique the available funding sources at different stages of a business's development.

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

(2a) Evaluate how the legal form of an organization, corporate governance, compensation dynamics and other market frictions impact business decisions.

Sources:
Sherman, Raising Capital, Ch. 2,4,6,9

Commentary on Question:
This question tested candidate's understanding of different sources of funding that a company can use and corporation structures.

Solution:
(a) Identify one likely source of funding for each stage of business growth:

  (i) Seed/Start-up stage

  (ii) Growth stage

  (iii) Mezzanine/Bridge

  (iv) Harvest

3. **Continued**

Commentary on Question:
Most candidates did well on this question. For full credit, candidates had to successfully list at least one source of funding appropriate for each stage. Correct answers not listed in the model solution also received full credit.

  (i) Seed/start up stage: personal savings, credit cards, home equity line of credit, 401k and retirement account/pension/life insurance borrowing

  (ii) Growth Stage: Private placements

  (iii) Mezzanine/Bridge: Commercial banks

  (iv) Harvest: IPO

(b) Describe how RPPC's structure as a corporation aligns with its mission and strategic goals (Case Study, Section 1.1 & Section 1.2) with respect to:

  (i) Funding availability

  (ii) Legal structure

  (iii) Governance

  (iv) Ownership

Commentary on Question:
Candidates performance on this question was mixed. Successful candidates clearly described if a corporation structure aligned well or did not align well with RPPC's mission. Unsuccessful candidates did not link how a corporation structure aligned with RPPC's mission. Candidates who simply stated RPPC's mission without describing it from a corporation perspective did not receive credit.

  (i) Funding availability: RPPC's expansion goal requires a lot capital, a corporation gets better access to capital markets to raise additional capital for business expansion.

  (ii) Legal structure: RPPC is planning on global expansion across diverse businesses. Incorporating will protect the founding members' personal assets. They will not be personally liable for the corporate liabilities. Also as the goal is to invest in diverse business, setting up a holding company which own shares in other companies can prevent the creditors from one business having access to another business's asset.

3. Continued

   (iii)   Governance: The management will be more centralized and Board of directors will be making decisions for the business independently. However, there is increased governance requirements associated with being a public corporation, making it more complicated to align interest between different stakeholders.

   (iv)   Ownership: There is no limit to the number of shareholders a corporation can have. RPPC 's original 4 partners' ownership will be diluted if they plan on adding more shareholders, which based on the growth of RPPC down the road, is likely. But given RPPC's long term growth goals, this is a necessary trade off.

(c)   RPPC is planning to invest in new ventures that develop solar energy technologies.

   (i)   Evaluate RPPC's ability as a venture capital investor.

   (ii)   Recommend at which stage of business growth RPPC should invest given its risk appetite (Case Study Section 1.3.6). Justify your recommendation.

Commentary on Question:
Candidates generally did well on part (i) and most candidates got full credit on part (ii).

(i)
- RPPC would be a good fit as a VC investor in new solar energy ventures.
- RPPC is a large holding company that has multiple businesses and hence being a VC investor aligns well with the overall strategy of investing in diverse businesses.
- As a big company, RPPC has a large capital position which can help provide funding
- Able Energy Consulting hired by Blue Ocean can provide market data and insights
- With a variety of businesses, RPPC already has established relationships and distribution networks.

(ii)   RPPC should choose to invest at later stage when the product development is already done. RPPC 's risk appetite states that it doesn't want to take risks that are opaque and would like to have a good understanding of low probability tail events. At early stages of new technology development, a lot of these will be unknown.

3. **Continued**

(d)   Blue Energy, a start-up company developing solar energy technologies, has offered RPPC a private placement opportunity.

> (i)   Describe one advantage and one disadvantage for Blue Energy to use private placement financing.

> (ii)   Evaluate the appropriateness of RPPC as the private placement investor for Blue Energy.

> (iii)   Identify key sections of a private placement memorandum.

Commentary on Question:
Candidates performance for (i) was mixed, (ii) was poor and (iii) was good. For (ii), the question tested RPPC's capability as the private placement investor, not whether they should invest. Candidates who interpreted as the later generally received credit if they provided sufficient justification.

> (i)   Advantage: Reduced costs because it is exempt from many of the extensive transaction and reporting requirements, making it a good choice for early-stage companies
> Disadvantage: As a private deal, the list of potential investors is limited.

> (ii)   RPPC qualifies as an accredited investor. It has the sophistication and expertise of an experienced investor. RPPC should be able to prove their ability to fend for themselves and properly evaluate an offering in the purchaser questionnaire. So, it is appropriate.

> (iii)   Description of the company
> Risk factors
> Terms of the offering
> Financial Statements

4. **Learning Objectives:**
4. The candidate will understand how to identify and recommend appropriate model risk assessment and vetting techniques for risk management models.

Learning Outcomes:
(4a) Assess methods and processes for quantifying and managing model risk within any business enterprise.

(4b) Design and evaluate stress-testing and back-testing processes.

(4c) Interpret stress-testing and back-testing results.

Sources:
Dowd, Measuring Market Risk 2nd ed, Ch 13

Dowd, Measuring Market Risk 2nd ed, Ch 16

SOA, Model Validation for Insurance Enterprise Risk and Capital Models

Commentary on Question:
Overall candidates did well on this question, the main point that was often missed was the fact that model risk is always underestimated.

Solution:
(a) Interpret CRS' classification of model risk as 'low'.

   Commentary on Question:
   Very few candidates were able to answer this question, they instead tried to explain the type of model that would have low model risk.

   Model risk is always underestimated. It is a pessimist's paradise, if it looks good, don't trust it. If it looks bad it's probably worse.
   Since they classified the risk as low we cannot interpret anything of value from the classification.
   Also, since "low" isn't quantified it isn't an actionable definition.

(b) Explain three ways that model risk can increase due to using CRS for model development.

   Commentary on Question:
   Many candidates did well on this portion, some were not able to identify the correct risk name but were able to describe the risks well.

   Conceptual Risk – since the model is being built by consultants there is a possibility of relevant risks to Frenz not being included because of a misunderstanding of the purpose of the model.

4. Continued

Implementation Risk – risk of model errors or bugs, this is often the most underestimated of the model risks.

Output Risk – risk that the model users at Frenz do not understand the model outputs, there is a possibility they are used incorrectly if they are not understood.

(c) You receive a follow-up email from Kaplan before you have a chance to respond to his first:

"In addition, since the CRS model is so much more advanced, I don't think we need to spend time on validating the model, or conducting stress testing going forward."

Critique Kaplan's statement.

Commentary on Question:
Most candidates were able to speak to the importance of validation, however some struggled with the importance of stress testing.

A vendor model should always be validated, especially if it is more complicated and could be harder to understand.

The complexity of the model is irrelevant to the need to stress test. The purpose of stress testing is to measure the risks of the portfolio and understand the impacts of tail risk events.

