

Industrial Organization and Data Science

Instructors: Justin Rao, Affiliate Professor & Senior Researcher, Microsoft

Jacob LaRiviere, Affiliate Professor & Senior Researcher, Microsoft

Emails: justin.rao@microsoft.com

ilariv@microsoft.com

Final Exam Study Guide

The final will be 6:30-8:20pm, Thursday June 9th, Savery 136pm

The final will focus on topics covered in the second half of the course, but since this material built on the first half, all material is “fair game,” but we’ll give some guidance of where to focus your energy.

First half material to focus on:

- Basic material: definition of elasticity, extensive/intensive margin, substitutes/complements, fixed vs. marginal costs, interaction terms in regression, basic R formulas for regression, interpreting R output as in the HWs
- Lerner equation and optimal pricing formula, the importance of marginal costs (not fixed costs) in pricing and the impact of substitutes/complements.
- Versioning and product-based price discrimination.
- Two-part tariffs

Second half material

Auctions

- Rules of and how to bid in the following auctions:
 - o first-price sealed bid auction (not the bidding formula, but the dynamics and the complexities)
 - o second-price sealed bid auction
 - o ascending auction
- Two main problems auctions encounter
 - o Not enough entry (or barriers to entry or blocked entry)
 - Why is it important to have many bidders?
 - What are common barriers to entry?
 - o Collusion
 - Examples from Klemperer article
- When are auctions generally used, why do they work, how does it relate to generating competition from the bidders
- When are posted prices generally used
- Definition of reserve price and how reserve prices are used
- Basic knowledge of the 3 examples from the lecture

Example questions:

- 1) Suppose you are bidding in a second price, sealed bid auction and your value for the good is \$20. What should you bid? Why not bid lower than this amount? Why not bid higher than this amount?

- 2) Suppose you are running an auction second price, sealed bid auction (you are the auctioneer) and you value the good at \$20 (that is, you'd rather not sell it if you can't get at least \$20).
 - a. What should you set the reserve price to be?
 - b. Now suppose you change the format to a first price, sealed bid auction. Should you still set the same reserve price? If yes, why? If no, which direction should you move the reserve price (up/down) and why?
- 3) Ascending auctions tend to allocate the good to the bidder with the highest value. In general, this is a good thing, but the Klemperer article raises an important consideration about why this can actually be bad, what is this reason?
- 4) A friend tells you they want to sell a few items on eBay and is wondering if they should use "buy it now" and set a price, or instead run an action with a low starting bid. For the following goods, what is your recommendation and why?
 - a. A new tablet computer they got as a gift but don't want
 - b. A vintage leather jacket
 - c. A used smartphone that is 2 years old

Intertemporal Elasticity

- Key components
 - Discount rate (greek letter delta) versus interest rate (r)
 - Value of consumption
 - Expected prices over time
 - Storage costs
- Same product in different time periods is substitute
 - True for non-durables.
 - For durables irrelevant since can consume in each period (e.g., pizza versus TV therefore only thing that matters is delaying consumption).
 - Key feature for durables is incentive to lower price in each time period to get larger market
 - Cross price elasticity intuition transfers
- Adding externalities
 - Network, preference learning, product refinement all lead to optimal dynamic pricing.
 - With learning and small market, best to have low intro offer then increase price.
 - With learning and large market, reverts back to traditional durable good monopolist solution
 - With externalities, shade price down if positive and up if negative.

Example Questions:

1. For non-durable goods, if prices are constant across time and storage costs are positive, what must be true about future prices for consumers to buy multiple quantities of the same good? (Expected future prices must be greater than current period prices.)
2. If consumers know a durable goods monopolist will decrease price over time, are they more or less likely to buy today? Why? (Less likely to buy today; willing to forgo consumptive value for price saving. Being compensated to be patient in the form of lower price.)
3. If there is a negative positive externality to usage through network effects or informative product feedback, how does that externality manifest for the firm? (Higher consumer valuations, demand curve shifts out when previous period's usage base increases based upon a) larger user base or b) improved functionality.)

