

Lecture 5: Pricing Equilibria and Mergers

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Antitrust and Mergers

What is Antitrust?

- ▶ Debate: should we maximize **efficiency/social surplus** or should we focus on **consumer surplus**.
 - ▶ US antitrust law focuses primarily on harm to consumers.
 - ▶ EC tends to also worry about harm to competing firms.
- ▶ We know about DWL from market power from undergrad economics. However, without profits, why would firms innovate or perform R&D?
 - ▶ Law understands this and awards temporarily monopolies via patents.
- ▶ Today, I am going to focus mostly on **horizontal mergers** among competitors.

Antitrust Legislation : Sherman Act (1890)

Section 1 “Every contract, combination in the form of trust or otherwise, or conspiracy, in restraint of trade or commerce among the several States, or with foreign nations, is declared to be illegal” (Violation involves an **agreement**).

Section 2 “Every person who shall monopolize, or attempt to monopolize, or combine or conspire with any other person or persons, to monopolize any part of the trade or commerce among the several States, or with foreign nations, shall be deemed guilty of a felony”.

Three *per se* violations

- ▶ (1) price fixing (2) horizontal market division (3) refusals to deal.
- ▶ Other violations are *rule of reason*.

Antitrust Legislation : Clayton Act (1914)

- Section 2** Prohibits some forms of price discrimination, but only when it lessens competition.
- Section 3** Prohibits sales based on the condition that the buyer not buy from your competitor (includes tying and exclusive dealing), but only when effect may be to substantially lessen competition.
- Section 7** Prohibits mergers where the effect of such acquisition may be substantially to lessen competition, or tend to create a monopoly in any line of commerce.
- Section 8** Prevents a person from being a director of multiple competing firms.

Antitrust Legislation : Hart-Scott-Rodino Act (1976)

- ▶ Required pre-notification and registration of large mergers
 - ▶ Transaction: \$78.2 million
 - ▶ Size of Person: \$156.3 M with target of \$15.6 M or total transaction of \$312.6M
 - ▶ These are “inflation adjusted” each year.
- ▶ Initial review period is 30 days after which DOJ/FTC can request additional information or allow merger to proceed.
- ▶ Second review usually involves detailed information about price-cost margins, market shares, etc. (Usually more info available than to academic researchers).
- ▶ Can request information company would reasonably have (customer surveys, etc.).
- ▶ After second review can ask for **injunctive relief** or **remedies** which merging parties can oppose in court.

DOJ/FTC Horizontal Merger Guidelines

- ▶ DOJ/FTC describe markets as:
 - ▶ Highly Concentrated: $HHI \geq 2500$.
 - ▶ Moderately Concentrated: $HHI \in [1500, 2500]$.
 $\Delta HHI \geq 250$ merits scrutiny.
 - ▶ Un-Concentrated: $HHI \leq 1500$.
- ▶ Also consider **unilateral effects**/UPP and **coordinated effects**.
- ▶ Three steps:
 1. Market Definition
 2. Measure Concentration/Initial Screening
 3. Merger Simulation

Step 1: Market Definition

SSNIP

- ▶ Small but significant and non-transitory increase in price (SSNIP): smallest relevant market where a hypothetical monopolist could impose a 5% price increase. (For at least one year).
- ▶ Under linear demand this amounts to a price cost margin and an elasticity (sometimes the **critical elasticity**).

Tricky Examples:

- ▶ Whole Foods vs. Wild Oats
- ▶ Cellophane Fallacy.

Step 2: Concentration/Screening

- ▶ After we define the relevant market, compute the relevant HHI or UPP.
- ▶ There can be both geographic and product market issues in the relevant market.
- ▶ Some markets may be highly concentrated and others may not be.
- ▶ Can ask for **divestitures** as part of a **remedy** if there are a few problematic markets in an otherwise uncontroversial merger.

Step 3: Merger Simulation

- ▶ Simulate the price effects of the merger
- ▶ Take into account likely cost synergies (sometimes there are none).
- ▶ Estimate post-merger prices and welfare.

This is what we will talk about next.

Merger Simulation

Merger Simulation: Two Options

► Partial Merger Simulation

- Simulate a new price for p_j after acquiring good k holding the prices of all other goods (p_k, p_{-j}) fixed.
- Repeat for p_k and all other products involved in the merger.
- Compare price increases to **synergies** or cost savings.

