CFE SDM Model Solutions
Fall 2024

1. Learning Objectives:

2. The candidate will understand how sustainable growth and value can be created through strategic budgeting. The candidate will also understand measures of an organization's value and their uses in decision making.

Learning Outcomes:

(2d) Evaluate and recommend appropriate value measures for an organization.

(2f) Assess an organization's ability to create value and recommend actions to improve value creation.

Sources:

Damordaran on Valuation Book: Chapter 13 Value of Control

Damordaran on Valuation Book: Chapter 15 Value of Synergy

Valuation, Measuring and Managing: Ch 32 Divestitures

Commentary on Question:

Commentary listed underneath question component.

Solution:

(a) List the five key inputs that determine value, according to Damodaran.

Commentary on Question:

Candidates did very well, with most receiving full marks.

1. Cash flows from existing assets
2. Expected Growth rate during extraordinary growth period
3. Length of the extraordinary growth period
4. Cost of Capital
5. Cash, cross holdings, and other nonoperating assets

1. Continued

(b)

(i) Identify one financial synergy that BJA has realized by owning BJT. Justify your answer.

(ii) Identify one operational synergy that BJA has realized by owning BJT. Justify your answer.

(iii) Identify one synergy that Motors Inc. would realize by purchasing BJT. Justify your answer.

Commentary on Question:
(i) The average candidate addressed some aspects of financial synergy, earning partial or full credit based on their response quality. Those who mentioned operational synergy received no credit.

(ii) Most candidates performed well, though those who discussed economies of scale or scope struggled to apply these concepts effectively.

(iii) Most candidates did not answer this part of the question well.

(i) Financial synergy: Tax benefit. BJT has branches in Canada with lower tax rate. Tax benefit from increasing debt capacity. Both firms have positive earnings and stable net income based on the past 3 year's exhibit. This makes their combined report have an even more stable earnings which allows BJA to borrow more if BJA plans to. And this would create a tax benefit for BJA.

(ii) Operating synergy: Improve cost-efficiency: BJA can have tires directly from BJT rather than shopping at different providers. → mark-up is eliminated from the value chain.

(iii) Financial synergy: BJT has positive cash and cash equivalents in 2023, and a combination of a firm with excess cash can and a firm with high-return projects (buyer's fuel-efficient car project) can yield a payoff in terms of higher value for the combined firm.
or Operating synergy: Higher growth in new markets. The Automobile company can utilize BJT's distribution network and brand name recognition to increase sales of its products.

1. Continued

(c) Assess how each factor (A to D) would apply to divestiture of BJT by BJA. Justify your answers.

Commentary on Question:
Candidates performed better on parts B and C compared to A and D. Partial credit was awarded to those who provided sufficient justification, even if their answers didn't exactly match the listed answers.

a. Disentanglement costs: BJA needs to set up full and detailed disentanglement plans for this divestiture. This would go through legislation that incurs legal and advisory fees. In addition, there are other costs associated with intellectual property, relocation costs and retention bonuses for certain employees of BJA and BJT. BJA needs to evaluate these costs regarding the divestiture. Specific to this transaction, there are potential costs and scrutiny when US & Canada are involved, leading to exacerbation of legal fees.
b. Stranded Costs: BJA and BJT share the IT infrastructure and overhead will be allocated between the two companies. After this divesture, BJA needs to consume all the overhead of the IT infrastructure.
c. Lost synergies: BJA can have tires directly from BJT. However, after the divesture, BJA needs to shop in the market which results in higher costs
d. Stand-Alone value of BJT: BJT has had a good performance in the past 3 years based on its annual report with positive net income and cash flow. Selling BJT will negatively affect BJA's annual report.

(d) Describe two additional concerns BJA must consider for divestiture.

Commentary on Question:
Few candidates addressed the exact two points listed below. However, partial credit was given if candidates provided sufficient justification for the concerns they mentioned.

a. Legal and Regulatory Barriers
   Divesture might trigger an investigation. This is time-consuming and costly. BJA needs to take this into consideration.
b. Pricing and Liquidity concern
   This divestiture does not occur in the open market, so negotiation of the price might be a concern between Motors and BJA. If BJA wants a quick deal on this divesture, it might need to accept a lower price of selling BJT.

1. Continued

(e) BJA determines it will divest BJT.

(i) Compare and contrast public vs private transactions for divestitures.

(ii) Recommend whether BJA should sell BJT using a public or private transaction. Justify your answer.

Commentary on Question:
Many candidates' responses were light when comparing in question (i). They would have benefitted from more elaboration on the topic.

(i) Private transactions: used when a company can find a good buyer. Allow the company to sell the business unit at a premium and capture value immediately. However, this will result in taxable gains.
Public transactions: used when a company cannot identify another company as a better owner. Shareholders do not earn premiums from the divestiture, but significant value may be created in the future.

(ii) Recommend private transactions. BJT is a private company and thus IPO does not apply to it. It should use a private transaction type (trade sale or joint venture with valid reasons).

