Endogenous Products

Charlie Murry

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Roadmap of Talk

Motivation

Berry and Waldfogel (1999, RAND)

Berry and Waldfogel (2000, QJE)

Eizenberg (2014, ReStud)

Endogenous Product

- *What do I mean by this?*[1]

- Firms consider market interactions (pricing, etc) when optimally choosing entry of products, or positioning of products in characteristics space, or product-line length.

[1] This is not an accepted term in the literature.

Way-back Motivation – IO pre-1980

- Understand the "effect" of x on profits/prices/sales.

$$y_{jt} = \beta_0 + \beta_1 * HHI_{jt} + \beta_2 * x_{jt} + \alpha * \mathbf{z}_{jt} + \varepsilon_{jt}$$

- Many times the level of observation is the industry.
- If not, still have rather aggregate data on the firms.
- *HHI* or shares are endogenous. Typically no serious attempt to truly identify the effect.
- Example: what is the "effect" of concentration on prices.
  - Typically, theory makes a stark prediction.
  - But market structure is endogenous. So the empirical strategy is very important!
- 1980's revolution in IO (Tirole et. al.): Let's think seriously about strategic interactions and choices like price, entry, marketing, product positioning.

Mankiw and Whinston (1986 RAND)

Main Idea

- Firms face strategic interactions in prices/quantities.
- Free entry condition with non-zero fixed costs to enter.
- Entrant causes incumbent firms to reduce output
- *Entry of last entrant is more valuable to entrant than society*
- Because net total increase in production (lower prices) is less valuable than fixed costs.

Mankiw and Whinston (1986 RAND)

Two Takeaways

1. Entry is endogenous – long run? short run? Different for different industries.

2. Socially optimal may not be privately optimal with imperfect competition.
    - Post-entry business stealing – new entrant makes profit at expense of incumbents.
    - If this is true for marginal entrant, so private value greater than social value.

Mankiw and Whinston (1986 RJE)

Details

- Quite general assumptions lead to weakly excessive entry compared to second best (social planner entry with post-entry competition)

  Assumption 1. $Nq_N > \hat{N}q_{\hat{N}}$ for all $N > \hat{N}$ and $\lim_{N\to\infty} Nq_N = M < \infty$.

  Assumption 2. $q_N < q_{\hat{N}}$ for all $N > \hat{N}$.

  Assumption 3. $P(Nq_N) - c'(q_N) \geq 0$ for all N.

- What if additional entrants added welfare because of consumer love of variety?
  - Then there is a tradeoff and we'll need data to help identify the tradeoff.

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Main Idea

- Take Mankiw and Whinston to data.
- What is optimal number of radio stations?

Empirical Strategy

1. Estimate listener demand.
   - More listeners with more variety.
   - More variety in larger markets.
2. Estimate advertiser willingness to pay for advertisements.
3. Estimate entry costs (in revenues, $) a la Berry (1992).
   - Recall: Berry (1992) is a discrete choice with unit-less latent payoffs.

Revisit Berry (1992)

"Reduced form" profit function of the form:

$$\pi_{jm} = X_{jm}\beta + \Delta N_m + \epsilon_{jm}$$

with data on X and entry.

Just like probit, the scale of ϵ and therefore π is unit-less.

But if we know the **revenues** of entrants, then we should be able to say how much in Fixed Costs the entrants need to cover.

Radio

- Homogeneous goods, where listeners are sold to advertisers.
- Price of an ad:
$$p(N) = p(Ns(N))$$
- Price of ads (rev. per listener) declines in total listening share.
- Price a function of listener share, not total listeners. Implies num. of advertisers scales with market size.
- Fixed cost, F. Entry decision exactly that of Mankiw and Whinston.

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- Fixed cost, F. Entry decision exactly that of Mankiw and Whinston.
- *Yes, they ignore things like targeting, multi-homing, ads congestion...but we need to start somewhere. This paper is truly groundbreaking on multiple dimensions.*

Competitive v. Optimal Provision of Stations

Competitive Provision

- Profits of a radio station:

$$\pi(N) = Mp(N)s(N) - F$$

- Determination of number of equilibrum firms, N_e:

$$\pi(N_e) \geq 0 \quad and \quad \pi(N_e + 1) < 0$$

Social (2nd best) Optimal

- 2nd best: Social planner can set N, but not prices.