► Full Merger Simulation

- Write down the full system of post-merger FOC.
- Adjust post-merger marginal costs for potential synergies.
- Solve for all prices at the new (post-merger) equilibrium (p_j, p_k, p_{-j}) .

Differentiated Products Bertrand

Recall the multi-product Bertrand FOCs:

$$\begin{aligned}\arg \max_{p \in \mathcal{J}_f} \pi_f(\mathbf{p}) &= \sum_{j \in \mathcal{J}_f} (p_j - c_j) \cdot q_j(\mathbf{p}) \\ \rightarrow 0 &= q_j(\mathbf{p}) + \sum_{k \in \mathcal{J}_f} (p_k - c_k) \frac{\partial q_k}{\partial p_j}(\mathbf{p})\end{aligned}$$

It is helpful to define the matrix Ω with entries:

$$\Omega_{(j,k)}(\mathbf{p}) = \left\{ \begin{array}{ll} -\frac{\partial q_j}{\partial p_k}(\mathbf{p}) & \text{for } (j,k) \in \mathcal{J}_f \\ 0 & \text{for } (j,k) \notin \mathcal{J}_f \end{array} \right\}$$

We can re-write the FOC in matrix form:

$$q(\mathbf{p}) = \Omega(\mathbf{p}) \cdot (\mathbf{p} - \mathbf{mc})$$

Merger Simulation

What does a merger do? **change the ownership matrix.**

- ▶ Step 1: Recover marginal costs $\widehat{\mathbf{mc}} = \mathbf{p} + \Omega(\mathbf{p})^{-1}q(\mathbf{p})$.
- ▶ Step 1a: (Possibly) adjust marginal cost $\widehat{\mathbf{mc}} \cdot (1 - e)$ with some cost efficiency e .
- ▶ Step 2: Change the ownership matrix $\Omega^{pre}(\mathbf{p}) \rightarrow \Omega^{post}(\mathbf{p})$.
- ▶ Step 3: Solve for \mathbf{p}^{post} via: $\mathbf{p} = \widehat{\mathbf{mc}} - \Omega(\mathbf{p})^{-1}q(\mathbf{p})$.

Merger Simulation

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- ▶ The first step is easy (just a matrix inverse).
 - ▶ The second step is trivial.
 - ▶ The third step is tricky because we have to solve an implicit system of equations. \mathbf{p} is on both sides.

Solution Methods

We were a bit vague on how we were solving the system of equations for p^{post} , the post-merger price.

General problem $F(x) = 0$ or n nonlinear equations and n unknowns $x = (x_1, \dots, x_n) \in \mathbb{R}^n$.

$$\begin{aligned} F_1(x_1, \dots, x_n) &= 0 \\ F_2(x_1, \dots, x_n) &= 0 \\ &\vdots \\ F_{N-1}(x_1, \dots, x_n) &= 0 \\ F_N(x_1, \dots, x_n) &= 0 \end{aligned}$$

Solution Methods

Helpful to write $F(x) = 0 \Leftrightarrow x - \alpha F(x) = x$ which yields the fixed point problem:

$$G(x) = x - \alpha F(x)$$

Fixed point iteration

$$x^{k+1} = G(x^k)$$

Nonlinear Richardson iteration or Picard iteration.

We need G to be a **contraction mapping** for iterative methods to guarantee a unique solution (often need strong monotonicity as well).

Gauss Jacobi: Simultaneous Best Reply

Current iterate: $x^k = (x_1^k, x_2^k, \dots, x_{n-1}^k, x_n^k)$.

Compute the next iterate x^{k+1} by solving one equation in one variable using only values from x^k :

$$\begin{aligned} F_1(x_1^{k+1}, x_2^k, \dots, x_{n-1}^k, x_n^k) &= 0 \\ F_2(x_1^k, x_2^{k+1}, \dots, x_{n-1}^k, x_n^k) &= 0 \\ &\vdots \\ F_{n-1}(x_1^k, x_2^k, \dots, x_{n-1}^{k+1}, x_n^k) &= 0 \\ F_n(x_1^k, x_2^k, \dots, x_{n-1}^k, x_n^{k+1}) &= 0 \end{aligned}$$

Requires contraction and strong monotonicity.