(d) Propose three stress tests using scenario analysis to address Frenz's supply-chain risks (Case Study, Section 4.3 – Exhibit 2).

Commentary on Question:
Most candidates were successful on this section. Full credit answers had to relate to Frenz's supply chain risks as well as be a scenario, a mechanical stress of 10% increase to coffee bean price does not fit the criteria of a scenario.

1. Drought impacts key area for coffee beans, decreasing supply and driving costs up.
2. Trade war escalates to include tariffs on tea leaves.
3. Explosion at an oil refinery cuts the oil supply and leads to a large jump in oil prices.

(e) Calculate the maximum loss based on two costs from above that would produce the worst-case scenario.

4. Continued

Commentary on Question:
Candidates needed to realize that the two with the highest standard deviations needed to be selected. The standard deviation is what causes a loss in a stress test, the mean is irrelevant. Focusing on the mean led many candidates to incorrectly include tea leaves in the analysis.

Since coffee beans and shipping have the two highest standard deviations they are selected for the factor push analysis.
Maximum Loss = 2*10 + 2* 5 = 30

(f)

    (i)   Explain the meaning of the Confidence Level Parameter, α, in a VaR context.

    (ii)   Identify one advantage of factor push analysis compared to scenario analysis.

    (iii)   Describe two reasons why this mechanical stress test may misestimate Frenz's supply-chain risks.

    (i)   Confidence Level Parameter α is the equivalent of the random variable corresponding to the percentile on which VaR is calculated.

    (ii)   Factor push analysis may give us information about the likelihood of the loss concerned which scenario analysis does not provide.

    (iii)   1. Factor push assumes that the maximum loss happens at the extreme values of underlying variables which may not be true.
        2. Not all of Frenz's supply chain risks would be able to be included in a factor push analysis, such as political risk

5.

Learning Objectives:
5.   The candidate will understand how and when to apply various advanced techniques to evaluate non-hedgeable risk or uncertainty in any business enterprise, especially non-insurance organizations.

Learning Outcomes:
(5c)   Assess the appropriateness of Applied Information Economics (AIE) concepts for risk management.

Sources:
Measurement Solution, Hubbard, Chapter 11,12,13

Commentary on Question:
This question was designed to test the candidates' knowledge of different measurement and information quantification approaches. The goal was to test the candidates' understanding of Applied Information Economics, the Lens Model, and the Analytical Hierarchy Process.

Candidates tended to do either very well or very poorly on this question. Candidates that were familiar with one of the concepts generally tended to be familiar with all three concepts and were able to articulate how they could be applied at Frenz and the key differences between the approaches.

Solution:
(a)   Propose a process using Applied Information Economics (AIE) to strengthen RPPC's current risk appetite statement by better quantifying its risk tolerance.

   Commentary on Question:
   Candidates performance was fair on this section. This question could be answered using a number of frameworks. Credit was given for any Applied Information Economics framework that was appropriate.

   The following steps can be taken for Applied Information Economics:

   Step 1: Identify the appropriate experts to develop the Risk Appetite. This could include the executive suite (CEO, CFO, etc.), business line leaders, and the risk management department.

5. Continued

Step 2: Identify what specific problem RRPC is trying to solve with regard to measuring the risk appetite. Identify risk and reward tradeoff scenarios, such as Return on Investment compared to Probability of Loss. Identify any stratification methods used (such as different investment amounts or different scenarios for each business unit).

Step 3: Have the selected parties review the risk and reward tradeoff scenarios and evaluate them. The parties should identify whether specific risk/reward tradeoffs are considered acceptable for the company.

Step 4: Create a "risk appetite" for each stratification from Step 2 (e.g., a curve for $10M investments, a curve for $100M investments, etc.). This curve serves as the official Risk Appetite for RRPC, and projects that fall above the Risk Appetite curve should be rejected.

(b)

    (i)   Identify two weaknesses with RPPC's key indicators regarding the cost of capital.

    (ii)   Explain how an AIE approach could correct those issues.

Commentary on Question:
Candidates were generally able to come up with weaknesses of the current approach, but struggled to articulate how the AIE process would directly result in better key indicators. There were a number of weaknesses that could have been chosen. Full credit was given for all weaknesses that were correctly identified and how AIE could correct them.

Weakness #1 – The risk appetite does not vary by project investment size, business unit, project duration, or any other relevant criteria. The Risk Appetite simple states that "For any risk, the return on its economic capital must exceed the cost of capital acquired to fund that risk." Using this simple return on economic capital criteria is insufficient.

AIE Benefit #1 – The AIE exercise forces RRPC to vary their risk appetite by relevant risk factors, so that a single static criterion like return on economic capital.

Weakness #2 - Simply using the cost of capital (without any adjustments for other project risks or rewards) is considered to be too low of a hurdle rate. Typical hurdle rates are not adjusted for differences in risks of projects even though risk should be a huge factor in the decision.

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5. Continued

AIE Benefit #2 - Reviewing the risk/reward trade-off scenarios generates a more realistic Risk Appetite curve, that includes considerations for risk of loss and not just the cost of capital to fund a project.

(c)
- (i) Propose three factors for Frenz to include in the model to determine the optimal marketing strategy.

- (ii) Describe how Frenz would use the factors you proposed in part (i) in the Lens Model.

Commentary on Question:
Candidates performed well on part (c). The goal of the question was to test candidates understanding that the Lens model uses the selected factors as the inputs into a regression model, with the output as an increase in customers.

- (i) Frenz should select factors that are likely to vary by marketing strategy and which would be suitable inputs into a Lens-style regression model for determining the potential increase in customers. Three factors could be:
  - Expected length of time to acquire a customer
  - Advertising costs
  - Cost of new product development

- (ii) Using the factors above, Frenz should use the Lens model to develop a suitable regression model in the following way:

  - Generate a set of scenarios (at least 30) using a combination of values for each of the factors identified. The scenarios can be real or hypothetical. For example, one scenario may include marketing to senior citizens, with $8M spent on advertising, with a new product development cost of $1M, with an expected time to acquisition of two weeks.
  - Ask a panel of experts (such as the CMO, CFO, and members on the marketing and distribution teams) to estimate the projected increase in customers based on the values provided for each scenario.
  - Perform a regression analysis on the results, where the x variables are the three factors and the y variable is the increase in customers.
  - Plug each actual marketing initiative being considered into the regression model, to calculate an expected increase in sales for each initiative. Rank the marketing initiatives by the projected increase in customers.

(d) Describe how an Analytic Hierarchy Process could be applied to Frenz's selection of alternative marketing strategies.

5. **Continued**

Commentary on Question:
Candidates performance was fair on part (d). Many candidates were able to describe the fundamental approach of AHP and distinguish how it could be used by Frenz (distinctly from the Lens model).