- Consider social welfare the welfare of **advertisers** minus fixed station costs. Planner chooses N to max

$$M \int_0^{Ns(N)} p(x)d(x)$$

- with FOC Mankiw and Whinston (net business stealing):

$$\pi(N) + MNp(N)\frac{\partial s}{\partial N}$$

Alternative Scenario: Monopoly Entry

- Consider a monopolist who owns all of the stations.

$$N\pi(N) = R(N) - NF$$

- Internalizes the business stealing effect.
- Monopoly profit increases less in output than social planner because social planner values *inframarginal* benefit of reduction in price caused by additional station.
- In other words, the monopolist restricts output compared to Social Planner.
- Why is this important? The policy prescription is not to grant monopoly power.

Radio Data

TABLE 1 **Description of City-Level Data**

Variable	Units	Mean	Standard Deviation	Minimum	Census Population Survey
Share in-metro	%	12.909	12.909	5.172	17.841
Share out-metro	%	1.536	1.536	.000	10.422
N_1 (in-metro)	integer	18.585	18.585	6.000	47.000
N_2 (out-metro)	integer	5.748	5.748	.000	28.000
Population	millions	1.070	1.070	.133	14.034
Ad price	$100	2.766	2.766	1.466	6.213
Income	$1,000	35.531	35.531	21.860	51.936
College	%	46.969	46.969	28.300	65.100

To scale coefficients, the income and college variables are divided by 10 in the empirical work and Ad Price is per AQH listener-year.

DGP - Listeners

- Use survey data on radio listening habits.
- Nested logit a la Berry (1994).

$$u_{ij} = \delta_j + \nu_i(\sigma) + (1-\sigma)\epsilon_{ij}$$

- As $\sigma \to 1$ then stations are identical. Complete biz-stealing and total quantity does not expand with additional entrant.
- **Awkwardness:** Entry model has identical firms, but Berry (1994) is for heterogeneous firms – $\delta_j = \delta$.

$$s_j(N, \delta, \sigma) = \frac{1}{N} \frac{N^{1-\sigma}}{e^{-\delta} + N^{1-\sigma}}$$

DGP – Advertising Prices

- Fixed number of ads per hour.

- Price of ad proportional to # of listeners.

- Tot. Rev. is mkt ad price per listener $\times$ avg. # listeners.

- Inverse advertising demand curve:

$$p = \alpha(S(N))^{-\eta},$$

  where $S(N)$ is total share listening to radio, η is inv. elas. of demand, and α is a demand shifter.

- Estimating equation:

$$ln(p_k) = x_k\gamma - \eta ln(S_k) + \omega_k$$

Fixed Costs

- Firms can choose to enter/exit the market and incur fixed costs.

$$ln(F_k) = x_k\mu + \lambda v_k$$

- Fixed costs are the same for all firms (modulo the stochastic term), so we can estimate this as an ordered probit.
- Eqm: $\pi(N_e) \geq 0$ and $\pi(N_e + 1) < 0$.
- Unlike Bresnahan and Reiss, we have outcome data! What do we do here?!
- Use outcome data to construct variable profits $v(N) = Mp(N)s(N)$

Empirical Strategy

- Share equation (linear IV), ads price equation (linear IV), entry likelihood.

- Jointly estimate using GMM.

$$g(\theta) = \sum_k \begin{pmatrix} \xi_k(\beta, \sigma) z_k \\ \omega_k(\gamma, \eta) z_k \\ \partial ln(L_k(\theta)) / \partial(\mu, \lambda) \end{pmatrix}$$

- Key is that there is nothing "endogenous" in the log-likelihood function.

- *But What if radio stations with high demand shock δ_j also had high fixed costs, ν_{jk}?*

Big Picture Pause

Berry and Waldfogel have outcome data in the listener and ad market.

