Problem Set 4

Dynamic Pricing

Due: 11PM Eastern Time on Sunday, September 29

Econ 316: Industrial Organization

To turn in this problem set:

- Email as a pdf to submit.io.psets@gmail.com

Honor code

I am allowed to discuss the problem sets with others. However, I will write everything I submit, such as code, mathematical derivations, and final answers. I will not copy others. When I receive advice from others, I will cite them in my problem set.

For example, if student named "Juana Diaz" gave me advice on a line of code, I will write "(Received advice from Juana Diaz)" on that line. Receiving advice does not affect your grade or how the grader thinks of you.

Question 0

0A: I followed the honor code on this problem set. (Answer Yes or No.)

0B: How much time did you spend on this problem set?

Question 1: Dynamic pricing at Uber

Ride-sharing platform Uber uses a dynamic pricing algorithm to set prices every few minutes. In this question, we take (simulated) Uber data and use it to develop an optimal pricing algorithm. We then calculate the deadweight loss from the constant price that traditional taxi companies use.

Remember that the Uber process is that users open the app, then they observe the surge price multiplier (i.e. price P_t), then they decide whether or not to travel. Assume that the demand function (i.e. rides accepted at price P_t) at time t is

$$Q_t = \alpha_0 + \alpha_1 P_t + \alpha_2 A_t + \epsilon_t,$$

where A_t is the number of users who open the app and ϵ_t is a mean-zero error term.

Assume that marginal cost c is \$10 per ride. (We are ignoring the fact that different rides go for different distances.)

1A: The details of Uber's dynamic pricing algorithm are not public, but they say informally that the surge pricing algorithm is set to maximize social welfare, not short-run monopoly profits. But Uber is very focused on long-run profits. What might the short-run monopoly profit maximization problem not capture that might be relevant to them in the long run?

In the dropbox folder for this problem set, you will find UberData.csv, a csv file containing (simulated) data on number of accepted rides Q_t, prices P_t, app openings A_t, and vehicles available K_t for every five-minute period in one example week. The number of rides approximates demand for a large city. You will also find a python notebook called pset4_template.ipynb. Download both to the same folder, and modify the notebook as needed to answer the questions below.

1B: We saw in lecture that the pricing rule that maximizes social surplus is, “If there is enough capacity, set price equal to marginal cost. If the capacity constraint binds, then set price such that quantity demanded equals the capacity constraint.” Write the equation for the social welfare-maximizing price P_t^s using “if, then” statements and the variables $\{c, \alpha_0, \alpha_1, \alpha_2, A_t, K_t\}$. For this equation, assume $\epsilon_t = 0$.

1C: Estimate the demand function above using linear regression using OLS. (This is different from the cement example in Problem Set 2, because observing A_t gives you a good measure of the demand shock. Assume that after you control for app openings A_t, ϵ_t is conditionally uncorrelated with any information that Uber’s surge pricing algorithm uses when setting P_t. This isn’t perfect, but we don’t want to complicate things further.) Report the estimated α_0, α_1, and α_2 coefficients.

1D: Using your pricing rule from 1B, construct the vector of social surplus-maximizing prices P_t^s. Report the minimum, maximum, and mean.

1E: Write the equation for social surplus S_t^s at time t given surplus-maximizing price P_t^s, again assuming $\epsilon_t = 0$. (Hint: if the capacity constraint doesn’t bind, this is just a triangle above the marginal cost line. If the capacity constraint does bind, this is a trapezoid as drawn in the lecture slides.)

1F: Calculate the vector of S_t^s for each t in UberData.csv. Report the sum of social surplus over the week.

1G: Now imagine that price is always set at marginal cost, and if there is a shortage of vehicles, the consumers who can find a ride are effectively randomly selected from the set that would be willing to pay marginal cost. (This “random rationing” allows the simplifying assumption that the average consumer who finds a vehicle gets consumer surplus equal to the average consumer with WTP>c.) Write the formula for social surplus at time t under this pricing and rationing rule.

1H: Using your formula from 1G, calculate and report the sum of social surplus over the week.

1I: Compare your answers in 1H vs. 1F. Briefly recap the intuition for why rationing by price is more economically efficient than random rationing.