An Analytic Hierarchy Process can be used to compare pairs of criteria, such that the criteria could be ranked. The AHP could be used by Frenz Corporation to determine the factors (or success measures) for the marketing initiative, such as comparing "increase in sales" to "increase in brand loyalty," to figure out which outcome is more important.

(e) Identify three common weaknesses of the Analytic Hierarchy Process model.

Commentary on Question:
Candidates generally did well on part (e), as the weaknesses of the AHP were a more direct recall exercise. Candidates received full credit if they were able to identify three weaknesses of the AHP. Other legitimate weaknesses of the AHP were also accepted.

Weakness #1 – The AHP violates the "independence criterion" – adding in new variables which are identical for every choice should not change the rank order of previous variables, but it often does under AHP.

Weakness #2 – The AHP often exhibits "rank reversal" – removing a previously ranked variable can cause the remaining variables to switch order, creating a nonsensical ranking.

Weakness #3 – AHP is known to be sensitive to the choice of scales used in setting the comparison (known as "partition dependence").

6. **Learning Objectives:**
1. The candidate will understand how a business funds its activities with considerations for its business model, and the cost and constraints on the sources of capital, including other market frictions.

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

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

(2d) Assess the impact of behavioral factors in capital budgeting methods and capital structure policies.

Sources:
Handbook of Economics of Finance, Ch 5: Baker & Wurgler,

Jonathan Berk and Peter Demarzo, Corporate Finance, Third Edition, Ch 8: Fundamentals of Capital Budgeting

Case Study

Commentary on Question:
This question was designed to test the candidates' knowledge of behavioral factors that influence firms' decisions on financing / capital budgeting and ability to apply that knowledge to specific scenarios related to the case study.

Solution:
(a) Describe why future stock price returns may be lower after a seasoned equity offering targeted at new investors versus a rights offer targeted at a firm's long-term shareholders.

   Commentary on Question:
   Candidates did okay on this comprehension question, although some focused on tangentially related ideas such as pecking order theory as opposed to directly answering the question.

   Seasoned equity offerings are targeted towards new investors whereas rights offers are restricted to current shareholders.

   If a company believes their shares are overpriced, they are likely to target new investors via a seasoned equity offering to take advantage of that mispricing on behalf of their current shareholders.

6. **Continued**

Shares that are currently overpriced are likely to have lower future returns and thus a stock may perform relatively poorly after a seasoned equity offering.

(b)   Calculate RPPC's expected after-tax cost of capital. Show your work.

Commentary on Question:
Almost all candidates were able to successfully calculate RPPC's post-tax cost of capital.

-Cost of Debt = 8% * (1 - 35% tax rate) = 5.2%
-Cost of Equity = 14%
-Cost of Capital = Cost of Debt * (Debt / Value) + Cost of Equity * (1 - Debt / Value) = 5.2% * 40% + 14% * (1 - 40%) = 10.48%

(c)

(i)   Recommend which of the potential Business Lounge upgrades Blue Jay Air should pursue, assuming its goal is to maximize the return on capital. Justify your recommendation.

(ii)   Determine whether the investment decision would change if the managers of Blue Jay Air were compensated based on achieving the highest NPV. Show your work.

Commentary on Question:
Candidates did a very good job on this question, demonstrating their understanding of and ability to calculate different metrics used to judge capital allocation.

(i)   The return on capital of acquiring Luxury Lounges can be calculated using the following equation:
   • Initial Investment = Annual post-tax profits / return on capital (as annual post-tax profits continue in perpetuity)
   • Return on capital = Annual post-tax profits / Initial Investment = $4m / $35m = 11.43%

The return on capital of the renovation is given as 12.5%, which is higher than both RPPC's cost of capital and the return on capital of acquiring Luxury Lounges. Therefore, Blue Jay Air should choose to renovate their lounges.

6. Continued

    (ii)   The NPV of acquiring Luxury Lounges can be calculated as such (based on perpetuity formula):

- NPV = PV of After-tax profits @ cost of capital - Upfront Investment = $4m / 10.48% - $35m = $3.17m

The NPV of the lounge renovation CFs are also likely to resemble a perpetuity:
- Annual post-tax profits = Initial Investment * Return on capital = $10m * 12.5% = $1.25m
- NPV = PV of After-tax profits @ cost of capital - Upfront Investment = $1.25m / 10.48% - $10m = $1.93m

Because the NPV of acquiring Luxury Lounges is higher than the renovation, Blue Jay Air should go through with the acquisition.

(d)

    (i)   Explain why current shareholders would want Blue Jay Air to use the NPV standard.

    (ii)   Explain two reasons why managers prefer IRR over NPV.

Commentary on Question:
Candidate performance varied on this analysis question, with some struggling to describe the logic behind the NPV calculation and/or explain why IRR is so frequently used in the real world.

    (i)   When a company uses capital to make an investment, the present value of any returns above their cost of capital is what ultimately accrues to current shareholders. The NPV standard is the only method of capturing this because it considers both all future cashflows and the cost of capital in the same equation.

    (ii)

1) Cost of capital needs to be calculated, which can be difficult to estimate.
2) Even if a firm-specific cost of capital can be estimated, managers really should be using a project-specific rate.

(e)   Evaluate how over-confidence by Blue Jay Air management may impact their decision on Business Lounge upgrades.

6. Continued

Commentary on Question:
For this analysis question, most candidates were able to identify that management over-confidence could lead to the projection of higher cashflows or a lower risk assessment related to these opportunities, either of which would inflate the calculated NPV of the project.

Blue Jay Air appears to be very confident in the return on capital if they go through with the lounge renovation or the future annual profits from acquiring Luxury Lounges.

However, if these projects are riskier than the rest of RPPC's business, a higher cost of capital should be used and thus the NPV for these projects may actually turn out to be negative, in which case Blue Jay Air shouldn't move forward.

7.

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 identify and recommend appropriate model risk assessment and vetting techniques for risk management models.

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

Learning Outcomes:

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

(4a) Assess methods and processes for quantifying and managing model risk within any business enterprise.

(5c) Assess the appropriateness of Applied Information Economics (AIE) concepts for risk management.

Sources:

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

Hubbard, How to Measure Anything– Chapter 7

Commentary on Question:

Candidates needed to make important considerations around the modeling of significant risks. First, they needed to describe a process to make a rational decision about acquiring more information. As one way of estimating a financial option, they needed to understand the limitations of Black-Scholes. Alternatively, they needed to understand how to set up a stochastic process for estimating an option, limitations of that process, and how to address the limitations.

Solution:

(a) Describe the decision-making process to select between options A and B.

Commentary on Question:
The question provides the expected costs of two options to attain more information. Already having this, candidates needed to focus on how they would determine the expected value of the information to choose the best option relative to the different known costs.