Partial Merger Analysis

- ▶ Hold all other prices p_{-j} fixed at **pre-merger** prices.
- ▶ Adjust the marginal costs for potential efficiencies.
- ▶ Consider only the FOC for product j

$$0 = q_j(\mathbf{p}) + \sum_{k \in \mathcal{J}_f} (p_k - c_k) \frac{\partial q_k}{\partial p_j}(\mathbf{p})$$

- ▶ Solve for the new p_j given the change in the products controlled by firm f : $\mathcal{J}_f \rightarrow \mathcal{J}'_f$
- ▶ This is a single Gauss-Jacobi step (only products involved in merger).

Partial Merger Analysis: Why bother?

- ▶ We only need own and cross elasticities for products involved in the merger.
- ▶ Tends to show smaller price increases than full equilibrium merger analysis.
- ▶ Only solving a single equation rather than a system of J nonlinear equations.

Gauss Seidel: Iterated Best Response

Current iterate: $x^k = (x_1^k, x_2^k, \dots, x_{n-1}^k, x_n^k)$.

Compute the next iterate x^{k+1} by solving one equation in one variable updating as we go through:

$$\begin{aligned} F_1(x_1^{k+1}, x_2^k, \dots, x_{n-1}^k, x_n^k) &= 0 \\ F_2(x_1^{k+1}, x_2^{k+1}, \dots, x_{n-1}^k, x_n^k) &= 0 \\ &\vdots \\ F_{n-1}(x_1^{k+1}, x_2^{k+1}, \dots, x_{n-1}^{k+1}, x_n^k) &= 0 \\ F_n(x_1^{k+1}, x_2^{k+1}, \dots, x_{n-1}^{k+1}, x_n^{k+1}) &= 0 \end{aligned}$$

Requires contraction and strong monotonicity.

You can speed things up (sometimes) by re-ordering equations.

Newton's Method

1. Take an initial guess x^0
2. Take a Newton step by solving the following system of linear equations

$$J_F(x^k)s^k = -F(x^k)$$

3. New guess $x^{k+1} = x^k + s^k$.
4. Good (Quadratic) Local convergence
 - ▶ Requires J_F (Jacobian) to be Lipschitz continuous.
 - ▶ Linearity means we do not need to take the inverse to solve the system (just QR decomp – `backslash` in MATLAB).
 - ▶ Non-singularity of J_F is weaker than strong monotonicity (more like PSD).

Fixed Point Iteration?

- ▶ Can we iterate on the price relation until we converge to a new equilibrium?

$$\mathbf{p} \leftarrow \widehat{\mathbf{mc}} - \Omega(\mathbf{p})^{-1}q(\mathbf{p})$$

- ▶ While tempting, this doesn't work. (It is **not** a contraction).
- ▶ There is a modification that is a contraction for logit type models.
- ▶ You can always get lucky(!)

Morrow Skerlos (2010) Fixed Point

- ▶ For the logit (and variants) we can factor $\frac{\partial q_j}{\partial p_k}$ into two parts.

$$\Omega_{jk}(\mathbf{p}) = \underbrace{\alpha \cdot I[j = k] \cdot s_j(\mathbf{p})}_{\Lambda(\mathbf{p})} - \underbrace{\alpha \cdot s_j(\mathbf{p}) s_k(\mathbf{p})}_{\Gamma(\mathbf{p})}$$

- ▶ $\Gamma(\mathbf{p})$ and $\Lambda(\mathbf{p})$ are $J \times J$ matrices and $\Lambda(\mathbf{p})$ is diagonal and (j, k) is nonzero in $\Gamma(\mathbf{p})$ only if (j, k) share an owner.
- ▶ After factoring we can rescale by $\Lambda^{-1}(\mathbf{p})$

$$(\mathbf{p} - \mathbf{mc}) \leftarrow \Lambda^{-1}(\mathbf{p}) \cdot \Gamma(\mathbf{p}) \cdot (\mathbf{p} - \mathbf{mc}) - \Lambda^{-1}(\mathbf{p}) \cdot s(\mathbf{p})$$

- ▶ This alternative fixed point is in fact a contraction.
- ▶ Moreover the rate of convergence is generally fast and stable (much more than Gauss-Seidel or Gauss-Jacobi).