2. Learning Objectives:

2. The candidate will understand how sustainable growth and value can be created through strategic budgeting. The candidate will also understand measures of an organization's value and their uses in decision making.

Learning Outcomes:

(2b) Assess how effective strategic budgeting is in tracking progress of an organization's initiatives.

(2c) Demonstrate how an organization's strategic goals can be effectively incorporated into the financial budgeting decision making process.

(2d) Evaluate and recommend appropriate value measures for an organization.

Sources:

Handbook of Budgeting – Ch. 15 Budgeting of Shareholder Value (start from Economic Value-Added Section)

Handbook of Budgeting – Ch. 6 Strategic Planning and Budgeting Process

Commentary on Question:

This question evaluates the candidate's understanding of the connection between strategy and budgeting, as well as how strategic planning relates to Economic Value Added (EVA). It also assesses their knowledge of the factors affecting EVA and its application to one of Frenz's growth initiatives. On average, candidates earned just over half of the available points for describing the key factors or concepts.

Solution:

(a)

(i) Describe the role of strategic business planning in the budgeting process.

(ii) Describe how components of the strategic planning process can be incorporated into EVA implementation.

Commentary on Question:

To receive full credit, candidates needed to explain how budgeting aligns with the company's objectives and priorities outlined in strategic planning, and discuss the dynamics of change. They also had to describe how EVA is implemented in strategic planning and its goals. While most candidates successfully addressed the first part, their responses to the second part often focused on the components of strategic planning without clearly linking it to EVA.

2. Continued

(i) Budgeting supports the priorities and objectives of the company, which are reflected in the strategic planning. An institutionalized program of strategic business planning requires management to regularly assess the market within the context of the company's business objectives, product mix, marketing strategy, research and development program, management and organization structure, operations, and budget.

(ii) Applied to Frenz and their EVA implementation, each of these steps and components should be looked at in terms of potential NPV, EVA, and discounted CF implications and by extension the income statement and balance sheet. For example, for product mix, a company focused on EVA might review the existing product mix and potential investments to expand or change the product mix, and choose the mix with the highest Return on Invested Capital (ROIC), or shift invested funds away from products with lower ROIC to products with higher ROIC. EVA can be used to assess the productivity of capital, together with the other metrics. EVA can then be used to track the progress of initiatives towards meeting the company's objectives.

(b)

(i) Explain how increasing operating efficiency affects EVA.

(ii) Explain how changes in taxes affect EVA.

(iii) Explain how increasing leverage affects EVA.

(iv) Explain how decreasing average invested capital affects EVA.

Commentary on Question:
To earn full credit, candidates needed to explain the impact of each change. Most candidates successfully did this for part (i). However, the other changes required a deeper understanding of their impact on EVA. Many candidates overlooked that debt has a lower cost of capital, especially after taxes, and missed that the return on invested capital (ROIC) component of EVA includes average invested capital in the denominator, which can increase EVA when average invested capital decreases.

(i) ROIC can be increased by increasing NOPAT, which is done by enhancing operating efficiency. That is enhancing the return on a Frenz's existing invested capital base.

2. Continued

(ii) Changes in taxes affect both parts of the EVA formula, ROIC and COC, with opposite effects, making the net effect unclear. Since taxes have a direct multiplicative effect on NOPAT and only partially affect the COC calc (proportionate to the % of debt), it's likely that a decrease in taxes will increase EVA.

a. A decrease in taxes will increase the after-tax cost of debt, which increases the COC. Increasing the COC will decrease EVA.
b. Decreasing taxes will increase NOPAT, which increases ROIC and EVA.
c. An increase in taxes will have the opposite effects.

(iii) Increasing leverage, that is shifting from equity to debt (since debt has a lower COC, especially after taxes) increases interest cost, but does not affect NOPAT. Lowering the COC will increase EVA.

(iv) Decreasing average invested capital will increase EVA (all else equal), since when you pass average invested capital through the equation, you're left with NOPAT – (COC x Ave IC). In addition, to the degree capital is decreased by removing capital from underperforming projects (those with the lowest ROIC), that would further enhance the improvement in EVA by increasing average ROIC

(c) Identify the elements of the smart phone app initiative that would impact Frenz's EVA. Justify your answer.

Commentary on Question:
An effective response would require candidates to explain how the initiative could affect the variables that make up EVA. Many candidates were able to identify and justify at least one element. However, responses varied widely. Some candidates focused on one element in detail but overlooked others, while some did not fully or accurately describe the connection to EVA.

Frenz's smart phone app initiative will impact all parts of Frenz's EVA calculation. Specifically:

- Average invested Capital: The smart phone app initiative is a costly endeavor (increasing average invested capital). This will decrease EVA.
- NOPAT: Frenz is making the investment with the expectation that NOPAT will increase. Said another way, Frenz expects that Average ROIC will increase, believing that the smart phone app is relatively more profitable than other Frenz investments.
  - Frenz is hoping the customer data gained can be used and leveraged throughout the business to increase revenue.

