Estimating markups: Combing production and demand data

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Introduction

- Long tradition in IO to analyze impact of various competitive pressures on price cost margins:
  - Deregulation, Privatization, Trade liberalization and - protection, mergers, etc.
  - Data requirements and proprietary cost data make it hard to 'measure' p/mc.
- *Revolution* of empirical I.O (Bresnahan): FOC on oligopoly and demand system yields information on markups and marginal costs.
- Alternative approach using production data and different set of FOC from cost minimization.
- Different assumptions and data requirements to retrieve the same economic object of interest – i.e., markup (μ), and open up testing models of competition, demand and production.

Demand vs Production: Objectives.

- Ability to run counterfactual exercises for a variety of important policy evaluations, such as merger analysis, product introduction, and trade policy among others.
- The markups obtained from demand estimation are informative about margins at the final consumption level, whereas the production approach delivers markups at the level of production and therefore do not include the additional margins that are added further down the distribution chain.
- Both approaches are inherently complementary and the use of both approaches should depend on the data at hand, and the research question.

De Loecker and Scott (2022)

- Two approaches to estimate market power: *Demand* and *Production*
- Learn more about measuring market power and its determinants (cost, pass-through, etc.) but first step: compare production to demand approach.
- Goal of analysis:
  1. In some applications we only have one approach available: help evaluate assumptions/robustness,
  2. In other applications we have both approaches available: integrate both – joint demand/supply and insight surplus division.

Demand-Conduct Approach

- Core to empirical IO.
- Success in take-up: From IO to trade, development, health, and recently PF (e.g. education).
- This framework has found many applications, while validity of underlying assumptions remains understudied.
  - Consumers observing choice set,
  - Firms compete in known static and stable way,
  - Instruments for price and other covariates,
  - Restricted forms of consumer heterogeneity
- Recent work relaxing choice set (Sovinsky-Goeree, 2008), dynamics (Hendel and Nevo, 2006; Gowrisankaran and Rysman 2012; Scott, 2014).

Demand: assumptions on consumers

- Data: on price, quantity and characteristics (either aggregate or micro) for *a* market.
- Consumer i gets utility from product j:

$$U_{ij} = x_j \beta_i + \xi_j + \epsilon_{ij} \tag{1}$$

- Consumer knows choice set $\mathcal{S}$, chooses $\max_{j \in S} (U_j)$
- Heterogeneity: assume i.i.d. logit distribution on ϵ, parameterized distribution for preferences $F(\beta)$, e.g.

$$\beta_i \sim \mathcal{N}\left(\bar{\beta}, \Sigma_{beta}\right)$$

- Exclusion restriction on instruments: $\mathbb{E}(\xi_j(\boldsymbol{\theta}) Z_j) = 0$.
- Econometrics: cross-sectional techniques (mostly) with $\mathbb{E}(P_j \xi_j) \neq 0$

Demand: assumptions on firms

- After a particular form of industry conduct is assumed, marginal costs and markups may be recovered from demand.
- With a monopolist producer, approach looks like:

$$\frac{\partial \pi}{\partial q} = P + q\frac{\partial P}{\partial q} - c = 0$$
$$\mu \equiv \frac{P}{c} = (1 + \eta^{-1})^{-1}$$

- More common would be to assume static Nash Bertrand competition which yields a similar condition
- Note that we define markups as the P/MC ratio, not $(P - MC)/P$ (aesthetic choice – doesn't really matter)

Demand approach: example

- Output from BLP on firm/product markups for cars.

Table: Estimated Markups for Average and Selected Cars

(a) Demand Approach: BLP		
Model	Markup $(P - c)$	Markup(P/c)
Mazda 323	\$801	1.19
Ford Escort	\$1,077	1.23
Lexus LS400	\$9,030	1.49
BMW 735	\$10,975	1.41
Mean	\$3,753	1.31

Notes: Panel (a) is based on Table VIII from BLP (1995) for the year 1990 (in 1982 USD).