Estimate the EOL where EOL = chance of being wrong * cost of being wrong. This would apply in cases where the reward program is under-utilized (negative reputation) or over-utilized (too expensive).

7. Continued

Each option's value (EVI) is based on the EOL before – EOL after. The consultancy option may seem like a lot ($2M), but it may be small compared to its value.

However, when you have a lot of uncertainty you often assume you need a lot of data (95% reduction in this case), but the relationship between EVI and ECI shows the initial information (first 50% from a survey) reduces uncertainty significantly. We need to consider if the additional 45% would provide a diminishing return on information.

(b)   State two reasons why a Black-Scholes model is an oversimplification for pricing an option.

Commentary on Question:
This part was straightforward with most candidates getting full credit.

1. Log-return of stocks are proven to not follow a normal distribution.
2. Interest rate are constant when they change over time.

(c)   Describe the algorithm to simulate the price paths in the Heston model based on the Euler-Maruyama scheme.

Commentary on Question:
Most candidates could provide a high-level understanding of steps involved but not all steps or sufficient detail for full credit.

1. Initialize processes for volatility v_0 and stock price S_0.
2. Choose $\Delta = T / n$.
3. For $j = 1$ to n do
    a. Simulate $Z \sim N(0,1)$ and $Y \sim N(0,1)$.
    b. $W = p \times Z + \sqrt{1 - p^2} \times Y$.
    c. Update volatility: $v(j \Delta) = v((j - 1)\Delta) + k\left(\theta - v((j - 1)\Delta)\right) \Delta + \sigma \sqrt{v((j - 1)\Delta)}\sqrt{\Delta}W$.
    d. Update log-stock price $X(t) = \ln(S(t))$: $X(j \Delta) = X((j - 1)\Delta) + (r - \frac{1}{2}\left(v((j - 1)\Delta)\right)\Delta + \sigma \sqrt{v((j - 1)\Delta)}\sqrt{\Delta}Z$.
4. Interpolate X(t) linearly between j steps.

(d)

(i)   Explain why this can lead to an issue in the Heston model.

(ii)   Describe three methods to address this iteration error.

7. Continued

Commentary on Question:
Most candidates readily identified the issue placing a negative value in a square root of the processes. Acceptable methods to address the error included modifications to the iterative value or switching to other algorithms such as Anderson or Heath-Platen.

(i)   The prior iteration of the volatility is applied in a square root in part of the formulae for the processes of volatility and log-stock price. This results in an imaginary value.

$$\sqrt{v((j-1)\Delta)}$$

(ii)   Absorption: use the positive part of the previous iterate, $v((j-1)\Delta)^+$, throughout the formulae.
Reflection: use the absolute part of the previous iterate, $|v((j-1)\Delta)|$, throughout the formulae.
Partial Truncation: use the positive part of the previous iterate, $v((j-1)\Delta)^+$, in just the square root of the formulae.

8. **Learning Objectives:**
1.   The candidate will understand how a business funds its activities with considerations for its business model, and the cost and constraints on the sources of capital, including other market frictions.

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

Learning Outcomes:
(1a)   Identify and critique the available funding sources at different stages of a business's development.

(5b)   Apply cost of capital frameworks for risk evaluation in business decisions.

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

CRO Forum, Market Cost of Capital Approach to Market Value Margins

Commentary on Question:
Overall candidates performed moderately well on this question.

Solution:
(a)   Explain what is required to determine the value of Bailey's claim liability in a Solvency II framework.

   Commentary on Question:
   Generally, many candidates omitted references such as the values corresponding to a market consistent framework, that the market value margins only need to include the non-hedgable risks, and that the market value of liabilities needed to be what willing parties would be willing to pay in an open market. Simply listing the components in an overly concise fashion does not demonstrate the depth of understanding required to earn full credit.

   Market Value of Liabilities (MVL) under Solvency II (SII) contains five components:
   1) Present Value (PV) of Best Estimate Liability Cash-flow
   2) Market Value Margin (MVM) for financial non-hedgable risks
   3) MVM for financial hedgable risks
   4) MVM for non-financial non-hedgable risks
   5) MVM for non-financial hedgable risks

   MVL = SUM of the five components above

8. Continued

MVL defined: The market consistent value, price, at which two rational and well-diversified companies would be willing to exchange the underlying liabilities in normal market conditions.

(b)

    (i)   Identify one hedgable and one non-hedgable risk within Bailey's term product.

    (ii)   Explain why a Market Value Margin (MVM) is only required for non-hedgable risks.

Commentary on Question:
Many candidates performed well on this question. Specifically, very well on part (i), but part (ii) had fewer responses that demonstrated enough comprehension of the material to earn full marks. Generally, candidates that performed poorly on part (i) failed to properly demonstrate they understood the clear lines between hedgable and non-hedgable risks — e.g. the availability of reinsurance for a risk does not make it hedgable.

(i)
A hedgable risk would be interest rates
A non-hedgable risk would be the products exposure to mortality and its effect on the company's financials.

(ii)
Assets and products that directly address the hedgable risks trade in deep, liquid, and transparent markets which, when purchased appropriately, effectively reduce hedgable risks to zero. Since hedging of hedgable risks would eliminate them, only the non-hedgable risks need to be considered because the market does not have appropriate and accurate prices or values for them. Financial valuation methods use judgment and provisions for adverse deviation (PAD) to be a risk margin against the uncertainty in the valuation. In Solvency II, the PAD against the uncertainty in valuation is the MVM.
Non-hedgable risks cannot be diffused with market instruments so an insurer needs to hold capital. The "MVM is the cost of holding capital against non-hedgable risks.

(c)   Calculate the MVL for this product. Show your work.

8. Continued

Commentary on Question:
Candidates performed very well on this question. In general, common mistakes were:
- *Failure to determine the present value of liability cash-flow assuming the cash-flow occurred mid-year, as specifically referenced in the question*
- *Assuming the Solvency Capital Requirements only existed for the valuation date – no future capital requirements*
- *Discounting the Cost of Capital fees derived from SCR when the discounting already occurred in prior steps*

All Monetary Items in Millions.

Year:	1	2	3	Other Calcs
Claims @ Mid-Year:	$1.6	$2.2	$1.8	
PV Claims @ Beginning of Year:	$5.2	$3.82	$1.76	
SCR % of PV Claims:				15%
SCR @ Beginning of Year:	$0.78	$.57	$.26	
Capital Charge @ Beginning of Year:	$0.03	$0.02	$0.01	
Market Value Margin @ Beginning of Year:	$0.06	$0.03	$0.01	

Market Value of Liabilities = Present Value of Liabilities + Market Value Margin
= $5.2 + $.06 = $5.26 million

(d) Critique the method used to calculate the MVL in part (c).