- **2. Continued**

    - Frenz is hoping to use the app to better interact with customers, offering incentives for free drinks with app usage or to bring customers back after they've not been a customer for six months. This touch point should boost revenue.
    - Once the app is up and running, it should be relatively easy (less investment heavy/costly) to maintain. That is, lower ongoing expenses (lower average invested capital in the long run).
    - More revenue on two fronts plus the potential for lower ongoing expenses both should lead to higher NOPAT and ROIC, lower future AIC and higher EVA.
- Cost of Capital: Frenz's Debt to Equity ratio is projected to be less than 1 (slightly more equity than debt), with the ratio decreasing over time to about 2/3 (almost 50% more equity than debt). The case study does not list an explicit debt limit but does list the interest rate and capital risks related to making financing decisions. The decreasing debt to equity ratio implies Frenz could fund the smart phone app initiative with debt. This would decrease the cost of capital and improve EVA.
    - The shift to more debt would increase Frenz's interest expense, putting downward pressure on NOPAT, but the net effect would almost certainly be positive.
    - Interest rate risk would increase (or not decrease as the current income statement suggests).
    - Capital risk would also increase as Frenz would likely have less access to the debt markets after the smart phone initiative. At the very least, the higher debt to equity ratio would necessitate a higher interest rate on future debt.
- Taxes: The smart phone initiative is unlikely to impact Frenz's tax position or their tax rate.

3. Learning Objectives:

4. The candidate will be able to analyze and model dynamic systems and evaluate the risks and sustainability of these complex systems.

Learning Outcomes:

(4a) Identify and model the dynamic processes within a complex system:
- Develop and apply causal loop diagrams that model the feedback structure of complex systems
- Apply stocks and flows to dynamic modeling
- Apply dynamic modeling to business decisions

(4b) Explain the underlying factors that drive the sustainability and stability of a dynamic system:
- Evaluate the structure and behavior of dynamic systems
- Identify the factors that contribute to risk and instability in dynamic systems

(4c) Evaluate complex systems and describe how actuarial principles can mitigate risks and improve sustainability.

Sources:

Business Dynamics, Sterman, John D., 2000
- Ch. 3: The Modeling Process
- Ch. 12: Coflows and Aging Chains

Commentary on Question:

This question assesses the candidate's understanding of the modeling process for a specific risk facing a company, including the interactions of subsystems that can affect the outcome. Overall, candidates grasped the general framework but overlooked key details that connect it specifically to Frenz.

Solution:

(a)

(i) Apply steps I and II to the financial risks related to Frenz's Asian expansion.

(ii) Explain how steps III through V can be used to model the financial risks related to Frenz's Asian expansion.

Commentary on Question:

For full credit, candidates must accurately describe the step in relation to financial risks associated with the expansion, and link it back to examples from the case study. In part (i), candidates needed to state the problem and the dynamic hypothesis for Frenz's financial risk. Overall, most candidates were able to describe the five steps, but some lost points for not applying the steps specifically to Frenz.

3. Continued

- **Problem Articulation**: The expansion strategy requires significant capital. Frenz's new Chief Risk Officer, Robert Kaplan, is concerned because this strategy could strain cash flow significantly without additional debt financing. This situation might push Frenz's leverage ratio above the company's internal limit.
- **Formulation of a Dynamic Hypothesis**: Expansion will not be feasible if Frenz's leverage ratio surpasses its internal limit.
- **Formulation of a Simulation Model**: Define the scope of interactions to include in the model. Key variables from the case study should be considered: the location of Frenz outlets, quality, adoption of specialty coffee drinks, and the success of new drinks. These factors need to be linked to both cash flow and debt. The model should assess both short-term and long-term impacts, with model fit evaluated against Frenz's previous experiences or other market players.
- **Testing**: Conduct sensitivity testing on the model using other assumed variables, including extreme scenarios or tail risks.
- **Policy Design and Evaluation**: Based on the model results, Frenz can develop potential action steps to minimize losses, conduct "what-if" analyses, and perform sensitivity tests on various options to understand interactions between potential actions. Candidates may also note that modeling is iterative, which can earn partial credit.

(b) Describe Frenz's current state with respect to six of the flows from the sub-system diagram.

Commentary on Question:
For full credit, candidates need to identify six chosen flows within the context of the overall market growth model and accurately describe the relationship between Frenz and the global market. Many candidates earned most of the points but missed some due to insufficient explanation or not addressing the directional influence.

Frenz → Global Market

- **Delivery of Product**: To customers via location or service.
- **Sales Effort**: The product above cannot be sold without sales effort. Advertising/branding are typical answers.
- **Quality**: The product has quality attributes that the market deems valuable. Frenz is a quality brand and uses quality coffee.
- **Delivery Delays**: Supply chain related.
- **Price Info**: Frenz is a high-quality and relatively high-priced coffee house.

3. Continued

- **Product Suitability**: Suitability refers to whether the product meets the needs of the market. This generally includes factors like taste, speed of delivery, and freshness.

