CFE SDM Model Solutions
Fall 2023

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:

(2a) Explain how strategic budgeting can create value and sustainable growth.

(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. 30 ZBB

Handbook of Budgeting – Ch. 2 Balanced Scorecard-based Budgeting & Performance Management

Commentary on Question:

Candidates generally performed well on this question, in particular on the recall and comprehension parts. The Candidates did often provide reasonable responses to questions requiring application to the case study.

Solution:

(a) List the six problems for top management created by the traditional incremental approach.

Commentary on Question:

This was scored out of 4. Almost all Candidates got this.

1. Budgeting requests exceed funding availability, often forcing management to recycle the process.
2. Difficulty in translating long-term objectives into action plans (and budgets).
3. Key problems and decision areas are not highlighted.
4. Alternatives are not identified

1. Continued

    5. Difficulty in adjusting budgets and operations readily to changing situations
    6. Trade-offs among long-term goals and programs, operating needs, and profits are not clearly identified

(b)

(i) Explain how the evaluation of alternatives under ZBB reinforces a particular method of securing an increase in Economic Value Added (EVA). Justify your answer.

(ii) Identify a change made to BJA's Operations that is an example of (i). Justify your answer.

Commentary on Question:
Part i was done well. For part ii, some candidates did not identify a change made but a potential change that could be made; partial credit was awarded in this case. Also for part ii, some candidates did not provide justification for their answer.

(i) EVA – Capital is withdrawn from uneconomic activities or sent to more economic activities.

ZBB – Alternatives to top management include "Eliminate the operation if no decision packages are approved".

Which of these funding levels is appropriate will be determined by the priorities established by top management and by the availability of total funding, which links back to withdrawing from uneconomic activities

(ii) BJA discontinued its travel agency. The travel agency's economic performance was not sufficient since it was only breaking even.

(c) Explain how a decision package would consider the IT manager's proposed initiative during the ZBB process.

Commentary on Question:
There were many reasonable responses to this question. Most candidates listed out what a decision package does and how each part applies.

Decision packages are used for evaluating and comparing alternatives.
The IT Manager's proposed initiative is an alternative method to achieve the objective of expanding Lucky 7. The alternative method is to expand the degree of effort by increasing staffing and maintaining CRM. There will be a cost benefit analysis against leveraging existing staff. The decision package can look at leveraging existing fees or charging new fees to implement the new solution.

1. Continued

(d)

    (i)   Identify the type of each alternative being considered by BJA's management team. Justify your answer.

    (ii)   Explain why the ZBB process would reject these alternatives.

Commentary on Question:
Part i was done well. For part ii, though, most earned only partial credit. Some candidates noted that BJA's business strategy was targeted towards business class and some candidates noted that the return was not adequate. It was rare that both points were presented, which was required for full points.

    (i)   **Elimination** – the loyalty program is removed from the operation.

            Current level – by definition, the same level of effort is being kept by BJA.

    (ii)   When determining the minimum level of effort…

        1. The minimum level may not completely achieve the total objective of the operation. (Even the additional levels of effort recommended may not completely achieve the objective because of realistic budget and/or achievement levels.)
        2. The minimum level should address itself to the most critical population being served or should attack the most serious problem areas.

(e)

    (i)   Describe the five principles of the dual operating system approach.

    (ii)   Critique Susan's approach to implementing ZBB with respect to the dual operating system approach.

    (iii)   Recommend how Susan and senior leadership can communicate the choice of ZBB to department managers to ensure successful change management.

Commentary on Question:
Most candidates did poorly on part i. Parts ii and iii were in general well done.

    (i)   Enlist many change agents not just a few full time appointees
            More leadership not more management
            Head and Heart not just Head

Want to and a get to, not just a have to mindset
Two systems, one organization – Hierachy and Network

(ii)   Susan was the only change agent so did not enlist many change agents
Susan took action with the decision solely and thus did not provide leadership for a team to act.
She did not engage the employees heart when considering this decision. She made a rationale decision at the price of disenganging other departments.
Others were not change agents, and there was no other voluntary input into her decision. So she took away what people want to and get to mindsets.
She used only one system to implement – Hierachy and ignored the network.

(iii)   She should get buy-in from the change agents before she rolls it out.
Ie. Present her case of ZBB and receive input from the change agents and implement adjustments accordingly. She can then present with a panel of change agents. She can provide logical justification showing how the results of ZBB align with the companies objectives and how EVA is optimized.

