IEOR 4650: Business Analytics
Spring 2019 Professor Adam Elmachtoub

Assignment 5: Prescriptive Analytics

Due date: April 19, 11:59am

Attention: Please prepare two files for each homework assignment: a .pdf file for your answers including relevant figures, and a .R file for your relevant R scripts. File names should be `Last_First_hw.pdf` and `Last_First_hw.R`, e.g., `Obama_Barack_5.pdf` and `Obama_Barack_5.xls`. Your submissions must be based on your own original work. Late submissions will not be accepted.

1. In this problem you will need to analyze the `home_and_kitchen_BOPS_data` dataset.

   (a) For each store, compute the percent change in sales before and after the BOPS initiative began. What is the average percent change for stores in USA? Canada?

   (b) Run a linear regression to predict the percent change, where the only features are an intercept and whether or not the store was part of the BOPS program. What is the effect of BOPS, and the standard error?

   (c) For each DMA, compute the percent change in sales before and after the BOPS initiative began. What is the average percent change for DMAs close to stores with BOPS?

   (d) Run a linear regression to predict the percent change in sales, where the only features are an intercept and whether or not the DMA was close to a store with a BOPS program. What is the effect of BOPS, and the standard error?

   (e) How do your conclusions in the previous parts change if we only use the 13 weeks of data before and after the BOPS initiative began?

2. Your company has decided to try an email campaign to get more visitors to their online retail website. In total, you have 10,000 different email addresses on file, but no contextual or feature information about any particular user. Your marketing team has come up with 5 different email templates, and they are not sure which one is the best. Thus an A/B testing solution is needed. From past experience, we know that the best possible type of emails convert 21% of users. Thus, an optimal solution earns $0.21T$ if T users are emailed.

   (a) Try all 5 algorithms on Slide 10 of Session 16 using the file emails.csv. The way to use the file is as follows. You will process each row as an email you will send. If you send email 4, then you observe what is in the 4th column only. A 1 indicates success, and 0 is a failure. You cannot observe what is in the remaining 4 columns.

For example, suppose for the $t = 5$th customer I decide to send email 1, then I only observe the binary entry in row 5, column 1, and the algorithm moves on to $t+1$. **Plot the cumulative regret of all the algorithms for the first** $10,000$ **customers.** (This is just $0.21t$ minus the number of successes you've observed so far. This will not be smooth like in the lecture slides because we are running this just 1 time, in th lecture I simulated the results many times and took an average. It is possible to have negative regret if you get very lucky!) Use $T_0 = 100$ and $\alpha = 0.75$. For all algorithms, assume that you have already sent 1 email of each type and it was a success (to avoid computational issues).

(b) For the UCB algorithm, what was the distribution of emails chosen for the first 100 customers? Last 100 customers?

3. A manufacturer makes 1500 laptops and 1000 desktops per month. Any laptop or desktop can be customized. The demand for standard laptops is 1300 a month, and customized laptops is 1000 a month. The net profit for a standard laptop is \$120, and for a customized laptop is \$200. The demand for standard desktops is 700 a month, and customized desktops is 400 a month. The net profit for a standard desktop is \$170, and for a customized desktop is \$400. Due to labor limitations, only 500 machines can be customized in a month. You can use MS Excel Solver, but please write your formulas clearly.

   (a) Write down a mathematical formulation to optimize the total net profit. Is it linear, nonlinear, or discrete?

   (b) Solve this problem and describe the optimal strategy and the optimal net profit.

   (c) What is the benefit of being able to customize 200 more machines?

   (d) What is the benefit from being able to sell 300 more desktops?

   (e) What happens if we manufacture 100 less laptops?