4. If there are network externalities associated with a good should a firm charge lower or higher prices than if there were no network externalities? (Lower; using base increases subsequent periods' adoption/purchase rates.)
5. Assume that a monopoly can costlessly adjust attributes of a product across time. For example, in a two period model the firm can adjust attributes so in period two the product is more valuable.
 - a. Assume the value of feedback varies with the size of the user base Q according to $f(Q) = 2Q^5$ and this value is add to valuations in the second period.
 - i. What is the marginal value of an addition user in period 1 to period 2 consumers? ($f'(Q) = Q$)
 - ii. Assume no discounting and a first period demand curve of $P(Q) = A - bQ$. What is the demand curve accounting for the externality? ($P(Q) = A - bQ + Q = A - (b-1)Q$)
 - iii. Show this effect graphically. (flatter demand curve)
 - iv. What is the implication for optimal first period price? (Lower to sell more.)

Freemium

- What are the three parameters that drive revenue in our simple model?
- What is the role of marginal costs in determining if a freemium strategy is viable?
- Both product-based price discrimination and freemium involve multiple versions of the product, where lower versions have less features or some restrictions, but what is the main way in which freemium differs from the traditional implementation?
- What is the difference between "hard freemium" and "soft freemium"? In general, in which category do free trials occupy?
- Understand the role of scale in free/freemium services

Example question:

- 1) Suppose a firm offers a free trial for two months and has acquisition rate of 0.3, a conversion rate of 0.5, nobody buys the premium version direction (buy high rate=0), they make \$10 per month if a customer converts, marginal costs per month are \$5 and the average customer lifetime is 12 months. Suppose there are 1 million customers in their market.
 - a. What is their total revenue currently? (must show work on exam, answer=\$15 million)
 - b. What are total costs (assume $FC=0$)? (answer=\$10.5 million)
 - c. Based on this, what is gross margin (answer=4.5 million). Supposed fixed costs are 1 million. What is net margin (overall profits). Answer=3.5 million.
 - d. They are considering reducing the length of the free trial to 1 month. Their data science team estimates the conversion rate will drop to 0.45 and the acquisition rate will drop to 0.28, what is the new revenue and new costs?
 - i. Rev=13.86 million
 - ii. Costs=8.33 million
 - iii. Gross margin=5.53 million the new strategy is more profitable.

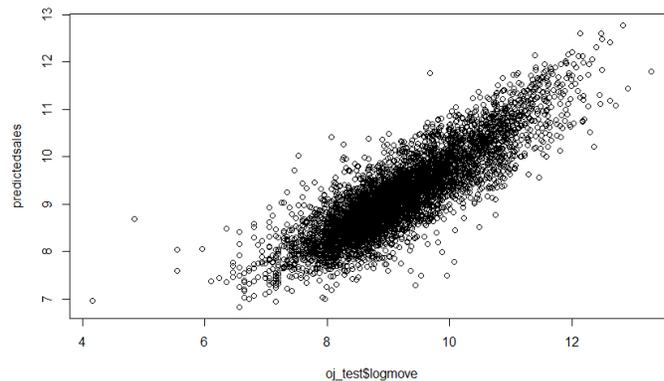
Prediction/classification/model fit & regression trees

- Understand train/test split for samples to do out-of-sample evaluation of fit
- What is our measure of "true R-squared"?
- What is a simple piece of code to split a sample into train/test in R?
- What is the overfit problem? How does out-of-sample testing help solve it?
- N-fold cross validation
- General knowledge of Lasso and Ridge regression