Unilateral Effects

What are Unilateral Effects?

- ▶ In 2010 the Horizontal Merger Guidelines were updated to reflect a movement away from HHI/concentration based measures and **Cournot** competition towards measures more in line with **Differentiated Bertrand** competition.
- ▶ Similar to partial merger analysis. Look at the incentives to raise prices for product j before and after a merger, holding all other prices fixed.
- ▶ Two key measures **Upward Pricing Pressure** (UPP) and the primary input into UPP the **Diversion Ratio**.
- ▶ Intended for initial screening stage of merger evaluation, but sometimes substitute for full merger simulation.

2010 Merger Guidelines

*In some cases, the Agencies may seek to quantify the extent of direct competition between a product sold by one merging firm and a second product sold by the other merging firm by estimating the diversion ratio from the first product to the second product. **The diversion ratio is the fraction of unit sales lost by the first product due to an increase in its price that would be diverted to the second product.** Diversion ratios between products sold by one merging firm and products sold by the other merging firm can be very informative for **assessing unilateral price effects, with higher diversion ratios indicating a greater likelihood of such effects.** Diversion ratios between products sold by merging firms and those sold by non-merging firms have at most secondary predictive value.*

Unilateral Effects

- ▶ Eliminating competition between the merging firms can itself constitute a substantial lessening of competition
- ▶ Developed in the 1992 Guidelines, and larger role in the 2010 Guidelines
- ▶ Based on modern theoretical literature: Farrell Shapiro (1990), Werden (1996), Farrel Shapiro (2010), Froeb and Werden (1998)
- ▶ Extension to multiple products/firms may be tricky (Carlton 2010, Hausman, Moresei, Rainey (2010)).
- ▶ Doesn't go as far as pass-through literature (Bulow Geanakoplos Klemperer (1985), Jaffe Weyl (2013)).
- ▶ Limited empirical results in academic literature: (Cheung 2013, Miller, Remer, Ryan, Sheu (2013), Conlon Mortimer (2013/5))
- ▶ Possibly more empirical experience at DOJ/FTC.

What is the Diversion Ratio?

Ignore all but two merging products

Pre-Merger

Firm maximizes π_j choosing p_j :

$$q_j(\mathbf{p}^{(0)}) + (p_j^{(0)} - c_j) \frac{\partial q_j(\mathbf{p}^{(0)})}{\partial p_j} = 0$$

Post-Merger

Firm maximizes $\pi_j + \pi_k$ choosing p_j only (with efficiency e_j):

$$q_j(\mathbf{p}^{(1)}) + (p_j^{(1)} - (1 - e_j) \cdot c_j) \frac{\partial q_j(\mathbf{p}^{(1)})}{\partial p_j} + (p_k^{(1)} - c_k) \frac{\partial q_k(\mathbf{p}^{(1)})}{\partial p_j} = 0$$

UPP Derivation

Difference between pre- and post- merger prices:

Let $UPP_j \approx p_j^1 - p_j^0$:

$$UPP_j \approx (p_k - mc_k) \cdot \underbrace{\left[\frac{\partial q_j}{\partial p_j} \right]^{-1} \left[\frac{\partial q_k}{\partial p_j} \right]}_{D_{jk}(\mathbf{p})} - E_j mc_j$$

$$GUPPI_j = D_{jk}(\mathbf{p}) \cdot \frac{p_k - mc_k}{p_j}$$

Leads some to state that diversion ratio $D_{jk}(\mathbf{p})$ is a sufficient statistic for unilateral merger effects.

UPP Derivation : Multiple Products

Extension to multiple acquisitions:

Very easy if we have that $p_j - mc_j = p - mc$ are the same for several values of j . Then

$$UPP_j \approx (p - mc) \sum_k D_{jk}(\mathbf{p}) - E_j mc_j$$

If several brands of acquisition have the same markup – can consider firm-level diversion. (We can aggregate diversion across similar flavors)

Empirical Measures of Pricing Pressure

Assumption Proportional to market share?

Price Cost Margins Hart-Scott-Rodino Act/ Discovery/ provided by merging parties.