Global Market → Frenz

- **Payment**: The global market pays Frenz for its services.
- **Orders**: Orders, similar to payment, signal that Frenz's efforts are desirable within the broader landscape.
- **Response to Price, Quality, Delays, or Suitability**: The market typically responds to attributes like quality, price, or suitability, as well as experiences such as delays. Customers may shift demand elsewhere as a result

(c) Labor shortages are expected to persist in the medium to long term. You have been asked to evaluate how this will affect Frenz with respect to its Operational Risk.

(i) Identify one flow in the sub-system diagram from Frenz to the Market that is impacted by the labor shortage. Justify your answer.

(ii) Identify one flow in the sub-system diagram from the Market to Frenz that is impacted by the labor shortage. Justify your answer.

Commentary on Question:
For full credit, candidates must provide a strong justification linking the impact of labor shortages to the appropriate directional impact on Frenz in relation to the market or vice versa. Many candidates received full credit, but several lost points due to inadequate explanations as they apply to Frenz or incorrect assessments of directional impact.

Frenz → Global Market

- **Delivery of Product**: Frenz provides premier coffee for its customers. A labor shortage could mean fewer baristas to serve customers, potentially impacting customer service with long queue lines.
- **Sales Effort**: A labor downgrade would challenge Frenz in terms of who and how they could still market the product and present it to the market.
- **Quality**: The product has quality attributes that the market deems valuable. Impacts on the labor side could cause downgrades in quality, ultimately affecting how the market perceives Frenz compared to competitors.
- **Delivery Delays**: A key aspect of Frenz's relationship with the global market is delivering its products/promises in a timely manner. Unfortunately, labor is involved in every step of logistics, including creating, maintaining, and running both the supply chain side and the coffee houses.

3. Continued

- **Price Info**: Price information would be more resistant to a labor shortage compared to some of the other factors. However, labor challenges could lead to price increases, affecting the prices Frenz needs to charge to maintain similar profitability.
- **Product Suitability**: Suitability refers to whether the product meets the needs of the market. This typically involves factors like taste, speed of delivery, and freshness. While labor doesn't directly impact these, it is a fundamental part of ensuring these attributes, and without proper labor, Frenz may produce a less suitable product. If labor causes macro-economic changes, it may also pressure the market to demand different attributes or products.

Global Market → Frenz

- **Payment**: The global market pays Frenz for its services. These payments directly support hiring and maintaining labor, becoming more crucial during a labor shortage. A lack of payment might exacerbate internal labor issues at Frenz.
- **Orders**: Orders, similar to payment, indicate that Frenz's efforts are desirable within the broader landscape. These orders are crucial for labor requirements, with fluctuations affecting how much labor is needed. Frenz monitors this closely to ensure profitability.
- **Response to Price, Quality, Delays, or Suitability**: The market typically responds to attributes like quality, price, or suitability, as well as experiences such as delays. A labor shortage will magnify these responses. For example, if expanding product offerings leads to delays in receiving a cup of coffee, customers may shift demand elsewhere.

(d)

(i) State the hypothesis to be tested for Frenz.

(ii) Recommend two changes to the model to test the hypothesis.

Commentary on Question:

For full credit, candidates must state the hypothesis as specified below and ensure that changes to the model for testing the hypothesis involve adding a variable (with a link) or creating a link between existing model points, clearly indicating the direction and whether the impact on flow is positive or negative. Many candidates proposed changes to the model but did not explain how these changes would integrate into the model.

(i) The hypothesis should be: "The increase in assimilation rate reduces the rookie quit rate and experienced quit rate".

(ii) Add a negative link from the assimilation rate to the rookie quit rate or add a negative link from the assimilation rate to the experienced quit rate.

4. Learning Objectives:

1. The candidate will understand and apply strategic management concepts and frameworks to develop an organization's financial and ERM Solutions.

4. The candidate will be able to analyze and model dynamic systems and evaluate the risks and sustainability of these complex systems.

Learning Outcomes:

(1b) Evaluate commonly used business growth strategies and their application under different economic risk and business environments:

- Critique and evaluate internal/organic and external/inorganic growth strategies.
- Assess and recommend growth strategies under different business situations and market opportunities, utilizing the applicable strategic management models.

(4a) Identify and model the dynamic processes within a complex system:

- Develop and apply causal loop diagrams that model the feedback structure of complex systems
- Apply stocks and flows to dynamic modeling
- Apply dynamic modeling to business decisions

Sources:

Business Dynamics Steman: Chapter 3 The Modeling Process

Business Dynamics Steman: Chapter 5 Causal Loop Diagrams

Business Dynamics Steman: Chapter 9 s-Shaped Growth: Epidemics, Innovation Diffusion, and the Growth of New Products

Commentary on Question:

Commentary listed underneath question component.

Solution:

(a)

(i) Explain why a Bass Diffusion Model is appropriate for modeling the growth of Darwin's travel insurance business.

(ii) Identify three errors in the suggested model.

(iii) Explain three limitations of the Bass Diffusion Model when applied to Darwin's travel insurance business.

4. Continued

Commentary on Question:
Most candidates recognized that the Bass Diffusion Model could be suitable for entering a new insurance market because it effectively addresses start-up modeling challenges. For full credit, candidates also needed to identify the interaction between advertising and word-of-mouth and how an S-shaped growth assumption would affect model considerations.