Commentary on Question:
Candidates performed moderately well on this question. In general, candidates were quick to identify either one positive or negative remark regarding this method. However, the question prompted candidates to "critique" this method, and a brief response, to the method does not constitute a thorough critique; need to at least reference one positive, one negative, and an opinion on the method.

The approached used is the Market Cost Of Capital (MCoC) approach.

8. **Continued**

Pro	Cons
Easy to Calculate - It allows for simplifying assumptions, which makes this approach easy to implement	**Assumes a Flat Yield Curve** – in reality, it's not
Passes Use Test – Companies already do methods like this; components for calculation readily available	**Circularity problem** – SCR used to determine MVM while the MVM impacts the calculation of SCR as well
Considerations – MVM is small relative to MVL, which makes the circularity problem immaterial for this analysis	**Variation in Cost of Capital** – Cost of Capital charge likely to vary by year
Appropriate - risks reflected are applicable and appropriate to the business risk	

This method is generally appropriate for calculating the Market Value of Liabilities for Single Premium Term Life. However, the SCR will be too conservative because there would be diversification benefits: across risk types. because annuities and term life have inversely related mortality risk, it is level 2 diversification, and across geographies because mortality shocks may be regional rather than all of Europe, it is level 4 diversification. We can calculate the SCR at the Enterprise Level and allocating down to the business units net of diversification.

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

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

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

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

Sources:
Heavy Models, Light Models and Proxy Models

Ferrara & Nezzamoddini, Interest Rate Swap - Exposed

Stochastic Modeling Ch 2
Stochastic Modeling Ch 1

Commentary on Question:
Commentary listed underneath question component.

Solution:
(a)   Describe how an interest rate swap can hedge GDC's interest rate exposure.

Commentary on Question:
Candidates were mostly able to answer this question. A few of them, although they identified the swap position correctly, didn't show the linkage to liabilities (floating rate bonds).

Rising interest rates will increase the coupon payments of floating rate bond. To mitigate that risk GDC needs higher payoff from the hedging instrument. GDC can enter to fixed payer, receive floating interest rate swap.

With right notional amount for the swap, GDC can convert combined swap and bond position to a fixed paying instrument and remove interest rate risk.

(b)   Describe the impact on GDC in terms of:

(i)   Financial position

(ii)   Risk exposure

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9. **Continued**

> **Commentary on Question**:
> *Most candidates could identify the impact on financial position and risk exposure.*

    (i)   If the yield curve steepens, then the forward rates will be higher. This means the payoffs from floating leg will be higher. This swap position will have higher profit in case yield curve steepens. There will be no impact on GDC in the sense that the swap will net out GDC's floating obligation.

    (ii)   With yield curve steepening the market value of swap to GDC and thereby liability of the counterparty increases. Consequently, GDC will be exposed to credit risk from the counterparty who may default since it is paying higher rate.

(c)   Explain how GDC could benefit from a stochastic interest rate model.

> **Commentary on Question**:
> *Most candidates mentioned scenario analysis and tail metrics as reasons but didn't talk about the reasons which make interest rates stochastic in nature.*

Even though main driver for interest rate is uncertainty around the level of future interest rates, the information available at current time regarding the future interest rate is limited to an understanding of distributional qualities. Therefore, GDC's current deterministic interest rate modeling approach provides limited information.
With a stochastic interest rate model, GDC will be able to understand the evolving economic, market and regulatory factors which impact future interest rates and imbue their future value with the characteristics of a random process

(d)   Contrast the following stochastic interest rate models:

    I.   Hull-White model
    II.   Heath-Jarrow-Morton model

> **Commentary on Question**:
> *Most candidates described the closed form solution of Hull White but couldn't identify Hull White as short rate model and HJM as forward rate model.*

The key points about Hull White interest rate model are
a. Hull White is a short rate model
b. Hull White has a closed form solution

9. Continued

In contrast, Heath-Jarrow-Morton (HJM) model has the following properties
   a. HJM is a forward rate model
   b. HJM doesn't have a closed form solution.

(e)   Determine the impact of using stochastic interest rates to model currency options.

Commentary on Question:
Almost no candidates could correctly identify the impact of stochastic interest rates on currency options. Candidates mostly focused on increasing complexity of the model.

The implied volatility of currency options observed from the dealer quotes are based on deterministic interest rates (market rates). Using these implied volatilities in stochastic model to determine FX option prices will make the prices higher. If the simulation involves stochastic interest rate on stochastic currency movement, we need to adjust the interest rate volatility down to reflect the higher implied volatility derived from market quotes.

(f)

   (i)   Describe four types of proxy models.

   (ii)   Explain to the CFO why using proxy models is not appropriate for managing GDC's derivative positions.

Commentary on Question:
Candidates did identify and describe proxy models correctly. Candidates mostly provided adequate reasoning for not applying a proxy model for GDC's derivative book.

The four type of proxy formula that can be employed for approximating economic capital are
   i.   Replicating Polynomials: This method involves simplified mathematical formula to replicate model outputs
          a. Both regression and interpolation is possible.
          b. The optimization is done for each component or as a whole
   ii.   Radial Basis Function: This method involves employing basis functions using interpolations.
          a. Both regression and interpolation is possible.
          b. The optimization is done as a whole.
   iii.   Replicating Portfolios: This method involves employing cash flows of market traded assets to replicate liability cashflows.
          a. Only regression is possible
          b. The optimization is done as a whole

9. **Continued**

iv. Commutation Functions: This method involves projecting individual risks combined and separately in a dot product formula.
  a. Both regression and interpolation is possible.
  b. The optimization is done as a whole.

Proxy models should be used when the market data is unknown or regular updating is too complex.
GDC's derivatives are all available in the market and GDC's derivative positions are relatively standard in the market with established valuation methodology. Proxy models would be more complicated and costly than just directly modeling the instruments using market data. In addition, possible frequent recalibration of the proxy model will add to the complexity.

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 especially when opposing factors are key decision criteria.

Learning Outcomes:
(2a)	Evaluate how the legal form of an organization, corporate governance, compensation dynamics and other market frictions impact business decisions.

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

Sources:
Berk & Demarzo – Chapter 25

Commentary on Question:
This question was testing the role of leasing in business decisions, including how different lease types affect business plans. Overall candidate performance was mixed, with more details under each part below.

Solution:
(a)
(i)	Compare a capital lease to an operating lease in terms of the impact on Bonham's balance sheet.

(ii)	Explain whether the FASB criteria would classify the lease as an operating or capital lease for Bonham.

Commentary on Question:
Many candidates received full credit on part (i). The most common mistake was saying the lease expense payment in an operating lease was a Balance Sheet impact.

Candidates generally performed poorly on part (ii). Most candidates were able to list one or two criteria FASB uses to classify leases, with very few candidates identifying all the criteria.

(i)	Under a capital lease, the equipment would be listed on Bonham's balance sheet. Under an operating lease, the Balance Sheet would not be impacted.