2. **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:
(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.

Sources:
Damodaran on Valuation – Chapter 15

Handbook of Budgeting – Chapter 17

Strategy to Beat the Odds

Commentary on Question:
The question tested candidates' ability to quantify synergy and evaluate a company's ability to move up the power curve. Candidates who performed well on this question accurately calculated the value of firm's synergy and thoroughly evaluated the acquisition's effectiveness in helping Snappy move up the power curve.

Solution:
(a)

(i) Calculate the value of Snappy using Discounted Cashflows for the next 5 years. Show your work.

(ii) Calculate the value of Snarky using Discounted Cashflows for the next 5 years. Show your work.

Commentary on Question:
Candidates generally performed poorly on this question. To receive full marks, candidates needed to show each step in calculating the value of each firm. Many candidates left out the terminal value calculation and/or did not discount the terminal value back to valuation date.
Values provided in Excel workbook are rounded. No mark is deducted for using either rounded or unrounded numbers.

2. **Continued**

Model solution is included in Excel workbook.

(b)

    (i)   Calculate the value of the synergy. Show your work.

    (ii)   Calculate an additional financial metric to evaluate Snappy's acquisition of Snarky. Justify your answer.

    (iii)   Discuss whether or not Snappy should pursue an acquisition of Snarky based on your answers in (i) and (ii).

Commentary on Question:
Candidates generally performed well on this question. To receive full marks, candidates needed to calculate the synergy generated by the acquisition and identify an appropriate financial metric such as ROC. Either conclusion (to or not to acquire) was accepted, but the justification needed to correspond to the calculated synergy and metric values.

Model solution for part (i) is included in Excel workbook.

    (ii)   Additional metric: Return On Capital. ROC is a good metric for executive performance as it is an useful measure of how efficiently a company is using its capital to generate profits
In the acquisition of Snarky, ROC increases with the combined firm.
- Snappy ROC: 7.31%
- Combined ROC: 7.35%

    (iii)   Recommendation: Acquire Snarky
The synergy calculated in part (i) is positive, however Snappy needs to ensure that not all of the synergy value will be given to Snarky (i.e. needs to retain some synergy value by reducing the purchase price). The increased ROC reaffirms the recommendation.

(c)   Explain how Snappy can compare acquiring Snarky versus paying Snarky to produce projections as a service.

Commentary on Question:
Candidates generally performed poorly on this question. To receive full marks, candidates needed to provide an approach such as a cost-benefit analysis on the acquisition (what is paid and what is gained). The question only asked what questions/decisions should be considered to perform the analysis.

2. Continued

1. What is the market premium Snappy will pay?
2. Will the value of the synergy be immediately realized, or will there be a time horizon?
3. What is the difference between the market premium and the [PV] of the synergy?
4. What is the present value of the services rendered over a similar time horizon as 2.?
5. Is there a control premium earned by Snappy in addition to the value of synergy?
6. What is the cost of transaction vs other opportunities in the market? How do the benefits compare on a relative basis over the cost?
7. Is the annual fee of using the service cheaper or more expensive than pursuing acquisition on a PV basis?
8. Are Snarky's services accretive or dilutive of current Snappy sales?

(d) Describe an incentive structure for the key employees at Snarky. Justify your answer.

Commentary on Question:
Candidates generally performed well on this question. To receive full points, answer had to link key employee retention with the incentive structure. The incentive could not be made immediately available.

The key purpose of the compensation plan is to align the key employees' economic interest with those of the long-term goals of the company given we don't want these employees to leave. To reduce key person risk, long-term incentive plan should be used instead of the annual incentive plans like yearly salary. It is recommended to provide those key employees with stocks with 5 years of vesting period to provide them with incentive to stay longer with the company. A bonus structure which accumulates for 5 years before it can be granted also works to retain skilled employees.

(e)
    (i) Define economic profit.

    (ii) Explain the Board's concern.

Commentary on Question:
Candidates generally performed well on this question. Most candidates were able to identify that economic profit is the total profit after accounting for cost of capital in part i. For part ii, most candidates were able to identify that the Board is concerned with the fact that Snappy is in the middle of the power curve and unlikely to move up.