So instead of just describing entry thresholds (like Berry, 1992), they map entry thresholds to welfare.

But in order to estimate the model, they make concessions to reality by

- doing away with observed and unobserved.

- ruling out selection on unobservables across equations.

Those two things are hard because it would introduce the multiple equilibrium pointed out by Bresnahan and Reiss.

Welfare of Free Entry

- Welfare in terms of advertisers and stations (not listeners).
- σ is the key parameter determining the biz-stealing effect.

TABLE 4 **Comparison of Free Entry, Optimality, and Monopoly**

	Free Entry	Optimal	Monopoly
In-metro entry	2,509	649	341
		(46)	(55)
Aggregate costs ($ millions)	5,007	1,144	602
	(3)	(92)	(101)
Aggregate revenue ($ millions)	5,100	4,334	3,959
		(204)	(173)
Welfare ($ millions)	5,331	7,640	7,422
	(3,064)	(3,037)	(2,878)
Ad price	277	326	375
		(11)	(48)
Listening share (%)	12.91	9.28	7.53
		(.19)	(.50)

The free-entry numbers without standard errors are calculated directly from data. The difference between free entry and optimal welfare has a standard error of 167.

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Motivation

Does innovation crowd out existing products and in turn harm consumer welfare?

How could this happen?

- Firms decide which products to sell each year.
- Products with poor amenities may be have lower margins.
- If carrying a product in the product is associated with fixed costs, then the firm may optimally choose **not** to carry those lower margin products.

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What do we need to answer this question?

1. Estimates of consumer welfare for baseline and counterfactual product configurations.
2. Estimates of fixed costs to quantify optimal product-line decisions and producer welfare.

Motivation II

From a methodological point-of-view, this is similar to Berry and Waldfogel.

However, product differentiation is first-order. It **is** the research question.
How to characterize total producer surplus (e.g. estimate fixed costs)?

Motivation III

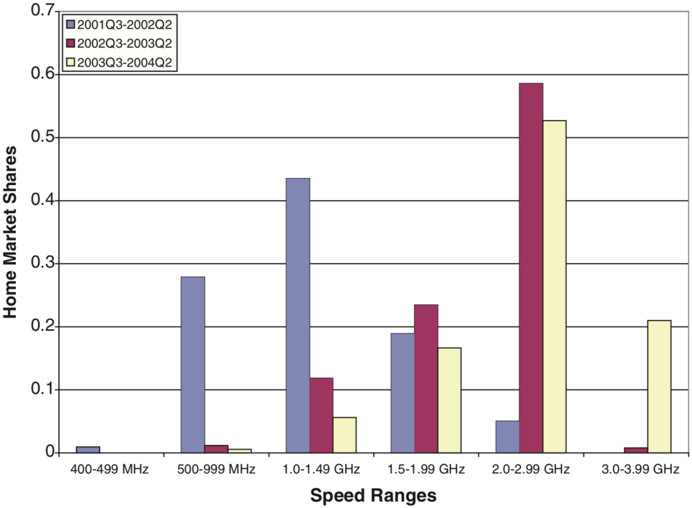

FIGURE 1
CPU speed range shares, U.S. Home Market, over the three sample years

Empirical Strategy

Estimate structural model of demand and supply of differentiated goods.

- Standard BLP identifying assumptions.

Use observed decisions on product entry/exit to estimate fixed costs.

- Construct bounds based on revealed preference a la **PPHI** and Ciliberto.
- Eizenberg uses the PPHI framework – circumvents the challenges faced by Berry and Waldfogel.

Model: two stage

1. Firms decide on products, based on *expected* profits.
2. After product lines are decided, firms compete on prices.

Demand and Supply

Demand
Key is to be able to get substitution patterns as realistic as possible so that consumer welfare makes sense.

$$u_{ijt}(\zeta_{it}, x_{jt}, p_{jt}, \xi_{jt}; \theta^d) = \underbrace{x_{jt}\beta + \xi_{jt}}_{\delta_{jt}} + \underbrace{[-\alpha_i \times p_{jt}] + \sum_{k=1}^{K} \sigma^k x_{jt}^k v_i^k}_{\mu_{ijt}} + \epsilon_{ijt} \tag{1}$$

Supply
Nash Bertrand in prices with the typical first order conditions.

