**HW 2 Solutions – Business analytics**

To solve the problem below you will need to do the following:

* 1. Use the Generalized Analytics Procedure (GAP) to set up your problem as follows:
     1. Define your model in words
        1. Identify the objective function in words
        2. Identify the random variables in words (none in this HW)
        3. Identify the decision variables in words
        4. Identify the constraints in words
     2. Formulate your model mathematically
        1. Define the random variables (none in this HW)
        2. Define the decision variables
        3. Define the objective function in terms of decision variables
        4. Define the constraints in terms of the decision variables. Please include any non-negativity constraints in your formulation
  2. Set up the problem in Excel and use Solver to find the optimal values of the decision variables. Ask Solver to create an Answer Report.
  3. Answer the questions stated in the problem (in words).

Please submit **only one file in PDF** format with your write-up. **Do not** submit your Excel file. Your writeup **must** include a screenshot of the answer report generated by Excel Solver with the date and time stamp. Also include the sensitivity analysis screen shot if you use it in your answers.

If you make any additional assumptions, state them clearly.

**Problem 1: Hyperloop**

Your newest venture idea is a Hyperloop service between Washington DC and Baltimore. The Hyperloop trains will offer customers a choice between coach and first-class tickets.

For the venture to comply with federal regulations, it must sell a minimum of 10 first-class tickets and a minimum of 10 coach tickets per trip. Currently the profit margin is $5 for each coach ticket and $8 for each first-class ticket. Due to safety reasons, the train total capacity is 50 travelers (excluding the crew).

While first-class tickets are more profitable, first-class seats take up more space relative to coach seats. The overall length of the seating area of the train is 2400 inches. The seat pitch for 1st class is 60 inches. The federally mandated seat pitch for coach class is 30 inches.

Another consideration for deciding on the allocation of the seats is the weight capacity of the train. The allowed total passenger payload is 10000 lbs. It is also known that first class customers are, on average, heavier than coach customers. The typical weight of a first-class customer is 200lbs, while the typical weight of a coach customer is 150lbs.

1. How many of each ticket should be sold in order to maximize profits?

**GAP:**

**Nominal language:**

Objective: Maximize profit from train tickets

Decisions Variable: How many coach and first-class seats should one train have.

Constraints: Federal regulation of minimum 10 first-class or coach tickets per trip

Safety reason of 50 travelers limit

Length limit for seating

Payload limit for passengers.

**Math formulation:**

Decision Variable: F (First class), C (Coach Class): # tickets of each type

Objective Function: maximize 5C + 8F

Constraints: F, C >= 10

F + C <= 50

60F + 30C <= 2400

200F + 150 C <= 10,000

F, C > = 0. (not technically required since F, C >= 10 already)

Answers: 30 First class seats, 20 coach class seats. Each trip can profit $340

Table

Description automatically generated

1. How much would Hyperloop earn over a 10-year horizon with 365-day service, and 100 trains per day, assuming full utilization and assuming that you implement your solution in part a)?

Multiply the maximum profit attainable with one train ($340) by the number of years, days in a year and trains per day:

10-year Profit = 10 \* 365 \* 100 \* 340 = $124,100,000

1. Now suppose that due to an unprecedented outbreak of a novel infectious disease, the Hyperloop must either redesign all train cars to follow the CDC guidelines for social distancing or shut down all operations. The full redesign would cost $50 Million and reduce the available seating area, and thus the maximum seating area of each train by 50% (The maximum number of passengers is not restricted). Given that you are unwilling to increase prices, how many of each ticket should be sold in order to maximize profits? Under the assumptions in (b) is the venture still profitable?

We cannot solve the problem by using sensitivity analysis since 2400\*0.5 = 1200 is larger than the allowable decrease of 600. However, we can solve the problem by re-entering it into solver with the new constraint (60F + 30C <= 1200) and re-running solver:

Answer: 10 First Class, 20 Coach. Each trip makes $180 profit

We can then compute the 10-year projection for profit as follows:

10\*365\*100\*180 = $65,700,000 > $50,000,000

Thus, venture is still profitable

1. See attached R/Python files.
2. Now suppose that you could spend capital to upgrade the train in one of two ways:
   * **Upgrade 1:** Spend $4 million dollars to increase the maximum number of travelers from 50 to 55.
   * **Upgrade 2:** Spend $8 million dollars to increase the seating area of the train from 2400 inches to 2600 inches.

You have three options. 1) Invest in Upgrade 1, 2) Invest in Upgrade 2, 3) Invest in Neither. Which choice maximizes profit over the 10-year horizon? Justify you answer with the sensitivity report.

* + Upgrade 1: Shadow price of 2 x 5 x 10 \* 365 \* 100 = 3,650,000 added revenue. Note that the change of 5 is within the allowable increase of 10. However, the additional revenue is below the cost 🡪 not worth spending $4M.
  + Upgrade 2: Spend $8 million dollars to increase the seating area of the train from 2400 inches to 2600 inches. Shadow price of 0.1 x 200 x 10 \* 365 \* 100 = 7,300,000 added revenue. Note that the change of 200 is within the allowable increase which is 300. However, the additional revenue is below the cost 🡪 not worth spending $8M.