Candidates generally could spot errors in the diffusion model by noting differences between the exam illustration and the syllabus text. Full credit answers also explained why these changes would affect the model's accuracy.

In Part (iii), candidates needed to identify challenges or mismatches between the model and the case study scenario, rather than general challenges of the Bass Diffusion Model. For example, the recovery from the pandemic might impact growth, or travel insurance buying patterns might not align with the model's assumptions.

(i) The Bass Diffusion Model effectively models product purchases and solves the startup problem, modeling the initial purchases of a product. Two main feedback loops represent the realistic model life of a product: As a product is first developed, advertising provides a primary source of growth, followed by positive exponential growth through word of mouth and excitement in using the product. And there is a negative feedback loop representing that the purchase potential is finite and there are only so many people available and willing to purchase the product (it caps the population).

Darwin's travel insurance business is in the beginning phases of development and purchasing, which makes this model appropriate since it will help Darwin solve the start-up problem and model the expected life cycle of the product.

(ii) The adoption rate does not influence the adoption from word of mouth directly. Adoption from word of mouth should be illustrated to impact the adoption rate positively.

The adopters stock should only be influenced by its inflow of adoption rate.

The total travelers would negatively influence the adoption rate from word of mouth. If total travelers increase faster than the current adopters, there will be less influence of the current adopters on total potential adopters.

(iii) The model assumes that the travel insurance adoption fraction is constant. In reality, recovery from the pandemic and seasonal travel patterns will drive changes in demand and adoption

4. Continued

The adoption rate from advertising and the adoption rate from word of mouth are assumed independent. In reality, these are related and as adoption from advertising grows it will impact word of mouth.

The model assumes that once a traveler purchases the insurance policy, they don't lapse and there are not opportunities for repurchases. Travel insurance is a short term insurance policy and actually more likely to be repurchased by prior customers than adopted by those who have never purchased

(b) Explain two limitations of using historical data to project future results.

Commentary on Question:
Most candidates addressed situations where past data might not predict future outcomes accurately, which is partially correct. For full credit, answers needed to discuss model fit and scenarios where multiple models with a good fit to historical data can produce significantly different forecasts, as well as the issue of data not being a reliable predictor.

1. Different models can and should produce different results even based on the same historical data. Multiple models may product a good fit to historical data and differ in their future projections.

2. Historical data may not be the best reflector of future data. Fitting to historical data likely misses potential shock events that have not yet been experienced but are plausible.

(c) Describe how the model, once calibrated, can be used by Darwin to solve business problems related to its travel insurance business.

Commentary on Question:
Most candidates answered this question in a general way, discussing how models can simulate future outcomes and how those results can be used for planning. Good answers went further, explaining how simulations could model adoption or sales and aid in planning. Full credit answers connected this to the case study by pointing out issues with planning for new business lines or addressing Darwin's specific challenges in allocating administrative costs. No credit was given to answers suggesting the model could simulate claims, as none of the inputs directly relate to claim frequency or severity.

4. Continued

Once calibrated, this model can be used by Darwin to model adoption rate of travel insurance. This can help Darwin prepare for the rate of adoption and demand, and if the model is expanded account for repurchases and discontinued use it may prove useful to modeling seasonality of overall customers. This can help Darwin develop appropriate systems to handle the demand, hire sufficient workers, and target potential problems before symptoms arise and Darwin is at a loss of what to do.

For example, Darwin could use this model to prepare for the admin requirements and sufficiently allocate capital in its budgeting process, build the admin system as required, hire appropriate workers, and not be overwhelmed by shocks in demand. Then if problems or different trends arise, Darwin can avoid just targeting the symptoms and creating compensating feedback loops. It can understand the drivers (adoption rate driven by two independent forces—advertising and word of mouth) and react appropriately by expanding its system or even lowering advertising costs if word of mouth is sufficient. Given Darwin's current problems with not having invested enough in developing its admin systems for in force policies, use of this model is critical to avoid repeating their mistakes.

5. Learning Objectives:

1. The candidate will understand and apply strategic management concepts and frameworks to develop an organization's financial and ERM Solutions.

3. The candidate will understand how to apply decision making models to general managerial decisions within specified business constraints.

Learning Outcomes:

(1a) Evaluate and apply strategic management concepts, recognizing factors that affect development and implementation of strategies:
- Analyze the firm's external environment and the internal organization.
- Describe and apply strategic management models, including Porter's five forces and value chain analysis.
- Define types of business-level strategies and recommend an appropriate business-level strategy for a given situation.

(3a) Apply fundamental techniques and frameworks of management science to make informed business decisions:
- Apply linear optimization models to managerial decisions.
- Develop decision trees, scenario tests, and simulation models.

(3c) Evaluate business situations and describe how quantitative and statistical methods.

Sources:

The Fundamentals of Management Science - Ch. 7 Linear Optimization

The Fundamentals of Management Science - Ch. 9 Discrete Optimization

The Fundamentals of Management Science - Ch. 10 Integration in Art of Decision Modelling

Understanding Michael Porter – Ch. 2

Commentary on Question:

Commentary listed underneath question component.