2. Continued

      (i)   Economic profit is the total profit after subtracting the cost of capital

      (ii)   Snappy's board is concerned with the fact that they are in the middle of the power curve. Acquiring Snarky is unlikely to deliver significant economic profit. In addition, the chances of moving up the power curve is low as only 8% of companies have moved from the middle to the top quantile in the past 10 years. The Board is also concerned with the type and size of the industry that Snappy is in, as its position on the power curve is also heavily influenced by these factors

(f)

      (i)   List the five moves that can help an organization move up the power curve.

      (ii)   Evaluate whether or not purchasing the equipment is an opportunity for Snappy to move up the power curve. Justify your answer.

Commentary on Question:
Candidates generally performed well on this question. Most were able to list the five moves to help an organization move up the power curve. Some candidates struggled with determining what moves purchasing the equipment would fall under and providing sufficient justification.

      (i)   Programmatic M&A
             Dynamic reallocation of resources
             Strong capital expenditure
             Strength of productivity program
             Improvement in differentiation

      (ii)   Purchasing the equipment is an opportunity for Snappy to move up the power curve as it falls under the "Strong capital expenditure" move since the purchase is a strong capital investment and "Strength of productivity program" move since this purchase will allow non-technical staff to efficiently perform financial forecasting work. Making one or two of these moves in combination with each other increases the chances of moving up the power curve. Although strong capital expenditure can increase the chances of moving both up and down the power curve, it is preferrable to the alternative of making no moves at all as that will lead to stagnation and a lack of capital growth.

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

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

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

(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.

Commentary on Question:
Commentary listed underneath question component.

Solution:
(a)   Sketch a causal loop diagram using the nodes below to illustrate the variables that have impacted SEA's profits.

Positive Customer Reviews

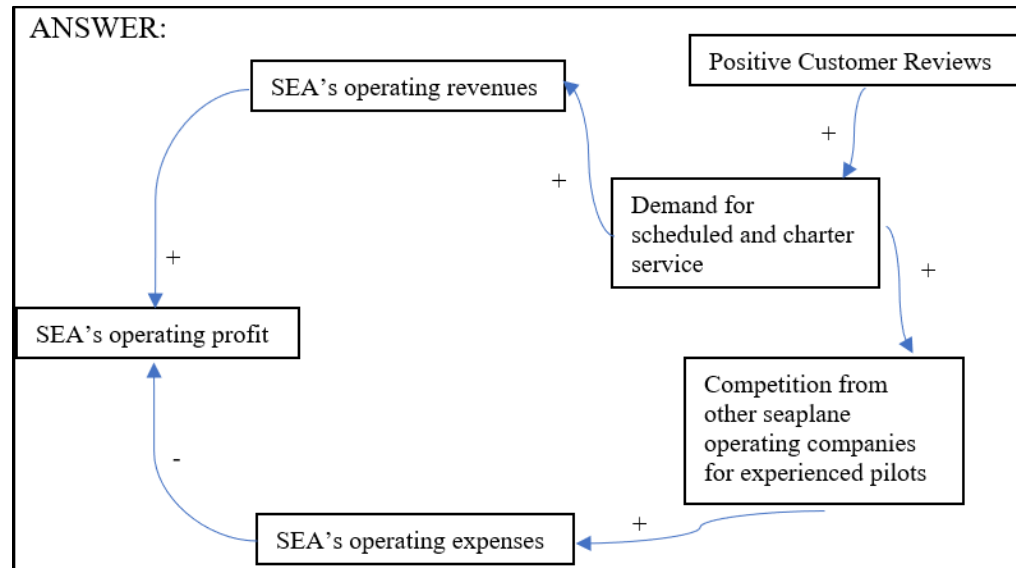Demand for scheduled and charter service

SEA's operating revenues

SEA's operating profit

SEA's operating expenses

3. **Continued**

Commentary on Question:
Most candidates were able to capture the main causalities. Demand impact on competition was missed by many candidates. Extraneous and contradictory nodes were penalized.

ANSWER: (causal loop diagram showing) SEA's operating revenues, Positive Customer Reviews, Demand for scheduled and charter service, SEA's operating profit, Competition from other seaplane operating companies for experienced pilots, SEA's operating expenses — with linkages labeled +, +, +, +, +, +, and −.

(b)   Describe how each of the following scenarios would change the model in (a):

(i)   Individual SEA employees receive a bonus for positive customer reviews.

(ii)   Customers may view the flight history of pilots and choose to fly with the best and most experienced pilots.

(iii) Significant increase in fuel costs around the world, coupled by a rise in interest rates and inflation.