(ii)	FASB would classify this lease as an Operating lease because none of the following criteria are met:
1.	There is no transfer of ownership at the end of the lease
2.	There is no option for Bonham to purchase the equipment at a bargain price

10. Continued

3. Bonham holds the equipment for 4 years, while the useful life is 9 years. FASB says if the lessee has control of the asset for more than 75% of its useful life, it is a capital lease. $4/9 < 75\%$ therefore this is not satisfied.

4. The PV of the lease payments are $120 [1 - (1/1.03^4)]/(1 - 1/1.03)] = 459M$. FASB criteria states if the PV lease payments are $> 90\%$ of the fair purchase price at the start of the lease, it is a capital lease. This is only $459/700 = 66\%$ of the fair purchase price therefore this criterion is not met.

(b) Explain why Zanco would prefer to lease rather than sell the equipment to Bonham.

Commentary on Question:
Performance was mixed on part b. Most candidates did not realize with Bonham being highly leveraged, Zanco may prefer to lease to be in a superior position to debtholders in the event of Bonham's bankruptcy. Partial credit was given for other answers, such as Zanco wanting to keep depreciation tax benefits.

Bonham is a highly leveraged company. If they undergo financial distress, Zanco would be in a superior position to Bonham's debtholders under a lease and would likely get the equipment back. If they lend Bonham money to buy the equipment, Zanco would have the same priority as Bonham's other debtholders.

(c) Recommend whether Bonham should buy or lease the equipment based on the cash flows. Show your work.

Commentary on Question:
Candidates generally performed well on part c. The most common mistakes were on the timing of the lease payments, various tax exclusions, and other calculation errors. More successful candidates were organized and clear in explaining how they arrived at their answer.

Buying the equipment:

	0	1	2	3	4
Capital Expenditure	-700M				
Depreciation tax shield		35M	35M	35M	35M
Maintenance Expenses		-3M	-3M	-3M	-3M
Expense Tax Savings		1.05M	1.05M	1.05M	1.05M
Sale of equipment					300M
Total FCF	**-700M**	**33.05M**	**33.05M**	**33.05M**	**333.05M**

10. Continued

Leasing the equipment:

	0	1	2	3	4
Lease Payment	-120M	-120M	-120M	-120M	
Tax Savings	42M	42M	42M	42M	
Total FCF	**-78M**	**-78M**	**-78M**	**-78M**	

	0	1	2	3	4
Lease – Buy FCF	622M	-111.05M	-111.05M	-111.05M	-333.05M

NPV Lease – Buy @ given discount rate of 3% = 11.97M
Bonham should lease the equipment, since it has a higher NPV than buying.

Note: Revenues were excluded above since they were the same in both options, but candidates could have included and arrived at the same answer.

(d)

    (i)   Explain how the lease cash flows change.

    (ii)   Recommend a change to the lease terms that would leave Bonham indifferent between buying or leasing the equipment based on the cash flows. Show your work.

Commentary on Question:
In part (i), most candidates explained only the additional depreciation tax benefits, forgetting that the lease payments would no longer be tax deductible.

For part (ii), very few candidates received full credit. Partial credit was given for attempting to solve for a new annual lease payment that would make the NPVs equivalent. Solving for an additional one-time payment was also accepted. Common errors were using the same lease cash flows as the tax lease, and various calculation inconsistencies.

    (i)   If this was a non-tax lease, Bonham would get the depreciation tax benefits (additional 35M for four years starting in year 1), but would also lose the tax deductibility of the lease payments (42M less for four years starting in year 0).

    (ii)   For Bonham to be indifferent between buying and leasing, the NPVs should be equivalent. We can set the PV of lease payments (there is no longer a tax impact given it's a non-tax lease) + Depreciation shield equal to NPV of Buying.

10. Continued

X (1 + 1/1.03 + 1/1.03^2 + 1/1.03^3) + 35 (1/1.03 + 1/1.03^2 + 1/1.03^3 + 1/1.03^4) = 310M

X = 115M

If the lease payment is reduced to 115M, Bonham would be indifferent between the options.

11.

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 and when to apply various advanced techniques to evaluate non-hedgeable risk or uncertainty in any business enterprise, especially non-insurance organizations.

Learning Outcomes:

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

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

(3d) Explain the differences and implications of the use of real-world and market-consistent constructs for risk assessment.

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

(5a) Critique methods for determining long term discount rates beyond what is observable in the capital markets.

(5c) Assess the appropriateness of Applied Information Economics (AIE) concepts for risk management.

Sources:

Hubbard, How to Measure Anything, Ch 4

Hubbard, How to Measure Anything, Ch 7

IAA, Stochastic Modeling, Ch 1

IAA, Stochastic Modeling, Ch 2

Commentary on Question:

This question tests aspects of stochastic modeling for IVA products, including calibration of parameters and the choice of risk measures. Successful candidates should be able to apply knowledge from the course of reading to the specific situation that Esparza is facing.

11. Continued

Solution:

(a) Explain why Esparza may not be able to make effective decisions using Applied Information Economics.

Commentary on Question:
Candidates generally did well on this question.

A decision was not defined before establishing the measurements. Measurements should be selected in support of a well-defined decision, including specific conditions for action, to focus the effort. Otherwise the measurements may become a wasted effort.

If the decision is not well defined in advance, there is also the risk that management may not recognize the need to act if it's subtle, or not be able to act quickly enough.

The list of things Esparza chose to measure for the dashboard is based on convenience and availability of data, instead of value of information. The shape of the EVI curve suggests that the value of information rises quickly with a small reduction in uncertainty when there is a lot of uncertainty, thus measurement effort is likely more valuable when directed at variables that are more uncertain. Esparza's uncertainty of the given list of variables is likely small, which is also indicated by availability of data. Thus measurements should focus more on other variables with a lot of uncertainties and material impacts on the decision they support.

(b) Assess the reasonableness of this methodology to generate risk neutral simulations.

Commentary on Question:
Most candidates identified the use of current market data is required for risk neutral simulation. Some candidates identified constant volatility cannot calibrate the stock prices at different maturities and strike prices.

Risk neutral models should be able to produce prices for instruments that match the observed price in the market. Geometric Brownian motion is a common model and a good starting point.

However, one of the shortcomings of the geometric Brownian motion with a constant volatility parameter (Black-Scholes) is its inability to match option prices over a spectrum of maturities and strikes. The implied volatility surface is not flat.

11. Continued

And when the volatility parameter is calibrated with historical index data (observed volatility), it's unlikely that the resulting model can produce the observed market prices of options. The model can't properly produce risk neutral simulations.

(c)   Simulate the index price at the end of year 1 and year 2.

Commentary on Question:
Performance for this question was mixed. When calculating the time two index price, very few candidates converted spot volatility into forward volatility.