Solution:

(a)

(i) State the objective function.

(ii) State the constraint functions.

5. Continued

Commentary on Question:
Candidates performed well on this portion of the questions. Most were able to state the objective function in section i. However, only a few correctly identified the production capacity constraint function. Many did not recognize the production trade-off between cars and trucks, which made it difficult to map the feasible region and find the optimal solution. To earn full marks, candidates needed to: 1) correctly state the final objective function, and 2) accurately state all constraint functions, including integer and non-negative constraints.

(i) Objective function based on profit (i.e. revenue – raw material expense – labor cost): **max(45*x + 100*y)**, where **x = number of car tires**, and **y = number of truck tires**

(ii) Constraint functions: **x + 2.5*y <= 5** (in millions, represents production capacity) **(1)**

-0.3*x + y <= 0 (truck tire limit) **(2)**

0.05*x – y <= 0 (truck tire minimum) **(3)**

x >= 0, **y >= 0** (positive solutions only)

x, **y** are elements of **P** (where **P** is the set of positive integers)

(b) For the optimization problem defined in part (a):

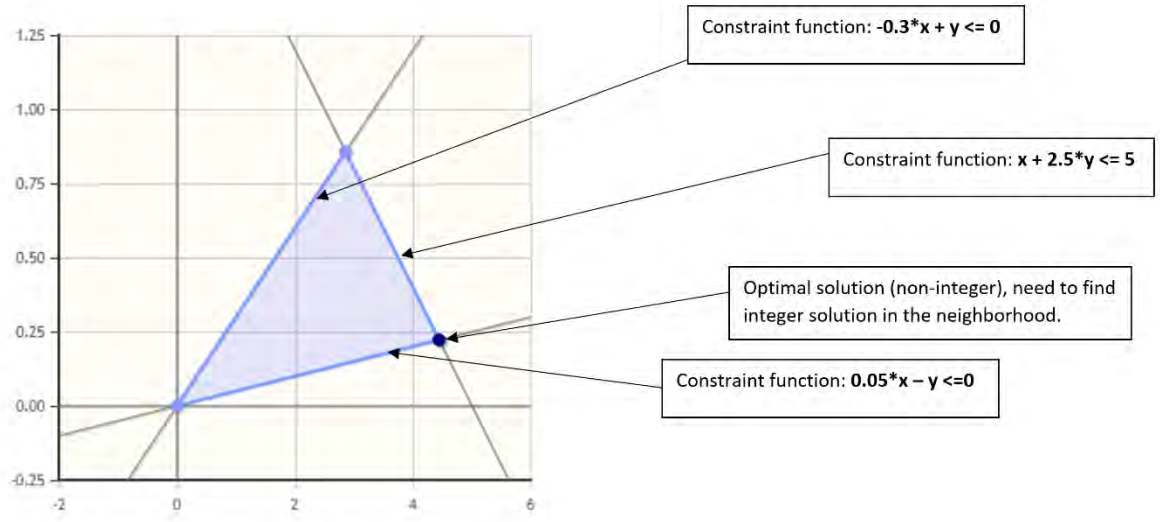
(i) Sketch the feasible region with binding constraints clearly labeled.

(ii) Calculate the optimal solution. Show your work.

Commentary on Question:
Candidates struggled with this section. Those who couldn't correctly identify the production constraint function also had difficulty mapping the feasible region and finding optimal solutions. Common errors included incorrect labeling of constraint functions, not calculating profits for all intersection points, and not checking for integer solutions. To earn full marks, candidates needed to: i) accurately graph the feasible region using the constraint functions from part a, and ii) calculate the optimal solution by comparing the final output at the intersection points.

5. Continued

(i)



(ii) Optimal solution occurs where constraint **(1)** intersects with constraint **(3)** (see intersection point on above chart), but then need to check integer solutions near that point.

Optimal integer solution is: **C = 222,222,225** where **x = 4,444,445** and **y = 222,222**.

BJT will begin producing airplane tires at the new plant, thus the optimization model needs to be reassessed.

(c)

(i) State the new objective function.

(ii) State the new constraint functions.

Commentary on Question:
Candidates performed well in this section, with most scoring between 75% and 100% of the total exam points for the question. Most were able to update their answers in part (a) to include the production of airplane tires and consistently calculate the constraint formula.

However, candidates had difficulty formulating the production capacity constraint, both in part (a) and here in part (c). Many assumed the capacity constraint applied to each individual tire, but it should have been considered for all three tires together, viewing rubber as a finite raw material to be allocated among the production of all three types of tires.

