SMM641 REVENUE MANAGEMENT AND PRICING

Problem Set 2

General Guidelines:

- The assessment will be based on both the quality of your analysis and the expositional clarity and presentation of your overall work. Specifically, your work should not only have some computations and a result, but it should also clearly describe the steps you take and allow a reader to follow your methodology and calculations with ease. Please also try to highlight any additional insights you might have discovered from your analysis.
- Please feel free to make assumptions that might aid your analysis. However, make sure that you provide a justification for all your assumptions.
- Please submit a single short report as a .pdf file per group to Moodle with a title page that indicates the names of all group members.
- Please make sure you also submit any codes separately (e.g., as an .R, or an .Rmd file), which should be clear to follow and be ready to run.

Question 1: (35 points)

London is considering an extension to its Congestion Charge programme, a daily charge for driving a vehicle within the charging zone between the hours of 07:00 and 18:00, Monday to Friday. The extension explores the revenue and environmental impact of introducing a two-tier congestion pricing policy for *peak* and *non-peak* traffic periods.

The City conducted a survey to learn more about the willingness to pay of drivers that may enter the charging zone during the peak and non-peak hours. In total, 345 such drivers have responded to the survey and their maximum willingness to pay for peak and non-peak periods is reported in the accompanying supplementary file. Assume that the respondents represent a total of 192,000 drivers the City estimates that may potentially enter the charging zone.

Perhaps the most important motivations for implementing a Congestion Charge are to reduce emissions and to generate funds to reinvest in improving public transportation services. A main factor that determines emissions per car is the average travel speed, which in turn is influenced by the number of drivers entering the charging zone. Suppose that the relationship between the number of drivers and average speed is given by the following:

$$\text{Average Speed (in km/h)} = 30 - 0.0625 * (\#\text{ of cars in thousands, '000}) \qquad (1)$$

Further, the emissions per car, which is generally measured in grams of CO_2 per kilometre, can be approximated by a piecewise linear function as follows:

$$\text{Emissions per car (g/km)} = \begin{cases} 617.5 - 16.7 * (\text{Average Speed}) & \text{if Average Speed} < 25 \text{ km/h} \\ 235.0 - 1.4 * (\text{Average Speed}) & \text{if Average Speed} \geq 25 \text{ km/h} \end{cases} \qquad (2)$$

(a) If the programme's objective were solely to maximise revenue and a single congestion

charge were to be applied across both peak and non-peak hours, which price would maximize the total revenue? With this price in effect, what is the total level of emissions?

(b) If the programme's objective were solely to maximise revenue and a peak period pricing strategy is to be implemented, with the price for the non-peak period set at £7, what price would you recommend for the peak period? Please note the resulting revenue and emissions and compare the findings with those from part (a).

(c) Suppose now that the programme's objective is to minimize emissions rather than maximizing revenue. However, the City would like to ensure that the programme can self-sustain its operation and that a sufficient portion of the revenue is allocated to reinvest in the public transportation infrastructure. Overall, the City requires that the revenue should not fall below £1.1 million per day. Assuming a non-peak period price of £7, what price would you recommend for the peak period? Please compare the resulting revenue and emissions level with that of part (b).

Question 2: (35 points)

A sandwich shop is choosing the prices and planning the shelf space allocation for a new set of sandwiches. The store is planning to carry four variants of sandwiches: Avocado and Brie Small, Avocado and Brie Regular, Super Veggie Small, and Super Veggie Regular. The store estimates that, on any given day, 100 customers will consider purchasing from this assortment (some of them may choose not to purchase).

The policy of the store is to charge the same price for a given size, i.e., the Small variants will have the same price and the Regular variants will also have a single price. In addition, the store owner feels that there needs to be at least a £1.50 price difference between the prices of the two variants. The unit cost for the Small variant is £1.00 whereas the unit cost for the Regular variant is £2.00.

In an experiment, the store asked 80 different individuals which of these variants they would purchase, if any. Each individual was shown a randomly chosen pair of prices. The possible price points for the Small variants were £1.50, £1.75, £2.00, £2.25, and £2.50, and the possible price points for the Regular variants were £3.50, £3.75, £4.00, £4.25 and $4.50. The accompanying supplementary file contains the resulting choice data along with the prices displayed to each of the 80 individuals at the time of their choice.

Using this data, determine the prices that maximise the daily profit from this assortment.

(Hints: Use the MNL demand model. First, use the data to estimate the parameters of the MNL model. Next, set up and solve a nonlinear optimization problem with prices as the decision variables.)

Question 3: (30 points)

Similar to Question 3 of Problem Set 1, please identify a practical setting in which any of the concepts and methodologies we have learned so far regarding price optimization can be implemented to potentially improve the service provider's profits/revenues. If you'd like, you

can either build on your setting you have described for Problem Set 1 or pick a different setting.

You are not expected to obtain and work with real data but I suggest you to make assumptions and work with simulated data to illustrate how you would implement your methodology and discuss any preliminary findings.

As before, please make sure to try to pick a setting that allows a sufficiently rich variation and extension to the examples we have covered in class, that is, your analysis should not be a very simple variation of the examples we have discussed in class but be somewhat challenging and require you to think creatively on how to solve the problem.

Finally, if you'd like, and if the setting is relevant and enables a sufficient depth of analysis, you will have the option to expand on your work for Problem Set 1 and/or 2 as the basis of your projects as well.