To simulate the price at year 1, use the implied volatility from the 1-year call option:
$S(1) = 1200 * \exp((0.06 - 0.1^2/2)*1 + 0.1 * 0.34) = 1311.7$

To simulate the price at year 2, first calculate the forward volatility:
$\sigma = \text{sqrt} [(0.2^2 * 2 - 0.1^2 * 1) / (2\text{-}1)] = 0.26$

Then calculate the simulated price at time 2:
$S(2) = 1311.7 * \exp((0.06 - 0.26^2/2)*1 + 0.26 * \text{-}0.21) = 1275$

(d)
(i)   Describe one deficiency of using a term structure for volatility calibration.

(ii)   Recommend an alternative model that improves the deficiency noted in part (i).

Commentary on Question:
Successful candidates were able to identify volatility smile and that term structure of volatility could not match all stock prices.

(i)   The revised approach incorporates the term structure of volatility, but cannot incorporate equity skew (curvature of the implied volatility surface with respect to equity price).

(ii)   An alternative is to use the Heston model, which models the volatility parameter stochastically and allowing the dynamics to be much closer to the observed market data.
The SDE can be described as follows:
$dS(t) = \mu(t) S(t) dt + \text{sqrt}(V(t)) S(t) dW(t)$
$dV(t) = k (\theta - V(t)) dt + v \text{ sqrt}(V(t)) dZ(t)$
$d[S \ V] = \rho dt$ (meaning the two processes above are correlated with parameter ρ)

11. Continued

(e)   Compare how the two measures would change under the following scenarios:

   (i)   Increase the interest rate hedge percentage

   (ii)   Equity volatility increases

   Commentary on Question:
   A handful of candidates did not make comparison on how the two measures would change under scenarios described in the question.

   i) Increase rho hedge to 90%
   Increasing the hedge should improve mitigation of risks in the tail, making the liability distribution less skewed in the negative direction, and reduce the volatility of the simulation results. Since CTE(95) is the average of all simulations worse than the 95th percentile, increasing the hedge should decrease this risk metric more than VaR(99) which is just the 99th percentile, though it should decrease too.

   ii) Equity volatility increases
   Due to the living benefit guarantees, the liability distribution is sensitive to economic changes in the tail, so as equity volatility increases, lengthening of the tail is more impactful than movement of the VaR percentile. While VaR may still increase, it doesn't move as much to reflect the impacts on tail risks of the worse economics. CTE will increase more as it would also reflect the lengthening of the tail distribution.

(f)   Recommend which risk measure Esparza should use for robust capital management. Support your recommendation.

   Commentary on Question:
   Candidates had satisfactory performance on this question. Candidates should explain how the chosen risk measure is suitable for robust risk capital management for Esparza. Generic answers such as "CTE is coherent" is not acceptable.

   The recommended risk measure is CTE(95).

   Because the liability distribution for the product has a long tail, using VaR is misleading as it doesn't reflect the magnitude of the potential loss beyond the VaR percentile. Using CTE as the risk measure is more reflective of the actual losses that the company may experience under adverse scenarios, thus it ensures that Esparza can still honor its obligations under such events.

11. Continued

As CTE(95) would decrease more than VaR(99) with increased hedging, using CTE(95) as the risk measure would encourage Esparza to develop better hedging strategies to avoid taking undesirable risks.

Also, as seen from part (e) that CTE would increase more than VaR if the economics worsen, it is a better measure for promoting a risk management culture as it is a more reflective and responsive function of actual economic risks.

(g) Describe the static control model approach to managing the IVA product's long-term living benefit liability.

The static control model starts matching hedgeable components of the liability with available market instruments and uses a total return approach for the unhedgeable risks. The model ends up solving an optimization problem over a space of static investment strategies.

There are three important properties of the static control model
1) Market consistency - the model reproduces the market information that has been input (usually 0-30 yr bonds)
2) Static Hedge Portfolio - the solution to the optimization problem is the static hedge portfolio from a market shock perspective.
3) Convexity margin - liabilities which cannot be expressed as a static linear combination of the available market instruments have a convexity margin which gets released as time moves forward

12. **Learning Objectives:**

4. The candidate will understand how to identify and recommend appropriate model risk assessment and vetting techniques for risk management models.

Learning Outcomes:

(4b) Design and evaluate stress-testing and back-testing processes.

(4c) Interpret stress-testing and back-testing results.

Sources:

Dowd, Chapter 15

Commentary on Question:

Commentary listed underneath question component.

Solution:

(a) Evaluate the appropriateness of the data for its stated purpose.

Commentary on Question:

Answers below do not include all valid responses. Other reasonable answers with justification were given credit, too.

- Daily forecasting is desired, yet weekly profit and loss (P/L) data was gathered. The time-step should be in sync.

- When consecutive horizon periods overlap with each other (i.e., rolling weekly averages), independently and identically distributed (iid) no longer holds and backtesting breaks down.

- Removing trading fees and/or assuming mid-point of bid-ask spread is logical, and preferred. Fees are not directly related to market risk taking, so they should be excluded.

- Removing bonds rated below investment grade makes sense if the company's investment only includes investment grade bond funds and thus P/L earned from other (i.e., credit) risk taking should be removed. However, if the company's portfolio includes more than investment grade bonds, then the removal is inappropriate.

- The data goes back two years, the assumptions were updated 18 months ago. Data older than 18 months should likely be excluded, too.

12. Continued

(b)
> (i) Identify four key observations from the chart.
>
> (ii) Interpret these observations with respect to model validation.

Commentary on Question:
Candidates in general did well in part (i). For part (ii) some candidates could not interpret the observation, but instead just repeated or stated the observation in (i) in a different way.

- This is a backtesting chart --> can be helpful in delineating regular profits or losses from more extreme ones.

- The upper (lower) risk bound is defined as VaR 90% (VaR 10%) --> very high profits (losses) go above (below) this level (or could say the number of positive and negative exceptions is therefore expected to be approximately 10% of observations)

- Since VaR is symmetric, we would expect to see the same number positive and negative exceptions --> but we do not see that, as the negative exceptions are more than double positive exceptions. (Note: this statement could be inverted and would still be correct)

- There is asymmetry of exceptions --> the risk practitioner would be advised to look into this further.

- There appears to be few (if any) P/L exceedances in the first third of the time series --> the temporal pattern of exceedances is worth exploring further

- The P/L are not frequently close to zero --> may imply frequent trading of liquid positions

- The risk (i.e., VaR) lines exhibit few, if any, abrupt changes --> may suggest no changes in volatility nor changes in the way risks are estimated.

- Risk lines do show some flatness and smoothness --> may imply risk measures are not being updated sufficiently quickly.

12. Continued

(c)

    (i)   Describe each of these three approaches for model validation.

    (ii)   Recommend one of these approaches as the next step in the risk model validation process. Justify your recommendation.