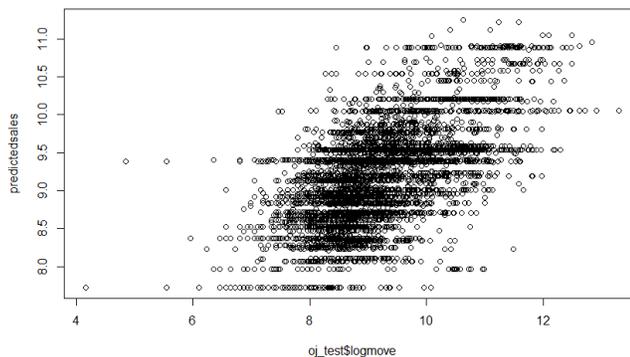
- Understand the distinction between measure of model fit (e.g. R-squared and variants) and estimating causal parameters.
- Intuition for regression tree algorithm
- Why initial regression tree splits will never change if additional leaves are punished less.
- Value for regression (inference across different groups) & prediction (conditional averages)

Example questions:

- 1) The following plot shows the true values of $\log(\text{quantity})$ for a test set on the x-axis and the predicted values on the y-axis, this regression included lags of price, interaction between price/brand/featuring, week dummy vars, etc.



- a. Where are the largest outliers in prediction error? What are some thoughts as to why?
- b. Draw the $y=x$ line on the graph. Is the prediction error generally symmetric around this line? (answer=yes, the line runs basically right through the middle of the dots)
- c. Here is the same plot for a simpler model ($\log(\text{move}) \sim \log(\text{price}) + \text{brand}$)



Explain why this plot reveals the fit of this simpler model is much worse. How does this relate to the observation that $\text{true R-squared} = \text{cor}(\text{predictions}[\text{test}], \text{truth}[\text{test}])^2$?

- 2) Suppose I ran a regression and got R-squared of 0.70 from the R-output. I then did a train/test split and computed "true r-squared" as above and it was 0.60 (i.e. quite a bit less). What would this tell you about overfit problems in the first regression? Why did the "basis R-squared" overstate model fit?
- 3) Why did we include `as.factor(week)` in our regressions? (beyond just getting better fit, what were we trying to control for)

- 4) In the regression tree algorithm the initial splits of a tree are always identical. If a subsample of the data were held out and cross validation used, would this necessarily be true? Why or why not? (Not necessarily, the actual data used for tree construction would be different. If tree stays the same, it means the tree is very robust.)
- 5) What is the difference between supervised and unsupervised machine learning? Provide examples. (Supervised machine learning means there is a LHS variable to be explained/predicted; example- quantity purchased over time. Unsupervised means there is no LHS variable and the data scientist is trying to classify behavior only; browsing behavior, TV watching behavior.)
- 6) If a tree never splits on a particular variable, is that variable unimportant for inference? (Not necessarily: it isn't as important as the other variables but it could still be important. For example, a tree may never split on `as.factor(week)` but using `as.factor(week)` as a control variable leads to more assuredness of estimated coefficients.)
- 7) Do experiments provide more information for inference or prediction? (Inference: it provides the causal impact of a variable on an outcome.)

Transfer Pricing

- Double Marginalization
- Welfare impacts versus allocation
- Two part tariff: fee plus MC per unit price
- Side payments to make different divisions "whole"
- Regulatory risks of vertical mergers
 - Solves double marginalization problem if can't be contracted away with two part tariff
 - Risks of
 - Foreclosure: upstream stops selling/increases price to other competing firms.

Example Questions:

1. What is the optimal internal price to set for goods? (MC)
2. Assume that AWS powers websites which compete with amazon.com, like etsy.com which sell craft retail merchandise.
 - a. What is the social welfare maximizing price to sell AWS services to etsy for? (MC)
 - b. What is efficient way for AWS to compensate amazon.com for powering competitors? (A fixed side payment which reflects how much AWS harms amazon.com.)
3. If horizontal mergers occur in commodity markets, would you expected double marginalization to be a larger, smaller or no unchanged regulatory problem? (Larger to unchanged: commodities generally aren't characterized by monopolies so downstream firms face competitive input prices. That said, if a single firm had a monopoly on a particular commodity due to mergers [e.g., rare earth materials for cell phones] then it could be a problem.)
4. Relative to double marginalization, using a two part tariff like franchise fees for fast food restaurants, benefits two groups. Who? (Upstream firm since they capture value through the franchise fee and consumers since a larger quantity is supplied to the market.)