Endogenous Products

Charlie Murry

Boston College

April 9, 2020

Roadmap of Talk

Motivation

Berry and Waldfogel (1999, RAND)

Berry and Waldfogel (2000, QJE)

Eizenberg (2014, ReStud)

Wollmann (2018, AER)

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.

Roadmap of Talk

Motivation

Berry and Waldfogel (1999, RAND)

Berry and Waldfogel (2000, QJE)

Eizenberg (2014, ReStud)

Wollmann (2018, AER)

Berry and Waldfogel (1999 RJE)

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.

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.

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.
- *Yes, they ignore things like targeting, multi-homing, ads congestion...but we need to start somewhere. This paper is truly groundbreaking on multiple dimensions.*

Free Entry

- Profits:

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

- Determination of num. of eqm firms, N_e:

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

- 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 (like MW86):

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

- and $\frac{\partial s}{\partial N}$ is negative from MW86 – so we know entry is excessive.

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

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.

Roadmap of Talk

Motivation

Berry and Waldfogel (1999, RAND)

Berry and Waldfogel (2000, QJE)

Eizenberg (2014, ReStud)

Wollmann (2018, AER)

Roadmap of Talk

Motivation

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

How could this happen?

- Lower-margin products that are dropped might be less-expensive.

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 producer welfare.

Motivation II

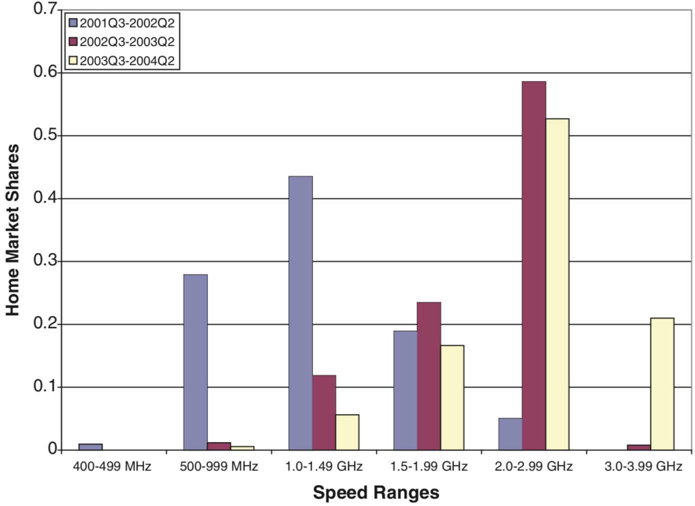

FIGURE 1

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

Empirical Strategy

Estimate model structural model that includes 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 and Tamer (2009).

Model: two stage

1. Firms decide on products, based on *expected* profits.
2. 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.

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

Upper bound on F_j

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

Upper bound on F_j

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

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.

Eizenbergs's Solution

Restrict distribution of ν.

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

Roadmap of Talk

Motivation

Berry and Waldfogel (1999, RAND)

Berry and Waldfogel (2000, QJE)

Eizenberg (2014, ReStud)

Wollmann (2018, AER)

Motivation I

- (This is starting to sound familiar)
- Changes to the competitive environment do not just result in equilibrium price changes, but also product repositioning.
- After a merger, or a closure, product repositioning could create equilibirum price affects that counter the traditional "static" price effects.

Motivation II

- GM and Chrysler bankruptcy and govt. bailout in 2008-2009.
- Multiple different options on the table:
  1. Let them fail.
  2. Govt. fully support.
  3. Allow takeover by competitor.

Commercial Trucks

- Roughly 10% of GM/Chrysler sales.
- Production is much more modular than consumer segment vehicles.
- Assemblers tend to switch product offerings more easily than consumer segment.
- Product introductions dynamic decisions. (sunk costs, different than Eizenberg)
- Set of brands constant, but churn in product offerings.
- Buyers are businesses $\rightarrow$ interesting cyclical variation.

Trucks Data

TABLE 1—SUMMARY STATISTICS

	Min.	Max.	Average over each period 1986–1994	1995–2003	2004–2012
Panel A. Count of product offerings by type					
Light-medium GWR conventional	20	24	21.0	21.7	22.3
Medium GWR conventional	14	27	25.0	20.8	20.4
Heavy GWR conventional	28	36	31.6	33.0	32.9
Light-medium GWR cabover	8	11	10.0	10.3	9.8
Medium GWR cabover	2	12	11.0	8.1	5.1
Heavy GWR cabover	0	8	7.4	1.8	0.0
Compact-front-end (all GWRs)	3	5	3.0	3.3	4.1
Long/extended cab (all GWRs)	9	16	15.4	11.6	9.7
All types	62	85	77.6	75.4	75.7

	Min.	Max.	Average over each period 1992–1994	1995–2003	2004–2012
Panel B. Prices charged and units sold					
Price (in 2005 $)	$70,324	$75,588	$73,075	$73,448	$72,104
Quantity (in 000s of units)	165,678	584,057	286,246	395,879	369,985

Truck Assemblers and the Bailout

- GM, Chrysler, Ford, PACCAR, International major American brands.
- GM and Chrysler – financial distress (also due to consumer segment).
- $85 bil. in government assistance in 2008 and 2009.
- What would have happened if no bailout?
- Aquisition by similar firm, different looking firm, or liquidation?
- (even with liquidation, those factories probably don't disappear)

Dynamic Product Choice is a Massive Problem...

so...

> *Each year we look at demand, what we offer, and what the competition is going to offer. We consider changing the lineup like adding a vehicle … We know who the customers would be, what we can charge, and the production costs—so we have the added margin. The margin over the investment gives a return on capital, and* ***we'll build it when it crosses some threshold*** *(emphasis added).*

Hurdle Rates

Estimation of Sunk Costs

Assumptions

1. “Second-stage” profits are known with certainty.

2. Error that reflects differences between the model’s estimates and true sunk costs and that is observed by the firms can vary only up to the characteristic-year level but no further. (structural errors)

3. All errors are mean independent of objects in the firm information sets.

- Imply there is selection in **how many firms**, not which firms, enter products. (Asm. 2)

- Essentially, condition on situations where we can ignore selection

Selection

- ν_2 are at the time level. (do not vary across firms)
- ν_2 are still *unconditionally* mean zero (like CMT).

Counterfactual I

Table 5—Counterfactual Outcomes

	Product entry and exit ignored			Product entry and exit allowed		
	Ford acq.	PACCAR acq.	Liq.	Ford acq.	PACCAR acq.	Liq.
Markups (percent)						
Most affected model	62.1	23.0	26.9	16.8	15.4	6.2
Most affected vehicle type	53.2	13.0	32.3	9.6	7.6	5.3
Market	10.9	3.0	4.0	0.8	0.5	−0.0
Output (percent)						
Most affected model	−34.4	−18.0	NR	6.7	16.5	8.9
Most affected vehicle type	−30.0	−8.6	−100.0	−63.9	−54.9	−64.7
Market	−5.1	−1.4	−11.2	−1.3	−1.3	−1.6
Compensating variation	119.0	33.0	253.0	22.0	26.0	28.0

Notes: This table compares market outcomes across counterfactual policy choices. The left three columns report predictions from an economic model that ignores product entry and exit. The right three columns report predictions from one that allows for this behavior. The first three rows report markup changes for the most affected model, the most affected product type (averaged over models of the same type), and the market overall (averaged across models). The next three rows are identical to the first three, except that they report output changes rather than markup changes. The final row reports compensating variation (for the counterfactual policy relative to the bailout). NR denotes not relevant. Compensating variation is expressed in millions of 2005$.

Counterfactual II