Often forgotten literature: PCM

- Old tradition: measure markups using firm-level accounting data
- Suppose firm maximizes $\pi = P(Q)Q - cQ$; we have

$$\mu = \frac{P}{c} = \frac{P\color{red}{Q}}{c\color{red}{Q}} = \frac{R}{TC}$$

  regardless of the form of competition.
- Concerns: CRS not plausible, especially in short run, fixed cost vs variable cost, and aggregation across markets and products.
- PCM's are a valid version of the *production* approach if we have CRS and only variable costs.

Production: expression for markup

- FOC from cost minimization problem:

$$P_{it}^{V} - \lambda_{it} \frac{\partial Q_{it}(\cdot)}{\partial V_{it}} = 0,$$

  where λ_{it} is the marginal cost of production at production level Y_{it}.

- With $\mu_{it} \equiv P_{it}/\lambda_{it}$ and

$$\frac{\partial Q_{it}}{\partial V_{it}} \frac{V_{it}}{Q_{it}} = \mu_{it} \frac{P_{it}^{V} V_{it}}{P_{it} Q_{it}}$$

Cars ... again

Table: Estimated Markups for Average and Selected Cars

(a) Demand Approach: BLP		
Model	Markup $(P - c)$	Markup(P/c)
...		
Mean	\$3,753	1.31

(b) Production Approach: DLW using BKP data		
Material expenditure	Unit price	Material cost share
\$7,493	\$10,672	0.85
	Markup $(P - c)$	Markup(P/c)
	\$1,852	1.21

- $\mu = 0.85 \times \frac{10{,}672Q}{7{,}493Q} = 1.21$

How to compare both approaches?

- **Market definition and Technology**:
  - Demand approach requires grouping of products under given demand (i.e. market definition)
  - Production approach requires grouping of producers under given technology.
- **Vertical structure**: Firm (manufacturing) level:
  - Demand data is typically *downstream* even if we want *upstream* markups and cost; e.g. BLP use list prices.
  - Recent marketing applications have moved away from this and interested in either retail or entire chain, introducing interesting but complicated vertical relationships
  - We model vertical structure market analysis.
- Use industry where approaches can overlap: both detailed demand and production (census) data available. Today we focus on the US beer market: and compare market-level (weighted across producers) markup.

Remainder of the talk

1. Production approach implementation,
2. Demand approach (Miller and Weinberg (2019, ECMA),
3. Comparison of markup estimates over time,
4. Joint approach: Model of retail competition.

Implementation: Demand

- We use Miller and Weinberg's (2017) demand system.
  - Mixed nested logit specification for retail beer demand in US
  - Estimated using IRI data, 2006-2011
  - Heterogeneous price coefficients, nesting out outside option
  - Instruments: interaction of diesel prices and distance from brewery to market
- Data aggregates over stores within region. Focus is on estimating **product-level** demand system.
- We re-estimated using pyBLP (Conlon and Gortmaker) with optimal instruments (Reynaert and Verboven)
  ...no surprises to report
- We will also apply the demand system to overlapping and more recent AC Nielsen data.

Downstream costs

- Suppose downstream markets are perfectly competitive and involve **known** unit cost τ. We have perfect passthrough of wholesale prices, and a single-product monopolist producer's FOC is

$$\frac{\partial \pi}{\partial q} = P + q\frac{\partial P}{\partial q} - c - \tau = 0$$
$$\mu \equiv \frac{P - \tau}{c} = (1 + \eta^{-1})^{-1}$$

  where η is the demand elasticity, and noting that $P - \tau$ is producer's wholesale price.

- We construct a measure of τ based on
  - State and federal excise taxes.
  - An estimate of shipping costs based on diesel prices and distance between market and producer's nearest brewery.
  - Estimated costs of retailing.

Production: Leontief

$$Q = \min\left(F\left(L, K\right), \beta_M M\right) \tag{2}$$

- Marginal cost becomes

$$\lambda_Q = \frac{P_M}{\beta_M} + \frac{w}{F_L} \tag{3}$$

- Markups

$$\mu = \frac{1}{\theta_L \frac{wL}{PQ} + \alpha_M} \tag{4}$$

- This functional form has strong foundations in terms of identification:
  - By-steps identification challenges,
  - Valid in imperfect competitive product- and factor markets.