Dell/HP/etc. are multi-product oligopolists.

Estimating Supply and Demand

Typical BLP set-up.

Except, makes clear that the products in the observed were *selected*.

BLP

$E[\xi \cdot z] = 0$

Eizenberg

$E[\xi_j \cdot z_j \mid q_j = 1] = 0$

where q_j is a selection indicator function.

This works as long as the following assumption holds.

Assumption 1. $E[\xi_j \mid X, F] = 0$

which is slightly more general than BLP.

Entry Stage

Firm d's profit

$$\mathbb{E}\pi_d = \mathbb{E}\left[\sum_{m \in S_d} \sum_{\ell \in L_{dm}} [p_{m\ell} - c_{m\ell}] s_{m\ell}(p) x M\right] - TF^d$$

for configuaration ℓ in product line m and TF^d total fixed costs.

Solution Concept

A Subgame Perfect Nash Eqm consists of product choices and prices that are a NE in every subgame. Assumes existence but not uniqueness.

Entry I

Main Assumption
Firms do not know ξ_{jt} or ω_j when deciding to supply a product to the market.

Why is this important?

Entry II

Specification of fixed costs: Firm-specific cost + error term.

$$F_j = F^d + \nu_j$$

Firm chooses subset of computers to offer from potential set.

Since there is no guarantee of a unique equilibrium, even if I specified a distribution for fixed costs, the probabilities of product-choice outcomes could not be pinned down, making it impossible to write down a well-defined likelihood function (Tamer, 2003).

Entry III

For Variable Profits (VP) and index variable of entry (A_d), the firm takes expectations over demand and supply shocks.

Upper bound on F_j. Products that entered found it profitable to do so.

$$F_j \leq E_{(e|\theta_0)}\left[VP_d(A_d; e, \theta_0) - VP_d(A_d - \mathbf{1}_d^j; e, \theta_0)\right] \equiv \overline{F}_j(\theta_0), \quad \forall j \in A_d^1 \tag{10}$$

Lower bound on F_j. Products that did not enter would have not been profitable.

$$F_j \geq E_{(e|\theta_0)}\left[VP_d(A_d + \mathbf{1}_d^j; e, \theta_0) - VP_d(A_d; e, \theta_0)\right] \equiv \underline{F}_j(\theta_0), \quad \forall j \in A_d^0 \tag{11}$$

Entry IV

Why doesn't a product enter?

1. Fixed costs are high.
2. Fixed costs low, but too much business stealing from same-brand products.

Need to measure demand substitution really well to capture the second mechanism.

Estimation – Fixed Costs

Variable Profits

- What ξ to use?

Equilibrium

- Does not assume order of moves, so mult eqm.
- Assume observed choices support an SPNE of 2-stage game.
    - No firm can unilaterally raise profits

Fixed Costs

- Fixed costs incorporate a "structural error" (ν_j) which is publicly observed.
- This results in a selection problem: In the data we will observe only the best ν_j's.
- PPHI propose three ways to deal with this:
    - Differencing.
    - Unconditional average of structural error + instrument.
    - Restriction on distribution of ν_j.

Selection on Fixed Costs

$$F_j = F^d + \nu_j$$

$$F^d + E[\nu_j \mid j \in A_d^1] \leq E[\bar{F}_j(\theta_0) \mid j \in A_d^1]$$

RHS is idnetified if $E[\nu_j \mid j \in A_d^1] = 0$
Solution: Restrict distribution of ν.

$$L_j(\theta_0) = \begin{cases} V_d^L(\theta_0) & j \in A_d^1 \\ \underline{F}_j(\theta_0) & j \in A_d^0 \end{cases} \qquad U_j(\theta_0) = \begin{cases} \overline{F}_j(\theta_0) & j \in A_d^1 \\ V_d^U(\theta_0) & j \in A_d^0 \end{cases}$$