5. Continued

(i) Updated objective function from (a) based on profit: **maximize the function**

= (100 – 30 – 25)*x + (300 – 100 – 100)*y + (2000 – 300 – 500)*z
= 45x + 100y + 1200z

Where, **x = number of car tires**, **y = number of truck tires**, and **z = number of airplane tires**

(ii) Updated constraint functions:

- x + 2.5*y + 5*z <= 5 (in millions, represents capacity)
- -0.3*x + y <= 0 (truck tire limit)
- 0.05*x – y <= 0 (truck tire minimum)
- x >= 0, y >= 0, z >= 0 (positive solutions only)

Where, x, y, z are elements of P (where P is the set of positive integers, i.e. positive integer solutions only)

(d) BJA determines that BJT will produce airplane tires exclusively for BJA. 10% of BJTs new plant production capacity will be allocated to produce airplane tires. BJA will pay $900 per airplane tire produced.

(i) Calculate the optimal solution to your model in part (c) given this new information. Show your work.

(ii) Compare and contrast how BJA and BJT may interpret the optimal solution in part (i).

(iii) Explain the limitations of this type of linear optimization model analysis.

Commentary on Question:
Overall performance on question (i) ranged from poor to moderate, with very few candidates earning more than 70% of the total exam points. Many candidates failed to isolate the constraint of dedicating 10% of production to airplane tires.

Candidates who couldn't determine the capacity constraint correctly in earlier parts carried those errors forward. Most points were lost due to arithmetic errors or misinterpretation of the capacity constraints provided.

Several candidates who were unsure how to proceed gave a generic explanation of optimizing a set of linear equations without performing any calculations.

5. Continued

Candidates received credit for (ii) if they could describe: (a) how entities were cross-subsidizing each other, (b) how transfer pricing benefits the group as a whole, and (c) how individual entity objectives could conflict, or provide other acceptable rationale.

For question (iii), candidates did not need to explain every reason in the solution. Mentioning 2-3 reasons (or other acceptable justifications) and providing adequate justification or examples of why those limitations hinder true optimization earned them credit.

(i) Since the number of airplane tires, **z**, is now fixed to account for 10% of the total production capacity, we have **z = 10% * (1 million capacity for airplane tires) = 100,000**.

Because **z** is fixed, it is no longer a variable in the updated objective and constraint functions:

Updated objective function based on profit: maximize **(45x + 100y + 100 * 100,000),** where **x** is the number of car tires and **y** is the number of truck tires.

Updated constraint functions:

(x + 2.5y <= 4.5) (in millions, noting that capacity has been reduced by 10%) **(1)**
(-0.3x + y <= 0) (truck tire limit) **(2)**
(0.05x - y <= 0) (truck tire minimum) **(3)**
(x >= 0, y >= 0) (positive solutions only)
Here, **x**, **y**, and **z** are elements of **P**, where **P** is the set of positive integers, indicating that only positive integer solutions are considered.

The updated optimal solution still occurs at the intersection of constraint **(1)** and constraint **(3)**. Although the slope of constraint **(1)** has been slightly modified, it is necessary to check for integer solutions near the optimal point. The updated optimal integer solution is: **C = 210,000,000**, with **x = 4,000,000**, **y = 200,000**, and **z = 100,000** (provided as a constant in the optimization model).

5. Continued

(ii) On a standalone basis, BJT aims to maximize its own profit. However, since BJT is owned by BJA, two dimensions must be considered: the profit of BJT (which is fully owned by BJA) and the overall operational savings/efficiencies achieved by acquiring airplane tires at a price below market value.

From BJT's perspective, selling airplane tires to BJA at $900 per tire is suboptimal, as BJT could earn $2,000 per tire on the open market. This means BJT is sacrificing profit for the benefit of BJA, which is undesirable from BJT's standalone perspective.

From BJA's perspective, receiving airplane tires at such a discounted rate is advantageous compared to the open market price. BJA benefits directly from the cost savings, as BJT forfeits profit by selling at a lower price. From a consolidated BJA viewpoint, it might be sensible for BJT to sacrifice profit to benefit BJA.

(iii) There are certainly limitations to using this type of linear optimization model for decision-making. The model relies on several simplifying assumptions that may not hold true in real-world scenarios. The model assumes that costs and sales prices will remain constant, which is unlikely in practice due to fluctuations in supply and demand. For instance, what happens if the cost of raw materials for tire production changes? Who will bear the financial loss in such a situation? Would BJT still be required to sell tires to BJA at a discounted price? These considerations are not addressed in the linear optimization model.

Additionally, the model requires integer solutions since it's not possible to produce a fraction of a tire. The solution must adhere to whole-number constraints. There may also be other real-world constraints that are not immediately apparent. For example, does it make sense to produce an odd number of tires when vehicles typically use an even number? This could introduce another constraint similar to the need for integer solutions, but focused on groups of tires.

Furthermore, the case study suggests there is a delay before the plant reaches full capacity, a timing element not considered by the linear optimization model.

5. Continued

(e) Evaluate the North American tire industry under each of Porter's Five Forces.

Commentary on Question:
Candidates generally performed well on this question. To receive full marks, candidates needed to: (a) identify Porter's 5 Forces, earning 1 point for each force; (b) assess the impact from high to low, earning 1 point for the impact; and (c) provide rationale for the chosen impact using examples or other justifications, earning 1-2 points for each rationale.