Implementation: Leontief Production

- Leontief production function:

$$Q_f = \min\left[\kappa_f M_f, F\left(L_f, K_f\right)\Omega_f\right]\exp\left(\epsilon_f\right),$$

- This calls for a regression of Q on L and K (note difference from traditional "value added"):

$$\ln Q_{ft} = \ln F\left(L_{ft}, K_{ft}\right) + \omega_{ft} + \epsilon_{ft}$$

- Leontief FOC implies that $\Omega = \frac{\kappa M}{F(L,K)}$ at each point or:

$$\begin{aligned} q_{ft} &= \ln \kappa_{ft} + \ln M_{ft} + \epsilon_{ft} && (5) \\ &= \phi_t(\boldsymbol{X}_{ft}) + \epsilon_{ft} && (6) \end{aligned}$$

- with $\boldsymbol{X}_{ft}$ all inputs, state dummies, wages, etc.

Production: main assumptions (panel data)

- Extract productivity shock ξ_{ft} through productivity process and first-stage $(\omega_{ft} - \mathbb{E}(\omega_{ft}|\mathcal{I}_{ft-1}))$.
- Exclusion restrictions to estimate production function:

$$\mathbb{E}(\xi_{ft}(\theta)Z_{ft}) = 0 \tag{7}$$

- With Z_{ft} lagged labor and current capital.

Production data

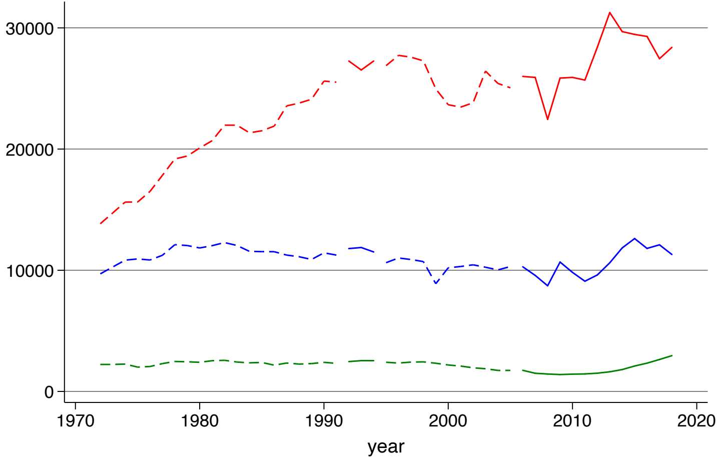
- US Census data on Breweries (NAICS 312120).
- Plant-level data on output (sales), input (expenditures), investment, exit/entry, etc.
- Period 1972-2012.

Table: Sum stats

year	nr plants/firms	Shipments
1997	529/494	18,203
2002	379/349	20,369
2007	398/373	21,196

Note: Dollar amount in $(1,000,000)$.

Industry



Markups (Demand-Conduct): 2007

Table: Markups: Conduct and Vertical Structure (IRI)

Brewer competition	(1)	(2)	(3)
Nash Bertrand	2.29	2.15	1.80
Nation-wide monopoly	14.91	14.88	14.68
Product-by-product	1.57	1.52	1.39
Retail cost correction	Yes	No	No
Distribution cost correction	Yes	Yes	No

Notes: We report sales-weighted markup: 1) Multi-product Nash-Bertrand, 2) collusion among domestic brewers, and 3) Nash-Bertrand with each product owned by a single-product firm.