Commentary on Question:
Candidates generally can describe Christoffersen Backtest, a few struggled with Rosenblatt and Berkowitz transformation. In general candidates did well in (i) also performed well in (ii)

(i)   Christoffersen Backtest :

Tests that the model generates the correct frequency of exceedances (coverage) and tests whether exceedances are independent of one another (independence).

$LRcc = LRuc + LRind$ (distributed as $\chi 2$-distribution with 2 degrees of freedom)

Can test coverage and independence hypotheses at the same time. But if test fails, can then test hypothesis separately to help establish where model failure arises.

Rosenblatt Transformation:

Focuses more on size of exceedances (not just frequency).

Transforms data so that we are dealing with them in terms of their forecast percentiles or forecast cumulative probability values (or could include formula: $pt = Ft(xt)$)
Requires assumptions about P/L distribution (e.g., Normal with forecast mean of X and std of Y). (Or could mention applying distribution equality tests.)

Berkowitz Transformation:

Enables testing of any independence prediction, where it arises, within the same framework used to test the rest of the null hypothesis.

Converts a uniform series into a standard normal series, and therefore enables us to test model adequacy through (easier, and more powerful) tests of standard normality.

Autoregressive process: $zt - \mu = \rho (zt\text{-}1 - \mu) + \epsilon t$ where zt is iid N(0,1) (could also discuss the likelihood ratio test and test statistic, which is the corollary).

12. Continued

(ii)   Recommendation: Christoffersen approach

Justification:

Frequency is a concern (disparate number of positive and negative exceedances), as is independence (temporal pattern). Christoffersen approach tests both.

Visually, the size of the exceedances do not seem overly concerning. Distribution of P/L may be unknown, or difficult to calibrate. No need to pursue Rosenblatt Transformation at this time.

Rosenblatt won't work b/c don't have P/L distribution.

Berkowitz LR test has a blind spot when it comes to skewness or tail heaviness which, given the data here, makes this a poor choice. Also, no reason (yet) to believe data is iid.

Transformations are more powerful (and useful) tools intended for additional analysis if no (or few) issues are visually apparent. That is not the case here.

13. **Learning Objectives:**
1. The candidate will understand how a business funds its activities with considerations for its business model, and the cost and constraints on the sources of capital, including other market frictions.

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

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

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

(3d) Explain the differences and implications of the use of real-world and market-consistent constructs for risk assessment.

Sources:
Corporate Finance, Third Edition, Ch 22: Real Options

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

IAA, Stochastic Modeling, Ch 1

Commentary on Question:
This question tests a candidate's understanding of real options and methods for valuing cash flows. Most candidates had good insight into types of real options, but many struggled to perform calculations to support real option valuation. Overall, candidates performed moderately well on this question.

Solution:
(a)
 (i) Identify the real options embedded in Autry's strategy.

 (ii) Describe four key insights in considering the real options identified in part (i).

 (iii) Explain which real option can be regarded as similar to a call option.

 Commentary on Question:
 This question tested high level knowledge of real options and how they may provide business value. Most candidates received full marks for part (a).

 (i) Real options include option to delay an investment, option to grow, and option to abandon.

(ii)
1) Out of the money real options have value
2) In the money real options need not be exercised immediately
3) Waiting is valuable
4) A company should delay investment expenses as much as possible

(iii)   A real option to delay or grow a project is similar to a call option. A call option gives the buyer the right to buy an investment at a future date at a fixed price.

(b)   Calculate the value today of the investment opportunity. Show your work.

Commentary on Question:
This question tests a candidate's ability to evaluate the embedded value of real options. A key component is to understand that the project NPV is out of the money without considering the real option to delay. Most candidates knew that they needed to calculate the NPV of the project if the interest rate increased to 12% and if it decreased to 6%. Many candidates were able to correctly calculate the NPVs, but fewer realized that the 12% scenario would be floored at zero. Most candidates knew that they needed to probability weight the two scenarios, but very few were able to calculate the correct probability value. Partial credit was awarded if a dummy probability value was used for the final calculation.

NPV today:
        $= 2m / 0.10 * (1 - 1.10^{-20}) - 20 = -2.973m$

Since the NPV is negative, Autry will delay building the additional facility.

Since the NPV at 12% would be even lower than in the 10% scenario, Autry will not build if interest rates rise.

NPV in one year if interest rate drops to 6%:
        $= 2m / 0.06 * (1 - 1.06^{-19}) - 20 = 2.316m$

To calculate the probability that the interest rate will rise:
        $S = 1/0.10 * (1 - 1.10^{-20}) = 8.514$
        $S_u = 1 + 1/0.12 * (1 - 1.12^{-19}) = 8.366$
        $S_d = 1 + 1/0.06 * (1 - 1.06^{-19}) = 12.158$
Then $p = ((1+r_f) * S - S_d) / (S_u - S_d)$
        $= ((1.08) * 8.514 - 12.158) / (8.366 - 12.158) = 78.1\%$

Value of the facility today:
        $= (0 * 78.1\% + 2.316m * (1 - 78.1\%)) / (1.08) = \$0.469m$

(c)   The CFO comments, "*This project is not risk free, and hence should be discounted at the company's WACC. Similarly, if we discount the option to delay at the risk-free rate, we would overestimate the value of the option.*"

Critique the CFO's comment.

Commentary on Question:
This question tests candidates' ability to critically evaluate the use of risk free and real-world scenarios. Many candidates knew that the project would be subject to interest rate risk and that the CFO's suggestion to use WACC was reasonable. Many candidates mistakenly believed that using the risk-free rate would cause the option to be overvalued. In fact, probabilities would be adjusted so that the option value would be the same whether real world or risk-free rates were used.

The CFO is correct that the project is subject to interest rate risk and should be discounted using rates appropriate to the risk and financing structure of the project. WACC is an acceptable rate to use in this case.

However, the CFO is not correct that the option value would be overestimated using the risk-free rate. The probability would be adjusted depending on the interest rate used, and the project value using real world or risk neutral interest rates would be the same.

(d)   Outline the steps to calculate the value of the project using Monte-Carlo Simulation.

Commentary on Question:
This question evaluates a candidate's understanding of stochastic processes. Most candidates realized that they could use a stochastic process to generate interest rate scenarios. Fewer were able to apply stochastic modeling techniques to generating and discounting cash flow streams and specifically apply to the situation of this project.

1. For each scenario, simulate a risk-free interest rate path.
2. At time zero, calculate the NPV of the project with the risk-free rate at year 1 to 20.
3. At time one, calculate the NPV of the project with the risk-free rate at year 2 to 20.
4. Continue to roll forward the NPV calculation one year until you have a stream of NPVs. Discount these back to time zero, floor any negative NPVs, and choose the highest for each interest rate scenario. Note that this corresponds to the optimal investment point in time for each scenario.
5. Repeat 1,000 times and average the value to get the final value of the project.