FMIS 3295 Business Analytics

HW#4 Optimization and Simulation

1. Upload your Excel spreadsheet as a response to this question. You are required to show how you arrived at the answers to receive full credit.
2. Epicurean is a manufacturer of kitchen equipment. Because of recent increases in demand, it is considering outsourcing some of its manufacturing processes. After receiving some quotes from other manufacturers, you’ve been asked to set up a model in Excel to decide whether to manufacture or to outsource its cutting board product. Apply the following parameters to the model:
   1. Selling price $5.00
   2. Demand Qty = quantity required of 100,000 units
   3. FC = fixed cost of manufacturing of $200,000
   4. Direct labor cost of $1.25
   5. Direct material cost of $0.75
   6. Quote for outsourcing P = $3.50  
      Calculate the savings (or loss) from outsourcing: (2 decimals, no commas) $xx.xx
3. Use the What-If Analysis tool in Excel to calculate the value of q that would make it profitable to manufacture.
   1. Create a one-way data table over a range from 0 to 300,000 in increments of 25,000 using the savings (or loss) from outsourcing as the output variable.
   2. Since this is a one-way table, it accepts only one input. Set the input column to the cell containing the quantity. Excel will calculate the savings for all the quantities in the table. According to the data table (given increments of 25,000), at what quantity is manufacturing more profitable? (0 decimal, no commas)
4. Epicurean can then decide whether to outsource or manufacture based on the expected demand for their product. Suppose that Epicurean receives five different bids for outsourcing. The different bids introduce a second input variable that needs to be considered in addition to quantity. Given that the bids are $2.89, $3.13, $3.50, $3.54 and $3.59 from five different manufacturers, we can construct a two-way table with quantities going down the column and the five bids going across as rows.
   1. Create a two-day table using the bids as row values. Since this is a two-way table it accepts two values. The first is the column input as entered above, and the second is the row input which is the outsourcing purchase cost.
   2. Assuming the purchase cost corresponds to the quality of the product (the higher the cost, the better the product) and Epicurean wants to maintain the high quality of its products, which bid will Epicurean choose if it is confident it can sell 175,000 cutting boards? (2 decimals, no commas) $xx.xx
5. Although the data table produces results for the range of quantities, it doesn’t give us the exact quantity where the transition occurs between manufacturing being cheaper than outsourcing. We can use the Goal Seek tool to find the precise quantity.
   1. In the Goal Seek dialog window, set the cell address (Set Cell input) for savings to zero (To Value input) and the cell address for quantity for the cell to change (By Changing Cell).
   2. Enter the exact quantity in which the precise quantity where the transition occurs between manufacturing being cheaper than outsourcing for the purchase cost of $3.50. ). (no commas, 0 decimal)
6. Duluth Generators is analyzing a transportation problem involving transporting products from three plans to four distribution centers. Duluth Generators operates plants in Cleveland, OH; Bedford, IN, and York, PA. The company distributes its generators through four regional distribution centers located in Boston, MA, Chicago, IL, St. Louis, MO, and Lexington, KY. Its production capacities, forecasted demand for the next three months, and per-unit shipping costs are known. Management would like to determine how much of its production should be shipped from each plant to each distribution center. Of course capacity at the plants must not be exceeded, and forecasted demand must be satisfied. Build the model using the parameters provided below.  
   Table 1 Per unit shipping costs

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Origin | Boston | Chicago | St. Louis | Lexington | Supply |
| Cleveland | 3 | 2 | 7 | 6 | 5000 |
| Bedford | 6 | 5 | 2 | 3 | 6000 |
| York | 2 | 5 | 4 | 5 | 2500 |
| Demand | 6000 | 4000 | 2000 | 1500 |  |

Trial values for the production levels are provided below  
Table 2 Forecasted Demand

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Origin | Boston | Chicago | St. Louis | Lexington | Supply |
| Cleveland | 5000 | 0 | 0 | 0 |  |
| Bedford | 1000 | 4000 | 1000 | 0 |  |
| York | 0 | 0 | 1000 | 1500 |  |
| Demand | 6000 | 4000 | 2000 | 1500 |  |

* 1. Using the SUMPRODUCT() function in Excel, build the model and calculate the total cost of the model given the parameters and trial values to be transported.