Diversion as Data (Farrell Shapiro 2010) *The diversion ratio might be estimated using evidence generated in the merging firms' normal course of business. Firms often track diversion ratios in the form of who they are losing business to, or who they can win business from.*

Diversion Surveys (Farrell Shapiro 2010) *Customer surveys can also illuminate diversion ratios, as can information about customer switching patterns.*

Demand Estimation If we can do this, can probably do full merger simulation. May depend on second-order information or parametric forms. Can also differentiate demand to get diversion.

Experimental Interpretation (Conlon and Mortimer 2015)

Population All individuals who at current prices would buy j .

Treatment Not buying j .

Outcome Fraction who purchase k instead.

Instrument p_j functions as the instrument (it monotonically increases probability of treatment).

Effect of Interest treat only those individuals purchasing j who are most price-sensitive. (ie: those who would leave j after a 5-10% price increase).

Diversion Experiments

- Consider an experiment designed to measure diversion, where everything else is held fixed and p_j is increased by Δp_j

$$\widehat{D}_{jk} = \left| \frac{\Delta Q_k}{\Delta Q_j} \right| = \left| \frac{Q_k(\mathbf{p}^{(1)}) - Q_k(\mathbf{p}^{(0)})}{Q_j(\mathbf{p}^{(1)}) - Q_j(\mathbf{p}^{(0)})} \right| = \frac{\int_{p_j^0}^{p_j^1} \frac{\partial q_k(p_j, p_{-j})}{\partial p_j} \partial p_j}{\int_{p_j^0}^{p_j^1} \frac{\partial q_j(p_j, p_{-j})}{\partial p_j} \partial p_j}$$

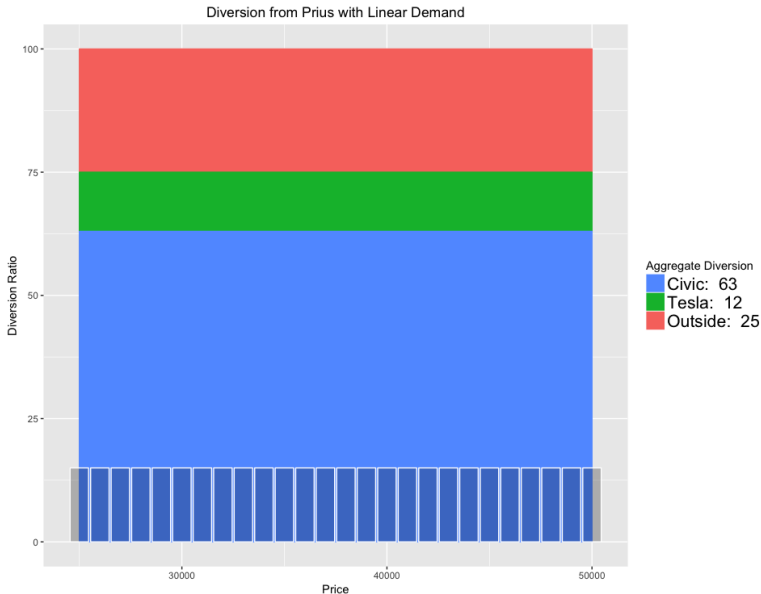
Diversion: Finite Price Change

Think about the **Local Average Treatment Effect**:

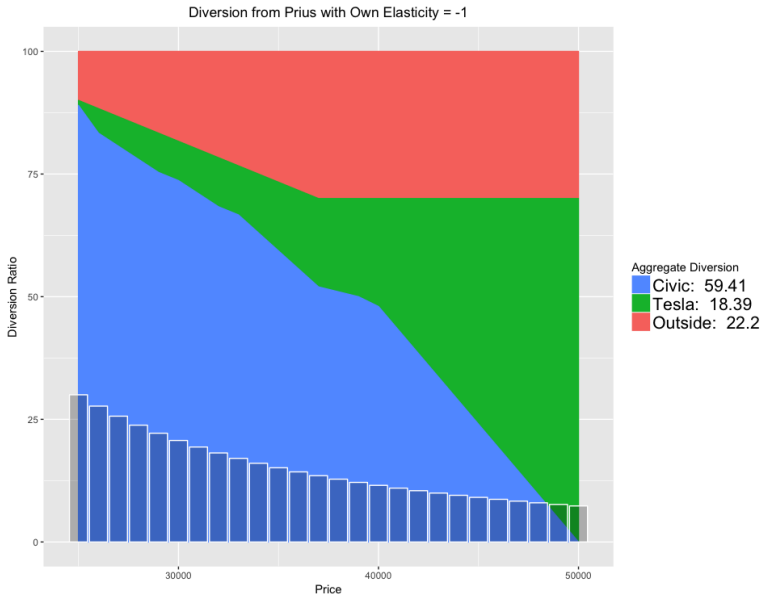
$$\widehat{ED}_{jk} = \frac{1}{\Delta q_j} \int_{p_j^0}^{p_j^0 + \Delta p_j} \underbrace{\frac{\partial q_k}{\partial q_j}}_{D_{jk}(\mathbf{p})} \left| \frac{\partial q_j}{\partial p_j} \right| \partial p_j$$

- ▶ Our estimated diversion measure is a weighted average of diversion, where the weights are the fraction of lost sales of j :
 $w(\mathbf{p}) = \frac{1}{\Delta q_j} \frac{\partial q_j}{\partial p_j}(\mathbf{p})$
- ▶ If demand declines quickly near the market price
 $ATE \approx D_{jk}(\mathbf{p})$ at $\mathbf{p}^{(0)}$.

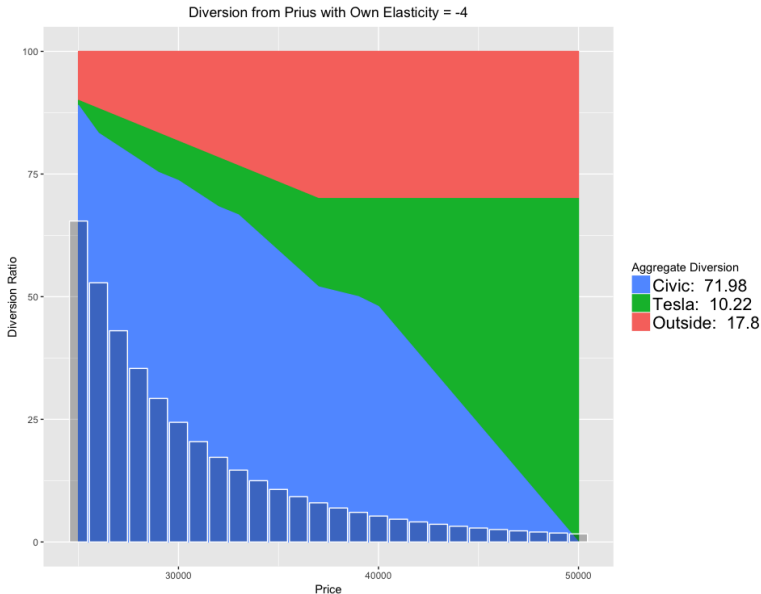
Thought Experiment – Linear Demand for a Toyota Prius



Thought Experiment – Inelastic CES Demand for a Prius



Thought Experiment – Elastic CES Demand for a Prius



Conduct

Conduct Overview

- ▶ A second set of important questions in IO is being able to use data to decide whether firms are **competing** or **colluding**.
- ▶ Absent additional restrictions, we cannot generally look at data on (P, Q) and decide whether or not collusion is taking place.
- ▶ We can make progress in two ways: (1) parametric restrictions on marginal costs; (2) exclusion restrictions on supply.
 - ▶ Most of the literature focuses on (1) by assuming something like: $\ln mc_{jt} = x_{jt}\gamma_1 + z_{jt}\gamma_2 + \omega_{jt}$.
 - ▶ In principle (2) is possible if we have instruments that shift demand for products but not supply. (These are much easier to come up with than “supply shifters”).