Candidates may answer along the spectrum from low to high depending on which points they focus on. Examples below highlight items that increase and decrease competitive landscape for each force.

Threat of New Entrants:

Moderate to High: The coffee shop industry has low barriers to entry - initial capital investment and operational costs are not too high.
However, establishing a higher-end brand and achieving customer loyalty can be challenging.
New entrants would need to invest in high-quality products, premium locations, and strong branding to compete effectively, which can be a deterrent.

Bargaining Power of Suppliers:

Moderate: For a higher-end coffee shop, sourcing high-quality coffee beans and other premium ingredients is key. If the shop deals with a limited number of specialty suppliers, those suppliers could have very high bargaining power.
However, the coffee shop may mitigate this by establishing strong relationships with multiple suppliers or sourcing directly from coffee growers to reduce dependency on any single supplier. (important to note that we are looking at the general market, not Frenz' position in specific geographies).

Bargaining Power of Buyers:

Moderate to High: Customers of higher-end coffee shops tend to be very picky and have specific preferences for quality and experience. If these customers can easily switch to other premium coffee shops or high-quality coffee-substitutions, their bargaining power increases.
However, brand loyalty and a unique customer experience can help mitigate this power.

5. Continued

Threat of Substitute Products or Services:

High: There are numerous substitutes for coffee, e.g. tea, energy drinks, and other specialty drinks. Additionally, with the prevalence of high-end home coffee/espresso machines customers might opt for homemade drinks (or drinks from convenience stores and fast-food chains).
The coffee shop can differentiate itself through superior product quality, unique offerings, and a premium customer experience to mitigate this threat.

Rivalry Among Existing Competitors:

High: The market for higher-end coffee shops can be quite competitive, especially in urban areas with a large number of similar businesses. Competitors may engage in price wars, promotional activities, and efforts to innovate and enhance customer experience. The intensity of rivalry can pressure profit margins and necessitate continuous improvement and differentiation.

(f) Explain how BJT's value chain allows it to differentiate itself within the North American tire industry.

Commentary on Question:
Candidates generally performed well on this question. To receive full marks, candidates needed to state three support statements.

Since BJT is owned by BJA, from the BJA shareholder perspective this could be beneficial on a holistic level. Yes, BJT is subsidizing BJA and foregoing some profit that it could get in the open market, but BJA is saving for the same reason. Alternatively, if BJA were to buy in the open market, BJT could be free to produce whatever, but from the BJA shareholder perspective that might be suboptimal. BJT could even opt to sell airplane tires in the open market, but that might result in a situation that has a comparable payoff from the BJA holding company perspective (vs. BJT selling to BJA at a discount).
In this way BJA is benefitting from economies of scope, by increasing efficiencies and controlling another part of the production process that would otherwise need to be outsourced.

6. Learning Objectives:

3. The candidate will understand how to apply decision making models to general managerial decisions within specified business constraints.

Learning Outcomes:

(3a) Apply fundamental techniques and frameworks of management science to make informed business decisions:
- Apply linear optimization models to managerial decisions.
- Develop decision trees, scenario tests, and simulation models.

(3b) Apply statistical and quantification methods to analyze managerial decisions with uncertain conditions:
- Apply probability distributions to business situations with random variables.
- Construct optimization models utilizing probability theories.

(3c) Evaluate business situations and describe how quantitative and statistical methods.

Sources:

The Fundamentals of Management Science - Ch. 1 Decision Analysis

Commentary on Question:

Commentary listed underneath question component.

Solution:

(a) Calculate the Expected Monetary Value (EMV) of each entry option using the decision tree provided. Show your work.

Commentary on Question:

Candidates performed quite poorly on this question, mostly losing points combining the initial growth and probability trees in Excel. This led to a wide range of answers that often did not make intuitive sense.

Solution found in attached Excel workbook.

(b) Recommend four ways to improve the decision tree model used in part (a).

Commentary on Question:

In general candidates were able to answer this question well. While there were many possible recommendations, candidates tended to focus on the improvements mentioned below.

6. Continued

1) There is no option to not enter the market
2) Time frames are unrealistic
3) Growth percent should not be the same across all options
4) Does incorporate the risk of failure

(c)

(i) Explain why partnering or buying an existing digital bank rather than building its own may be beneficial for Big Ben from a strategic management perspective.

(ii) Recommend an entry option for Big Ben. Justify your answer.

Commentary on Question:
Many candidates were able to score well on this question. Where candidates lost points they did not fully justify their recommendations using information from the case study or prior sub-questions.

(i) Darwin does not have a presence in the Digital Bank market as this is a new product for Darwin. Benefits from Partnering or Buying an existing digital bank include:
- Buying/partnering will increase speed to market
- There is lower risk of failure compared to building its own R&D
- This adds new capabilities to Darwin

(ii) I recommend Big Ben buys the existing digital bank. The initial investment to buy the digital bank fits within RPPC guidelines and the investment is returned within two years. The total Expected Monetary Value is the highest of the three options.
Additionally, Darwin can expect increased speed to market and lower risk of failure compared building its own digital bank.