Commentary on Question:
Candidates were able to draw relevant causalities from each scenario however to get full marks they had to refer to the specific nodes used in the first part of the question.

(i)   A bonus for positive customer reviews will incentivize higher customer service and likely increase the number of positive reviews. The positive review will increase the demand which will increase both operating revenues and profits.
        Bonus payouts will also directly increase operating expenses and negatively impact profits.

3. **Continued**

(ii)   Viewing safety records will increase positive customer reviews and increase demand for SEA's business.
Extra procedures may also increase competition for experienced pilots and increase expenses.

(iii)   Increased fuel costs, interest rates, and inflation would increase SEA's operating expenses which would negatively impact profits.
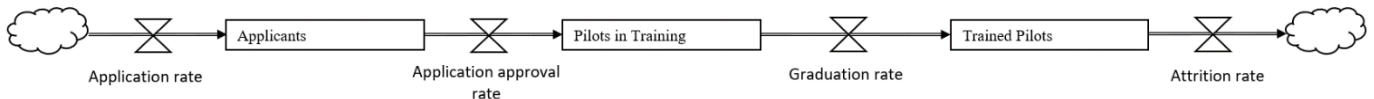
Inflation and rising interest rates may also impact the consumers propensity to consume and reduce demand for tourism. This will negatively impact revenues and profits.

(c)   Sketch and label a stock and flow diagram for pilot training including the below components.

| Applicants |
| Trained Pilots |
| Pilots in Training |
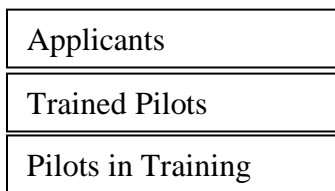
Commentary on Question:
Majority of the candidates were able to sketch and label the diagram correctly and received full marks.

Application rate → Applicants → Application approval rate → Pilots in Training → Graduation rate → Trained Pilots → Attrition rate

(d)   An HR consultant in the industry offered an assessment to SEA.

"*With so much competition, retaining experienced pilots is too difficult! To ensure SEA has enough resources to carry out its international expansion strategy, SEA should constantly hire as many new pilots as possible because we should assume we will always be losing experienced pilots.*"

Critique this statement.

Commentary on Question:
Most candidates received partial marks for identifying relevant points. To get full marks, they had to identify at least 3 valid points and refer to the case study.

3. Continued

The assessment doesn't consider the supply line. It ignores the employees that have been hired but have not started. It also ignores the delay and assimilation to get new employees up to speed before they're at a reasonable productivity and flight rate similar to existing employees.

The approach ignores the seasonality and the demand for new pilots which is much higher in summer than winter.

The assessment doesn't consider equilibrium of the number of pilots which will cause a constant mismatch of staffing goals. Overshooting or undershooting the number of pilots at a given time will disrupt SEA's equilibrium. The hiring rate should match the overall quit rate accounting for assimilation/training and productivity.

Hiring too many new pilots that require on the job training could reduce the productivity of the already established pilots. So constantly hiring as many new pilots as possible could burnout current pilots and increase their quit rate.

Having too many junior pilots may negatively impact the overall safety rating of the airline decreasing overall demand and profits.

4. **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 Steman: Chapter 4 Structure and Behaviour of Dynamic Systems
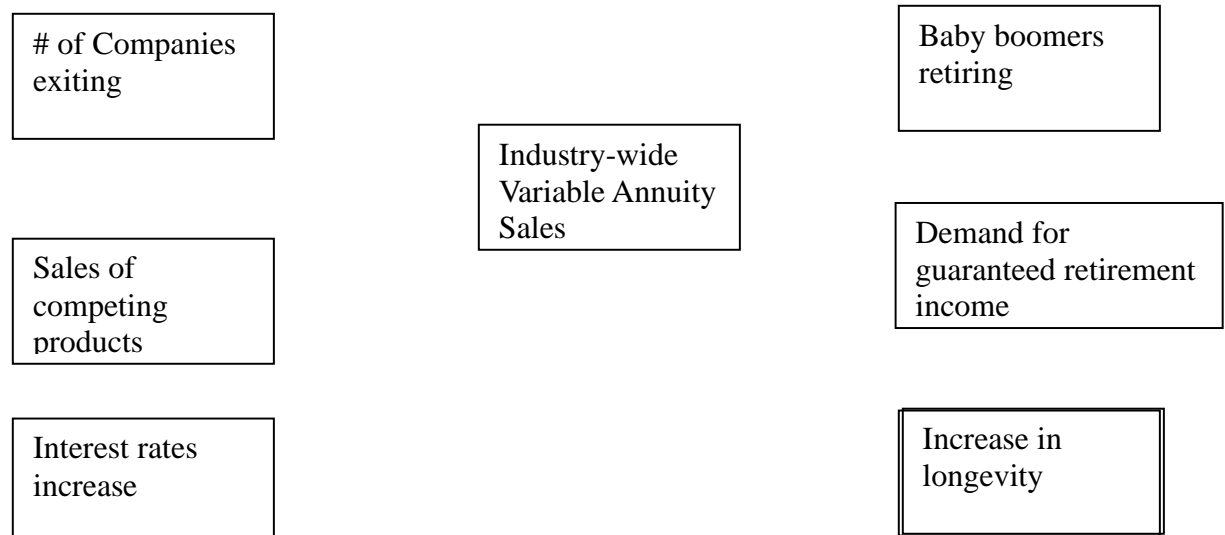
Business Dynamics Steman: Chapter 5 Causal Loop Diagrams