Testing For Collusion: Challenges

- ▶ Recall the Ω matrix which we can write as $\Omega = \tilde{\Omega} \cdot * O$, where $(.*)$ is the element-wise or Hadamard product of two matrices.
 - ▶ $\tilde{\Omega}$ is the matrix of demand derivatives with $\Omega_{(j,k)} = \frac{\partial q_j}{\partial p_k}$ for all elements.
 - ▶ $O_{(j,k)} = 1$ if (j, k) have the same owner and 0 otherwise.
- ▶ Mergers are about changing 0's to 1's in the O matrix.
- ▶ Matrix form of FOC: $q(\mathbf{p}) = \Omega(\mathbf{p}) \cdot (\mathbf{p} - \mathbf{mc})$

Testing For Collusion: Challenges

We derived those conditions from multi-product Bertrand FOCs:

$$\begin{aligned}\arg \max_{p \in \mathcal{J}_f} \pi_f(\mathbf{p}) &= \sum_{j \in \mathcal{J}_f} (p_j - c_j) \cdot q_j(\mathbf{p}) + \theta_{fg} \sum_{j \in \mathcal{J}_g} (p_j - c_j) \cdot q_j(\mathbf{p}) \\ \rightarrow 0 &= q_j(\mathbf{p}) + \sum_{k \in (\mathcal{J}_f, \mathcal{J}_g)} \theta_{jk} \cdot (p_k - c_k) \frac{\partial q_k}{\partial p_j}(\mathbf{p})\end{aligned}$$

- ▶ Now we have generalized the O matrix.
- ▶ Instead of 0's and 1's we now have $\theta_{fg} \in [0, 1]$ representing how much firm f cares about the profits of g .
 - ▶ If f and g merge (or fully colluded) then $\theta_{fg} = 1$
 - ▶ Often in the real world firms cannot reach fully collusive profits and $\theta \in (0, 1)$.
 - ▶ Evidence that $\theta_{fg} > 0$ is not necessarily evidence of malfeasance, just a deviation from **static Bertrand pricing**.

Reasons for Deviations from Static Bertrand

Biased estimates of own and cross price derivatives: For anything to work, you have correct estimates of $\tilde{\Omega}$. My prior is most papers **underestimate** cross price elasticities.

Vertical Relationships: Who sets supermarket prices? Just the retailer? Just the manufacturer? Some combination of both? Retailers tend to **soften** downstream price competition.

Faulty Timing Assumptions: Bertrand is a simultaneous move pricing game. Lots of alternatives (Stackelberg leader-follower, Edgeworth cycles, etc.).

Dynamics and Dynamic Pricing: Forward looking firms or consumers might not set static Nash prices. [e.g. Temporary Sales, Switching Costs, Network Effects, etc.]

Unmodeled Supergame: Maybe firms are legally tacitly colluding, higher prices might be about what firms believe will happen in a price war.

Testing For Collusion: Bertrand Deviations

Algorithm #1:

- ▶ Recover $\tilde{\Omega}$ from demand alone.
- ▶ Recover marginal costs $\widehat{\mathbf{mc}} = \mathbf{p} + (O \cdot * \tilde{\Omega}(\mathbf{p}))^{-1} q(\mathbf{p})$.

Challenges:

- ▶ Given $[\mathbf{q}, \mathbf{p}, \tilde{\Omega}, O]$ I can always produce a vector of marginal costs \mathbf{c} that rationalizes what we observe. [ie: J equations J unknowns].
- ▶ Maybe some vectors of \mathbf{c} look less “reasonable” than others.
 - ▶ ie: I have a parametric model of MC in mind.
 - ▶ Can test that model with GMM objective of c_{jt} on regressors.
 - ▶ Maybe marginal costs cannot deviate too much within product from period to period.
 - ▶ Marginal costs ≤ 0 seem problematic. [Might just be that your estimates for demand are too inelastic...]

Testing For Collusion: Simultaneous Supply and Demand

Algorithm #2:

- ▶ Recover $\tilde{\Omega}$ from demand and parametric assumption on supply (GMM with both sets of moments).
- ▶ I can impose $c > 0$ by using $\ln mc_{jt} = x_{jt}\gamma_1 + z_{jt}\gamma_2 + \omega_{jt}$.
- ▶ The fit of my supply side will also inform my demand parameters, particularly α the price coefficient. [BLP 95 used this for additional power with lots of random coefficients and potentially weak instruments].

Challenges:

- ▶ Am I testing conduct? Or am I testing the linear functional form for my supply model?
- ▶ Will a missing z_{jt} change whether or not I believe firms are colluding?

Examples