Management Science

Individual Assignment 1

Due on November 16 at 23:59

Instructions

1. Submit a pdf file answering all 3 questions and a notebook with your code.
2. Your code **should be included in the pdf using screenshots**: you should not assume we will read the notebook, we will only execute it if we need to.
3. Handwritten equations and drawings (for the decision tree) are fine, as long as they are clear.
4. Points awarded are not necessarily proportional to the effort needed to answer a question.
5. Any questions on the assignment should be posted on the corresponding discussion forum in Canvas and not be sent via email. This way if I release any additional information it will be common for all.

Question 1:

Al is thinking to invest in the manufacturing of business shoes. To this end, he has to choose among three different types of manufacturing facilities:

- He can invest in small manufacturing facilities, which cost him \$500 initially and result in costs of \$77.5 per pair of shoes.
- He can invest in medium manufacturing facilities, which cost him \$4,000 initially and result in costs of \$65 per pair of shoes.
- He can invest in large manufacturing facilities, which cost him \$24,000 initially and result in costs of \$40 per pair of shoes.

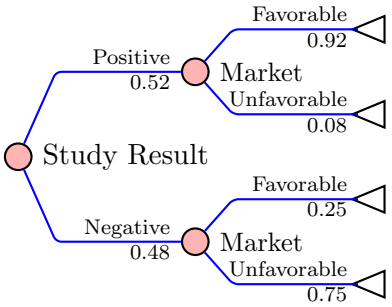
Al believes that under favorable market conditions (which will prevail with a 60% chance), he can sell 1,000 pairs of shoes for \$80 per pair. Under unfavorable market conditions (which will prevail with a 40% chance), he can only sell 600 shoes for \$80 per pair. Unfortunately, Al will only observe the market conditions after he has selected the manufacturing facilities.

a) Using a payoff table, decide whether Al should invest in small, medium or large manufacturing facilities, or whether Al should abandon the business idea completely. Assume that Al aims to maximize his expected profits. **(5 points)**

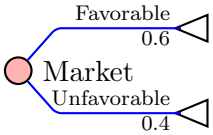
Assume that Al could conduct a pilot study to better understand the market for business shoes. The study would cost him \$700 and leads to a positive or negative outcome. Al estimates that when the market conditions are favorable the outcome of the study is positive with probability 80%, while when the market is unfavorable the outcome of the study is positive with probability 10%.

Al, being an expert on Bayes' theorem, calculates the probabilities of scenarios, depending on if he conducts a minor/major study as in Figure 1.

b) Using a decision tree, decide if Al should invest in a study, as well as which manufacturing facilities Al should invest in. Assume that Al can defer the choice of the manufacturing



(a) *study*



(b) *No study*

Figure 1: *Probability of scenarios*

facilities until the outcome of the pilot study is known (if he chooses to conduct such a study). **10 points**

c) What is the risk profile of the proposed policy? **5 points**

Question 2

The Texago Corporation has two oil fields (Texas and California), three refineries (New Orleans, Charlton, and Seattle), and two distribution centers (Pittsburgh and Atlanta). The below tables show the cost in dollars of shipping a barrel of oil from each oil field to each refinery and from each refinery to each distribution center. The oil fields Texas and California can supply 10000 and 50000 barrels of crude oil respectively, and the demands for distribution centers Pittsburgh and Atlanta are 20000 and 25000 barrels of petroleum respectively.

Oil Fields	Refineries		
	New Orleans	**Charlton**	**Seattle**
Texas	$11	$7	$2
California	$7	$4	$8

Refineries	Distribution Centers	
	Pittsburgh	**Atlanta**
New Orleans	$11	$7
Charlton	$7	$4
Seattle	$5	$3

a) Define the decision variables and write a linear programming model that minimizes shipment

costs while satisfying the demands of distributors without exceeding available supplies in oil fields. Hint: At refineries you need to preserve flow. Input=Output. (20 points)

b) Solve the model from a) using Gurobi. What is the optimal solution? How much are the transportation costs? (25 points)

c) Generate the sensitivity report from b). Include a screenshot of the sensitivity report in the pdf file you submit. Answer the following questions using the sensitivity report.

   i) What would be the impact on the transportation costs if the supply at Texas increased to 15000. Would the optimal solution change? (5 points)

   ii) What would be the impact on the transportation costs if the supply at California decreased to 40000? Would the optimal solution change? (5 points)

   iii) Texago must deliver an additional 10000 barrels to either Pittsburgh or Atlanta. Should they deliver it all to Pittsburgh, all to Atlanta, or split it? Why? Can you calculate the additional cost? (5 points)

   iv) A new motorway has been built between California and Seatle, reducing the shipping cost to \$7 per barrel. What will be the effect on the transportation costs? (5 points)

Question 3 A windsurfing rental shop at the Canary Islands has two rental stations at positions A and B. Enrique, the manager, is estimating that in the following 7 days they will need to have available the following number of sails in the two stations.

day	1	2	3	4	5	6	7
demand at A	45	20	20	25	15	28	15
demand at B	8	12	23	30	12	10	33

At the beginning of the week they can buy (used) sails at a price of 200\$ each, and initially locate them at any station. At the end of a day they can relocate any sail to the other station, at a price of 20\$ if it is to be available for rental in the coming morning or 5\$ if it will become available the day after (a sail used on day 1 at B, can be used again on day 3 at A).

a) Formulate a Linear Programming model to determine the optimal purchasing and relocation policy. You can write all terms and constraints explicitly if you wish, you do not have to use mathematical notation. **(5 points)**

Hint: One way to set up your variables would be as follows:

variable	meaning
P_A,P_B	Number of sails purchased at the two stations.
E^d_{AB},E^d_{BA}	Number of sails sent at the end of day d, available for use at day $d+1$.
C^d_{AB},C^d_{BA}	Number of sails sent at the end of day d for use at day $d+2$.
I^d_A,I^d_B	Number of sails available for rental at day d (inventory).

If you use mathematical notation denote by s^d_A,s^d_B the number of sails needed on day d.

b) Solve in Gurobi. What is the optimal policy? What is the total cost, and how is it decomposed to purchasing, cheap transportation and expensive transportation ? **(5 points)**

Hint: This model is a bit tricky, critically examine the output, to see that it makes sense, and if necessary revise your model a).

c) Solve the problem in Gurobi for the whole year (365 days) where the demands are given in the file **sails.csv**. How many sails did you buy in total? What is the maximum number of sails you needed on a given day at A and B together? Comment on the result as compared to the one week results. How many sails did you transport in total using each type of transportation service? What is the total cost, and how is it decomposed to purchasing, cheap and expensive transportation? **(5 points)**