1. Using PowerPoint drawing tools, draw the network diagram for the model in the previous question displaying all the values in Table 1. We don’t know if the trial values in Table 2 is the optimal solution to the problem. A linear programming model can be used to solve this transportation problem. Underneath the network diagram, write out the objective function (the objective of the model which is to minimize the total costs using x as a decision variable), and demand and supply constraints for the model (8 all together) using equations.
2. Use Excel’s Solver and the Simplex LP method to calculate the optimal model to minimize transportation costs for Duluth Generators.
   1. When the Solver Results dialog box appears, select Restore Original Values in the spreadsheet, and in the Reports section, select Answer Report, and click OK.
   2. What is the total cost for the optimal transportation model for Duluth Generators? (Include $ sign, 2 decimals, no commas)
3. What is the production volume that should be transported from Bedford to Lexington?
4. In the Epicurean case above, we built a model that had up to two inputs vary. When more than two variables are dynamically changing the What-if Data Table would not be sufficient. Additionally, we have no idea how the values would change. Using a Monte Carlo simulation, we can generate values for the variables that would most likely represent real life and suggest whether such an investment is a good idea. A data scientist examined how materials and direct labor costs, as well as the first year’s demand could vary and determined specific probability distributions for each. The data scientist believes that the direct labor cost will range from $1.00 to $2.00 and is described by a discrete probability distribution shown below (e.g. 20% probability that direct labor cost will be $1.20). In this case, direct labor cost can only take the values shown in the chart. Direct materials cost depends on many factors including the general economy, price of oil, demand for the material and suppliers’ pricing policies, but the data scientist is confident it will be between $1.80 and $2.20 per unit, so the data scientist decides to use a uniform distribution saying that the cost per unit is equally likely. Based on comparable products, the data scientist believes the first-year demand is described by a normal probability distribution shown below with a mean or expected value of 125,000 units, and standard deviation of 10,000 units. Which of the random variables is the most unpredictable? (respond with either "fixed", "labor", "material" or "demand")

|  |  |
| --- | --- |
| Figure 1 | Figure 2 |
|  | Figure 3 |

1. Given a fixed cost of $150,000, direct labor cost per unit of $1.50, material cost per unit of $2.00 and total quantity of 120,000, what is the total profit for Epicurean's product? (include $ sign, 2 decimals, no commas)
2. Generate values for the three random variables using the probability distributions with the help of Excel random number generator RAND().
   1. For direct labor, the value of the random variable is generated using the values from Figure 1 to produce the following table:

|  |  |  |
| --- | --- | --- |
| Cost per unit | Probability | Random number interval |
| $1.00 | 0.1 | 0.0 – 0.1 |
| $1.20 | 0.2 | 0.1 – 0.3 |
| $1.50 | 0.4 | 0.3 – 0.7 |
| $1.80 | 0.2 | 0.7 – 0.9 |
| $2.00 | 0.1 | 0.9 – 1.0 |

* 1. Use a VLOOKUP() function to locate the correct per unit direct labor cost based on the random probability generated within the interval. The formula for the VLOOKUP function is VLOOKUP(RAND(),lookup table,column containing cost per unit,TRUE). The first column of the VLOOKUP table has to contain the values of the intervals in ascending order.
  2. For the materials costs, the value of the random variable is generated using the formula lower bound + RAND()\*(upper bound – lower bound).
  3. For the demand, the value of the random variable is generated using the formula NORM.INV(RAND(),mean,standard deviation) where the mean of demand is 125,000 and standard deviation is 10,000.
  4. Enter these formulas into the model in the spreadsheet.
  5. Start building the Data Table. In the leftmost column create a series from 1 to 1,000 (use Edit>Fill>Series) to label each trial. In the first row, enter the cell addresses of the random variables from the parameter area. Select the whole table (excluding the labels) and then run the What-If Data Table function. Leave the Row input cell box blank and enter any empty cell in the spreadsheet into the Column Input box. Click OK. All 1000 simulation trials are created.
  6. What is the least value that direct material cost can take? (include $ sign, 2 decimals, no commas)

1. What is the value for direct labor cost given the random probability of 0.5? (include $ sign, 2 decimals, no commas)
2. Calculate the value for direct material cost given the random probability of 0.5 (include $ sign, 2 decimals, no commas)
3. Calculate the quantity demanded given the random probability of 0.5 (2 decimals, no commas)
4. Calculate and enter the average profit (since this is randomly generated, your answers will vary, but should be within the bounds set by your simulation). (include $ sign, 2 decimals, no commas)
5. Calculate the probability of the number of trials whose profit is less than zero (use the COUNT() and COUNTIF() functions).(include % sign, 2 decimal places)