Markups (Production): 2007

	(1)	(2)	(3)
Technology	Gross output	Value added	
		Restricted Profit	Leontief
	Cobb-Douglas		
Variable M	1.52		
	(0.32)		
Variable L	2.02	5.00	2.08
	(1.78)	(0.86)	(0.06)
	Translog		
Variable M	1.70		
	(0.83)		
Variable L	3.45	1.05	2.05
	(5.23)	(1.09)	(18.10)

Comparing Markup Estimates

Aggregation

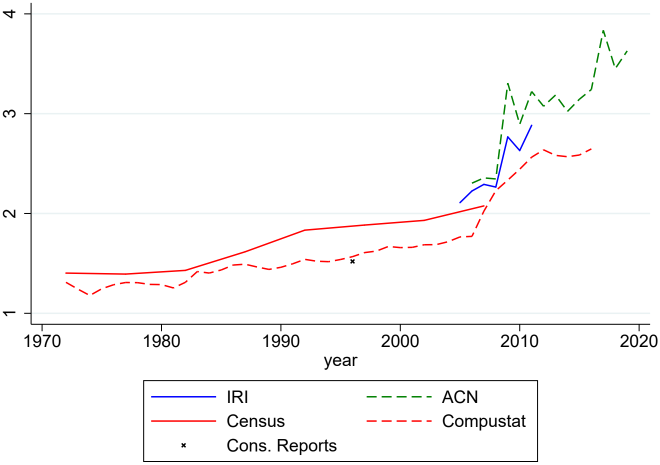
- We aggregate markups from each approach by year, focusing on only domestic producers.
- Demand-based markups:

$$\mu_t^D = \frac{\sum_m \sum_j R_{mjt} \mu_{mjt}}{\sum_m \sum_j R_{mjt}}$$

  where j denotes product, m denotes region-month, and R is revenue.
- Production-based markups:

$$\mu_t^P = \frac{\sum_f R_{ft} \mu_{ft}}{\sum_f R_{ft}}$$

Estimated brewer markups over time



Consumer Reports

Retail Competition

Retail behavior assumptions in the literature

1. *Perfect competition, no retail cost*: BLP, for instance. Effectively pretends there is no retailer. This implies perfect wholesale-retail pass-through and no wedge between the brewer and retail price.
2. *Perfect competition with a retail cost*: $P^r = P^b + c^r$.
3. *Retailers with market (monopoly) power*

Literature:
vertical structure tests: Berto Villas-Boas (2007), Bonnet and Dubois (2010)
store choice: Katz (2007), Ellickson, Grieco, Khvastunov (2020)

Demand approach: vertical structure

- For ease of exposition, suppose there is a single-product monopolist brewer.
- Symmetric retailers in symmetric equilibrium.
  - Anything between perfect substitutes and independent demand (retail monopoly)
- Let's consider three elasticities:
  - η^B elasticity faced by brewer
  - η^R elasticity of retail demand as retail prices change together
  - η^r elasticity faced by individual retailer (w.r.t. unilateral price change)
- Note that η^R comes directly from the **product** demand system. We're taking for granted that this is what comes out of the demand estimation.

Demand approach: vertical structure

- η^B elasticity faced by brewer
- η^R elasticity of retail demand as retail prices change together
- η^r elasticity faced by individual retailer (w.r.t. unilateral price change)

- Letting P^R denote a retail price charged by all retailers

$$\eta^B = \eta^R \frac{dP^R}{dP^B} \frac{P^B}{P^R},$$

- Note two reasons for $\frac{P^B}{P^R} < 1$:
  - Costs of retailing
  - Retailer markups

Demand approach: retail markups

$$\eta^B = \eta^R \frac{dP^R}{dP^B} \frac{P^B}{P^R},$$

- Retail markup will generally increase as retailers get more market power. Note individual retailer's FOC:

$$\frac{P^R}{P^B + c_r} = \left(1 + \frac{1}{\eta^r}\right)^{-1}.$$

  where η^r is an individual retailer's demand elasticity w.r.t. a unilateral price change, and c_r captures retail marginal costs net of wholesale prices.
- With two retailers engaged in symmetric Bertrand equilibrium