Commentary on Question:
Commentary listed underneath question component.

Solution:
(a)   (*3 points*) Sketch the causal links, identifying their polarity, to complete the diagram below. Include at least three delays.

4. Continued

Commentary on Question:
In this question a successful candidate must demonstrate clear understanding of causal loop diagram, including building causal links, identifying polarity correctly and considering delays. Hardly any candidates received full credit, but almost all candidates received partial credit.

Partial points were rewarded if
- *candidate demonstrated an understanding of causal loop diagrams, but missed some of the finer details.*
- *3 out of 6 factors contributing to VA sales are used*
- *the direction of arrows is correct but polarity is misqualified*
- *only 1 or 2 delays are identified*

Proposed Diagram:
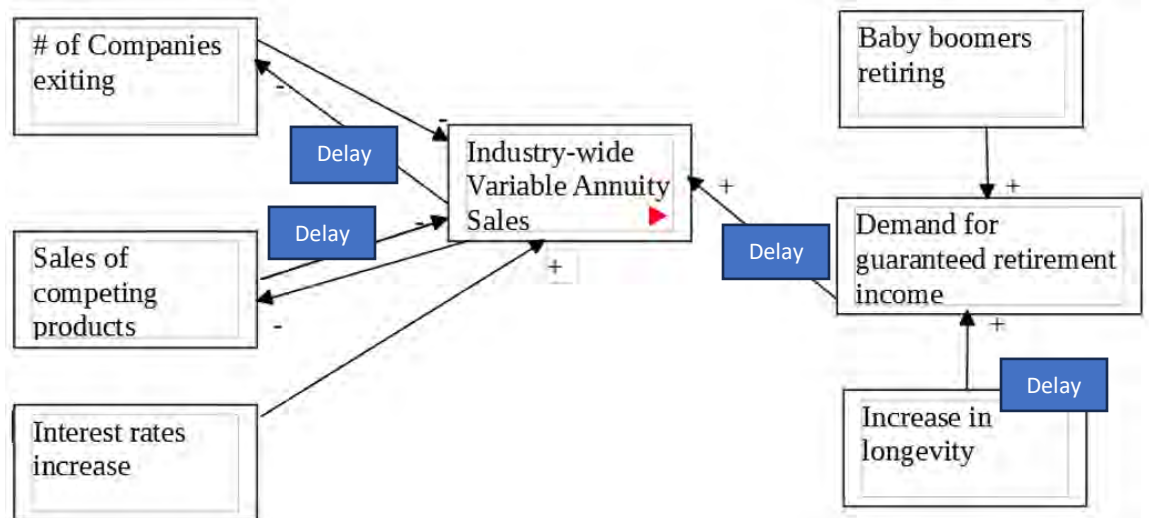
Delays: There is a delay between realizing people are living longer and need for guaranteed retirement income
There is a delay between falling sales and companies exiting the VA space
There is a delay between the need of guaranteed income and VA sales (first, we had mutual funds)
There is a delay between appearance of competing products from banking/mutual funds and insurance companies exiting the space
There might be a delay between introduction of competing products and fall in VA sales (and vice versa)

(b) List the three fundamental modes of dynamic behavior.

