**HW 5 – Business analytics**

This homework is due before class 6. Please submit two files: your write-up and your Excel file. If you make any additional assumptions, state them clearly.

To solve the problem, 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 firm’s/manager’s objective function in words
        2. Identify the decision variables in words
        3. Identify the random variables (risk sources)
        4. Identify the constraints (optional here)
     2. Formulate your model mathematically
        1. Define the decision variables
        2. Define the random variables (risk sources). What is the probability distribution of those random variables?
        3. Define objective function in terms of decision variables and random variables.
        4. Define the constraints (optional here)
     3. Solve the problem in Excel
        1. Generate **MANY (>1000)** random draws from the specified distribution (see step ii.2above)
        2. For each random draw calculate the objective function value
        3. Try different values for your decision variable and choose the value of decision variable that results in the highest objective function value, on average.
  2. Answer the questions stated in the problem (in words).

*Note: I recommend starting with the GAP (Steps i and ii above). However, if you prefer to go straight to Excel, points will not be deducted.*

**Beyond Armor**

The Baltimore based company Beyond Armor (BA) is exploring a new business opportunity: selling custom screen-printed sweatshirts for college football bowl games. BA is trying to determine how many sweatshirts to produce for the upcoming Tangerine Bowl game. During the month before the game, BA plans to sell their sweatshirts for $30 each. At this price, they believe the demand for sweatshirts will be uniformly distributed between 5,000 and 15,000.

One month after the game, BA plans to sell any remaining sweatshirts to the local TJ Maxx and Marshalls outlets for $12 each. At this price, BA believes they will be able to sell either 500 units with probability 30%, or 750 units with probability 40% or 1000 units with probability 30%.

Any remaining sweatshirts will be donated to a local charity.

BA can order custom screen-printed sweatshirts for $10 per sweatshirt in lot sizes of 200. Use simulation modeling to answer the following questions.

1. Determine the average profit that BA would earn if she orders 10,000 sweatshirts.

**Model in words:**

* **Objective:** No objective (Just estimate profit)
* **Decision Variable:** None
* **Randomness:**  Pre-game and post-game Demands

**Mathematical model:**

* **Decision Variable:** None
* **Random variables:**

B: Before game demand, B ~ Uniform [5000, 15000]

A: After game demand, with an empirical distribution.

|  |  |  |  |
| --- | --- | --- | --- |
| Value | 500 | 750 | 1000 |
| pdf | 30% | 40% | 30% |

* **Objective function:** No objective function; just estimate profit as follows:

Total Profit = Before game Revenue + After game Revenue – Total costs

Before Game Revenue = B \* 30 if B <= 10000;

10,000 \* 30 if B > 10000,

After Game Revenue = 0 if B >=10000

A \* 12 if B <=10000 and A <= 10,000 – B

(10,000 – B) \* 12 if B <=10000 and A > 10,000 – B

Total Costs: 10,000 \* 10

**Solution in Excel (See Excel spreadsheet for details):**

Procedures for generating random variables A and B:

B = 5000 + rand() \* 10000

* A: After game demand, with an empirical distribution.

|  |  |  |  |
| --- | --- | --- | --- |
| A | 500 | 750 | 1000 |
| Pdf | 30% | 40% | 30% |
| Cdf | 30% | 70% | 100% |

We will generate a random number, Rand\_A, using rand()

If Rand\_A <= 0.3, A = 500;

If 0.3 < Rand\_A <= 0.7, A = 750;

If Rand\_A > 0.7, A = 1000

**Answer:** Based on 1001 draws, the average profit is around $166,000 - $175,000

1. How many sweatshirts would you recommend BA order to maximize expected profit?

**Model in words:**

* **Objective:** Maximize total profit
* **Decision Variable:** Sweatshirts ordered
* **Randomness:**  Pre-game and post-game Demands

**Mathematical model:**

* **Decision Variable:**

X: Number of sweatshirts ordered

* **Random variables:**

B and A, same as in part a

* **Objective function:**

Maximize Total Profit = Before game Revenue + After game Revenue – Total costs

Before Game Revenue = B \* 30 if B <= X;

X \* 30 if B > X,

After Game Revenue = 0 if B >= X

A \* 12 if B<=X and A <= X – B

(X – B) \* 12 if B<=X and A > X – B

Total Costs: X \* 10

**Solution in Excel (See Excel spreadsheet for details):** similar to a), Change X in increments of 200 until you find the highest total profit.

**Answer:** Based on simulation result, Beyond Armor will have maximum total profit if they order approximately 12,200 sweatshirts (Exact numbers may be different depending on realization of trandom variables).

1. Due to an outbreak of a novel infectious disease, the governor has announced that there is a 50% chance that all sport events will now be held without a live audience. If that happens, BA will not be able to sell any sweatshirts for $30, and instead will only be able to sell to TJ Maxx and Marshalls, (in the same quantity as in the original problem formulation). How many sweatshirts would you recommend BA order to maximize expected profit? Is the venture still profitable?

Note that BA makes their order quantity decisions before they find out whether sporting events are allowed to be held.

Use the “data table” function to find the optimal order quantity.

**Model in words:**

* **Objective and Decision Variables:** same as in part b
* **Randomness:**  Pre-game, post-game Demands and sports events audience

**Mathematical model:**

* **Decision Variable:**

Same as in part b

* **Random variables:**

B and A, same as in part b

S: Sports events audience, equals to 0 if no audience and 1 with audience

50% to have no audience and 50% to have live audience

|  |  |  |
| --- | --- | --- |
| S | 0 | 1 |
| Pdf | 50% | 50% |
| Cdf | 50% | 100% |

* **Objective function:**

**Total Profit** = Same as part b, except before game demand is now B\*S

**Solution in Excel (See Excel spreadsheet for details):**

In addition to part b), we will generate a random number, Rand\_S, using rand()

If Rand\_S <= 0.5, S = 0;

If 0.5 < Rand\_S, S = 1

**Answer:** Based on the simulation result, the total profit is more volatile with the new regulation. The venture is still profitable on average, but nearly half simulation draws result in a loss. Beyond Armor will have maximum average total profit if they order around 7,600 – 9,600 sweatshirts (between 38 and 48 lots). The venture is still profitable.

1. Use your calculations in part c) to create a plot of the expected profit as a function of order quantity. The plot should show order quantity on X-axis and expected profit on Y-axis.

What do you observe? How sensitive are the profits to deviations from the optimal order quantity? If you deviate from the optimum, is it better to deviate up (order more than the optimum) or down (order less than the optimum)?

**Answer:** The profit function is relatively symmetric around the optimal order quantity. For small deviations, profit losses are about the same if one deviates up or down from the optimum. However, large deviations (lot sizes above 80) lead to substantially lower, potentially negative profits.