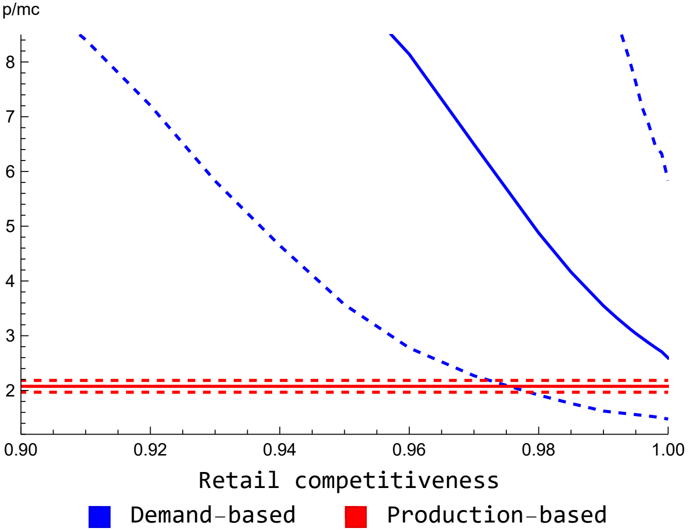
$$\eta^r = \eta^R - \eta^{cross}$$

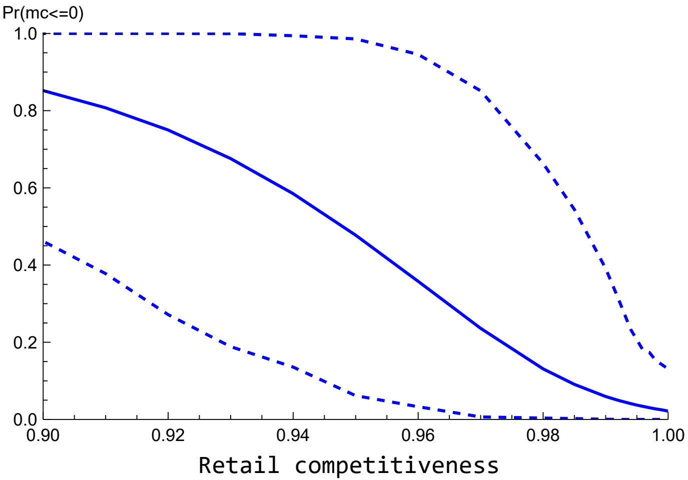
  where η^{cross} is the cross-price elasticity between retailers.

Demand model: store choice

$$\widetilde{s}\left(\boldsymbol{r},\boldsymbol{r}';\theta\right)=\frac{\exp\frac{\gamma}{1-\gamma}V\left(\boldsymbol{r};\theta\right)}{\exp\frac{\gamma}{1-\gamma}V\left(\boldsymbol{r};\theta\right)+\exp\frac{\gamma}{1-\gamma}V\left(\boldsymbol{r}';\theta\right)}$$

- $V\left(\boldsymbol{r};\theta\right)$: inclusive value
- $\gamma = 0$: retail monopoly
- $\gamma \to 1$: competitive retail
- Note that while we assume one symmetric competing store, thanks to the "Bertrand Paradox", we can span everything from monopoly to perfect competition.
- Also note that γ has a structural interpretation as the degree of differentiation in the retail sector.


p/mc
8
7
6
5
4
3
2
0.90
0.92
0.94
0.96
0.98
1.00
Retail competitiveness
Demand–based
Production–based


Pr(mc<=0)
1.0
0.8
0.6
0.4
0.2
0.0
0.90
0.92
0.94
0.96
0.98
1.00
Retail competitiveness

Main findings

- Markups from our baseline implementation of each approach line up well, in terms of levels and changes over time.
  - Note: our most recent release of production results was in November 2016. Miller and Weinberg's reproduction materials only became available later.
- Demand approach only matches up with production approach if differentiation among stores is *relatively limited*.
  - This is in contrast to studies presenting evidence of limited responsiveness to retail prices at competing stores (Dellavigna and Gentzkow) and that consumers don't flee stores in response to unilateral price increases (Hoch, Drèze, Purk).
  - Largely consistent with papers in tradition of BLP ignoring retailer double marginalization but downstream costs should be taken into account.

Future avenue(s)

- Huge potential for combining production+demand approaches
  - Robustness of markup estimates,
  - Over-identification allows us to relax and/or test assumptions on production and/or demand,
  - Learn about conduct at each node of the vertical chain,
  - Open up bargaining/interactions.