4. Continued

Commentary on Question:
This is a retrieval question. Candidates performed very well in this part. Most candidates were able to list all three fundamental models of dynamic behavior and get full credits.
Partial points were awarded if the candidate listed one or two of the fundamental modes, and if they substituted one of the combination modes (s-growth, overshoot and collapse, growth and overshoot)

Exponential Growth, Goal Seeking, and Oscillation.

(c) VA sales are expected to follow the Projected Inforce Statistics from Exhibit 5 in the Case Study.

   (i) Describe one relevant operational consideration for determining the mode of dynamic behavior of Darwin's VA sales.

   (ii) Identify a result from Darwin's sensitivity testing from Exhibit 5 in the Case Study that is relevant to determining the mode of dynamic behavior of Darwin's VA sales. Justify your answer.

   (iii) Describe the complex pattern of dynamic behavior of Darwin's VA sales based on your answers to (i) and (ii).

   (iv) Describe a response to the operational consideration identified in (i) that would create a compensating feedback loop. Justify your answer.

   (v) Describe a response to the operational consideration identified in (i) that would not create a compensating feedback loop. Justify your answer.

Commentary on Question:

For (i) about half the candidates struggled to identify operational considerations relevant to identifying the dynamic behavior. Half credit was awarded for answers that listed viable considerations from the case study. The other half was awarded for justifying the consideration.

For (ii), the question incorrectly referenced Exhibit 5 instead of referencing the Sensitivity testing from Exhibit 4 in the Case Study. Many candidates detected this error and referenced the correct Exhibit. Candidates who referenced Exhibit 5 were not penalized.

4. Continued

For (iii), well-structured answers to (i) and (ii) referenced carrying capacity issues and delays. Taken with the forecasted exponential growth, full marks were awarded for growth with overshoot (or S-shaped growth with oscillation). Partial credit was awarded for S-shaped growth.

For (iv) and (v) a full credit answer required candidates to 1) identify an appropriate operational response, 2) connect it to an operational consideration from (i), and 3) explain why that response would create a compensating feedback loop. Very few candidates received high marks on this part. Candidates struggled to identify operational responses that connected back to part (i). Very few candidates demonstrated an understand of compensating feedback loops, often confusing them with reinforcing loops. Many candidates received at least some partial credit.

(i)

Darwin does not have enough resources to manage the inforce business as legacy products and systems require a lot of resources. The systems Darwin uses at this moment are not fully scalable and require manual operations. These constraints would lead Darwin's sales to slow as they hit the company's internal carrying capacity. Delays between selling policies and issues administering them could cause oscillations in sales.

(ii)

In the Exhibit 4 in the Variable Annuities Section, there is a noticeable drop (%) in Statutory capital between 2024 and 2025 in the Base scenario. In the "Sales Up 15%" scenario this drop increases to 9%. This could mean distress for the VA business, as they require statutory capital to support new sales while they require additional resources to administer the benefits for the new customers. These liquidity issues and resources constraints suggest Darwin is approaching their carrying capacity, and they take time to show up indicating delays in the system.

(iii)

Darwin's forecasts indicate exponential growth for the foreseeable future. However, at some point the internal constraints and need for additional statutory capital will make satisfying new customers and effectively administering their benefits difficult. There might be a lag between sales of policies and the point where administration issues and limited capital affect future sales. This combination will create a growth with overshoot (S-shaped growth with oscillation.

4. **Continued**

(iv)

Compensating feedback is a reaction from the system that undercuts the intention of a policy. It is the result of a policy directed at the symptom of the structure. Therefore, a compensating feedback loop would be a loop that has negative or opposite effects than intended. A response that could elicit such feedback would be to hire more employees to administer the new sales. While one would think this would decrease the delay time, it is only alleviating a symptom of the problem. Since the administrative processes themselves are built to be efficient and are lacking capabilities, increasing the number of employees using such poor systems will not result in a shorter delay. It may increase cost while causing more manual errors.

(v)

Rather than hiring more administrative employees, Darwin could invest to upgrade their systems to automate the administration of the benefits. Though costly upfront, it would greatly expand their sales/administrative capacity. This would not create a compensating feedback loop since profits from new sales would not be offset by other loops related to operational inefficiencies.

5.   **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. 7 Linear Optimization, The Fundamentals of Management Science - Ch. 8 Nonlinear Optimization

Commentary on Question:
This question tests candidates' knowledge of linear and non-linear optimization models. Successful candidates demonstrated ability to set up objective functions and constraints based on business context. Generally, candidates performed well in the first half of the question, related to linear optimization model. Performance varied in the second half, related to non-linear optimization model.

