

Problem Set #3

Due October 2, 2013

Rather than doing a traditional problem set this week, I am asking you to carry out an empirical project using data on the Joint Executive Committee. To do the project you will need a data file which you will be able to get from the TA. Those of you who have not worked with an econometrics package before or who haven't had a lot of econometrics may do better to work on the project in groups and discuss how to interpret the results you get, but each of you should try to learn how the programs work and think about interpreting the results by yourself. It would be very easy to sit and watch an experienced programmer do all of the empirical tasks in a total of less than fifteen minutes, but it would not be particularly educational. For those of you not familiar with any statistical package, STATA is good one for projects like this one. Some useful commands to look up in the STATA manual are INFILE, REGRESS, SUM, LOGIT, SAVE, and GEN.

Part I — Some basics

The file called PORTER.PRN is an ASCII data file which contains 328 observations on 22 variables. They are in order

WEEK	A variable which takes on values 1 through 328. Week one is the first week of 1880 and week 328 is the sixteenth week of 1886.
QUANTITY	Total JEC shipments of grain (in tons) for the week.
PRICE	The cartels posted price (in cents per 100 pounds) for grain shipments.
LAKES	An indicator variable for whether the Great Lakes were open to navigation.
COLLUSION	An indicator for whether the firms were reported to be colluding.
DM1-DM4	Four dummy variables Porter uses to capture changes in cartel composition.
SEAS1-SEAS13	Dummy variables for each of thirteen four week periods.

(a) Read the data into a statistical package and look at summary statistics to convince yourself that the data was read in correctly. Try a simple OLS regression of  $\log(\text{QUANTITY})$  on a constant,  $\log(\text{PRICE})$ , LAKES, and (twelve of) the seasonal dummy variables? If you were to view this as an estimate of a demand curve what would the price elasticity of demand be? Why does this number seem unreasonable?

(b) Try doing the regression instead using instrumental variables with the COLLUSION variable as the instrument for PRICE. How does the reported price elasticity change? Is the estimate closer to that in Porter's paper or that in Ellison's paper and why? How do you interpret the coefficient on the LAKES variable? On the seasonal dummies? What is the R-squared of the regression and what do you make of it?

(c) Try the regression with the DM2 variable instead of COLLUSION as an instrument for price. In what way do the results look "worse" and why do you think this happens.

(d) Estimate a supply equation as in Porter and Ellison using the LAKES variable as an instrument for quantity. What does the magnitude of the coefficient on COLLUSION tell us about the effect of collusion on prices? What might the coefficient on QUANTITY in this regression indicate about the nature of costs in the JEC?

### PART II — Model derivation and interpretation

(a) Suppose that rather than the log-log specification of demand you've been using so far, you tried others and found that a linear specification of demand like

$$Q_t = \alpha_0 + \alpha_1 P_t + \alpha_2 Lakes_t + u_t$$

seemed most appropriate. Show that for this demand curve the optimal price for a monopolist with a constant marginal cost of  $c$  to set is

$$P_t = c - \frac{1}{\alpha_1} Q_t.$$

Given this result, what functional form would you choose for the the supply curve in the model?

(b) What pricing rule would result with this demand curve if the industry instead consisted of perfectly competitive firms with total costs of the form  $c(Q_t) = c_0 Q_t + c_1 Q_t^2$  setting price equal to marginal cost? (For extra credit comment on whether this is the equilibrium of a Bertrand-like pricing game). Could one use an approach like Porter's to distinguish between these two models of behavior? Talk about why this is an important question.

(c) Suppose that demand is linear, but that the opening of the Great Lakes also affects the slope of demand and that there are additive seasonal shifts in demand so that the correct specification of demand is

$$Q_t = \alpha_0 + \alpha_1 P_t + \alpha_2 Lakes_t + \alpha_{3-14} Seasxx_t + \alpha_{15} Lakes_t P_t + U_{1t}.$$

How would a monopolist with constant marginal costs set prices in such an environment?

(d) Estimate the demand equation above and a supply equation motivated by the behavior of a monopolist with constant marginal costs using instrumental variables. (Try the Collusion variable and the Collusion variable interacted with the Lakes variable as the two instruments.) What price elasticity of demand is indicated by the estimates (evaluate the elasticity when price and quantity are at their sample means)? What do the results imply about the percent difference between the equilibrium prices in the collusive and noncollusive regimes (assuming that conditions are such that all of the other dummy variables in the equations are set to zero)?

If you assume that price wars involved marginal cost pricing what would you conclude about the degree  $\theta$  of collusion in the collusive periods?

Calculate an alternate estimate of  $\theta$  by focussing on another term in the supply equation. How do the estimates compare?

### Part III — More on the theory

Consider a repeated duopoly model. Firms 1 and 2 choose quantities  $q_{it}$  at  $t = 0, 1, 2, \dots$ . As in the Cournot model, the firms' products are undifferentiated and a market clearing condition

determines the market price. Assume that demand fluctuates over time, so that this market price is  $P_t(q_{1t}, q_{2t}) = A_t - (q_{1t} + q_{2t})$ . Suppose that the  $A_t$  are independent random variables with  $A_t \sim U[0, 12]$ . The firms do not know  $A_t$  when they choose  $q_{it}$ . Firm  $i$  cannot see  $q_{-it}$  and therefore cannot be sure what  $A_t$  was even after seeing  $P_t$ . Assume that firms have no costs of production.

(a) Find the fully collusive output  $q^m$  and the Cournot equilibrium of the one period game. What are the per firm profits in each? What would the distribution of market prices be in each?

(b) Suppose that  $A_t$  is observed after the firms choose  $q_{it}$  but before they choose  $q_{it+1}$ . For what discount factors could the firms sustain collusion by choosing  $q_{it} = q^m/2$  as long as no deviation has been observed and permanently reverting to the Cournot equilibrium if any firm has ever deviated.

(c) Now go back to the original assumption that  $A_t$  is never observable. Suppose the firms try to sustain collusion via strategies that are initially fully collusive and permanently revert to the Cournot equilibrium if the firms ever observe  $P_t < -3$ . For what discount factors will this punishment make it unprofitable for the firms to deviate to  $q^m/2 + dq$ ? Discuss the additional conditions that would have to be satisfied for this profile to be an equilibrium, and how you could construct collusive equilibria for the set of discount factors you've identified.

(d) How is the equilibrium described above similar to and different from the equilibrium that motivates Porter's empirical work and the equilibrium of the two-state version of the Green-Porter model described in Tirole's text (and in class)? Do you think the equilibrium would be a good one to use to motivate tests for collusion?

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