Solution:
(a)   State the objective function.

Commentary on Question:
Candidates generally did well for this part of the question. To receive full marks, candidates needed to include the $10,000 reimbursement as revenue. Partial marks were awarded for otherwise setting up the revenue and expense structure correctly.

B = Price for Business seat
E = Price for Economy Seat

Revenue = (50 * 70% * B) + (230 * 80% * E) +10,000
Expense = 200,000 + 150,000
Income = Revenue - E*pense

Max Income = (50 * 70% * B) + (230 * 80% * E) +10,000 – (200,000 + 150,000)

5. Continued

Given the model is set up with fixed demand (i.e. 70% occupancy for business and 80% occupancy for economy), the flight load is always greater than 100 passengers, hence the revenue reimbursement of $10,000 is maxed out.

(b) State the constraints.

Commentary on Question:
Most candidates were able to successfully state the constraints. A large portion of candidates failed to include the $10,000 reimbursement as revenue.
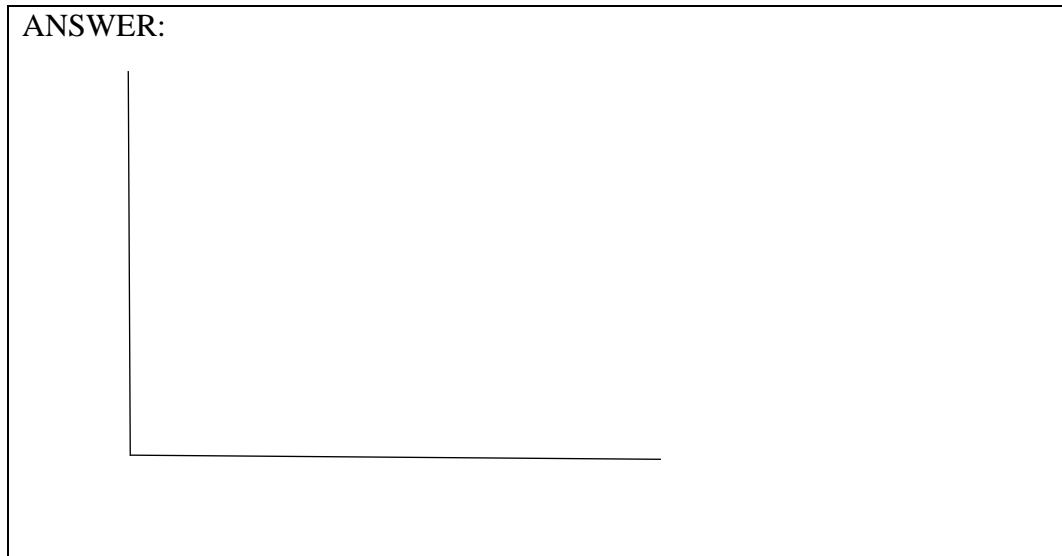
Profit Margin = (Revenue – Expenses) / Revenue <=10%
(35B + 184E + 340,000) / (35B + 184E + 10,000) <= 10%

B/E<=5
Non-negativity B, E > 0

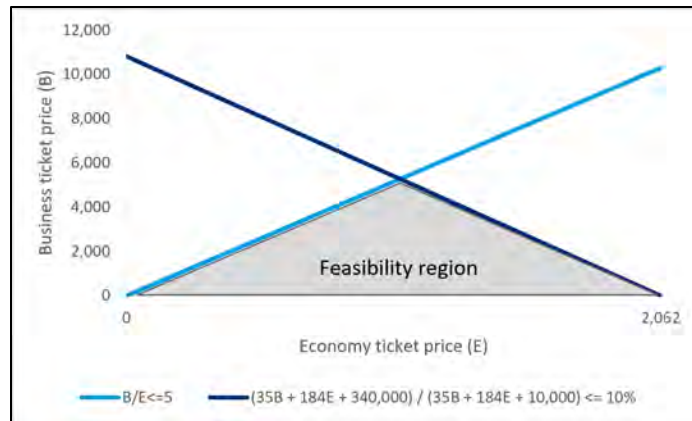(c) Sketch the feasibility region.

ANSWER:

Commentary on Question:
Candidates generally did well for this part of the question. Marks were awarded for graphing constraints from part b) and correctly identifying the feasibility region.

5. **Continued**

Non-negativity constraints are considered by not plotting past x- and y-axis.

(d)   Determine the optimal prices for each Business and Economy class seat.

Commentary on Question:
Candidates generally did well for this part of the question. Successful candidates were able to identify that optimal solution is where the constraint functions cross and solve the system of linear equations. To receive full marks, the profitability margin constraint must include the $10,000 reimbursement as revenue.

The optimal solution is where constraints cross, hence solving for the system of linear equations:

(35B + 184E +10,000 – 350,000)/ (35B + 184E +10,000) < 10%
B <= 5E

35B + 184E – 34,0000 < 3.5B + 18.4E + 1,000
31.5B + 165.6E <341,000
(plug in B = 5E)
31.5 * 5E + 165.6E < 341,000

E=1,055
B= 5,277

(e)   State three areas of flexibility when using the two-stage linear optimization modeling paradigm.

Commentary on Question:
Performance varied for this part of the question. To receive full marks, candidates need to state all three areas of flexibility related to two-stage linear optimization model.

5. Continued

      1. Modeling different number of states of the world
      2. Modeling different probabilities of states of the world
      3. Modeling different number of stages

(f)   List the possible states arising from the Demand and Fuel Cost Scenarios.

Commentary on Question:
Candidates performed well for this part of the question. Most candidates received full marks, which required listing out the four combinations of demand and fuel cost scenarios.

State	Fuel Cost	Reimbursement	Probability
1	50,000	50/passenger up to 7500	0.25
2	50,000	50/passenger up to 7500	0.25
3	500,000	200/passenger up to 10000	0.25
4	500,000	200/passenger up to 10000	0.25

(g)   State the objective function for the new two-stage model.

Commentary on Question:
Performance varied for this part of the question. Successful candidates were able to list out the four states, assign equal probability, and recognize the different reimbursement payments and fuel costs.

Max Income
$= 0.25 * [(50 * 70\% * B) + (230 * 80\% * E) + 7{,}500 - (500{,}000 + 150{,}000)]$
$+ 0.25 * [(50 * 70\% * B) + (230 * 80\% * E) + 7{,}500 - (50{,}000 + 150{,}000)]$
$+ 0.25 * [(50 * 70\% * B) + (230 * 80\% * E) + 10{,}000 - (500{,}000 + 150{,}000)]$
$+ 0.25 * [(50 * 70\% * B) + (230 * 80\% * E) + 10{,}000 - (50{,}000 + 150{,}000)]$

(h)   State the updated objective function.

Commentary on Question:
Most candidates were unable to incorporate the demand functions into the ticket sales. Very few candidates incorporated the demand functions into the reimbursement.

B = Price for Business seat
D_b = Demand for Business seat
E = Price for Economy Seat
D_e = Demand for Economy seat

$D\_b = (4{,}000 - B) / (4{,}000 - 1{,}000) => (4{,}000 - B) / 3{,}000$
$D\_e = (2{,}000 - E) / (2{,}000 - 500) => (2{,}000 - E) / 1{,}500$

5. **Continued**

Revenue = (50 * D_b * B) + (230 * D_e * E) + min(10,000, 100 * [50 * D_b + 230 * D_e])
Expense = 200,000 + 150,000
Objective function = Revenue - Expense

(i)   State the updated constraints.

Commentary on Question:
Candidates that did well on (h) were generally able to update the constraints correctly. Most candidates carried forward the constraints that did not change and were awarded partial marks.

Updated constraints:
Profit Margin = (Revenue – Expenses) / Revenue <=10%
Revenue = (50 * (4,000 – B) / 3,000 * B) + (230 * (2,000 – E) / 1,500 * E) + min(10,000, 100 * [50 * (4,000 – B) / 3,000 + 230 * (2,000 – E) / 1,500])
Expense = 200,000 + 150,000

1,000 <= B <= 4,000
500 <= E <=2,000

Old constraints carried forward:
B/E <= 5
Non-negativity B, E > 0

(j)   Recommend two additional enhancements to make the model more realistic. Justify your answer.

Commentary on Question:
Most candidates were able to suggest reasonable enhancements to the model. Full marks were only awarded for both describing the enhancement and proposing how the model should be updated.

Sample responses:
Demand can be enhanced with a seasonality component; this can be modeled based on the months in a year and historical business and leisure travel levels.
Fuel price can be enhanced with a variable component that depends on the load of the plane, such as the number of seats sold.