Applications of Differentiated Products Models

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- Talk 1: Differentiated Products Demand Estimation
- Talk 2: Product Choice and Variety
- Talk 3: "Policy" Applications

Today's Outline

- Intro
- Automobiles
  - 1955 Price War
  - Trade Policy
  - Optimal Firm Policy
- School Choice
- Health Care
- Radio Variety and Quality
  - Background
  - Model
  - Listening Demand
  - Ad Price
  - Bounds on CDF
  - Selection Problem
  - Data
  - Results
  - Conclusion
- Conclusion

Bresnahan's Paper on the 1955 Auto Price War.

Bresnahan '87 [5]

Idea

Test for "collusion" versus Nash price-setting.

Prices lower in the boom year of 1955 as compared to 1954 and 1956. One hypothesis: collusive behavior collapsed in the face of the boom.

Data

For each product (= car), we observe x_{jt}, p_{jt}, and q_{jt}. Such data is readily available from industry-oriented publications (such as *Automotive News* and Ward's.)

Problems include: aggregation of products (optional motors, equipment, etc.), list vs. transaction prices.

Intuition for "Identification"

Bresnahan notes that prices fell most in "competitive" ("crowded") parts of the vertical product space (low-priced cars.) This is consistent with a change to Nash pricing (as a cartel does not care about cross-product competition.)

Vertical Demand

Quality is a parametric index of x, say $\delta_j = exp(x_j beta)$.
Utility is:

$$u_{ijt} = \nu_i \delta_j - p_j$$

with $\nu_i \sim U(0, 1)$.

This gives a demand function

$$q_j = q_j(\delta_j, \delta_{-j}, p_j, p_{-j}).$$

which is "almost linear" in prices because of the uniform assumption on tastes.

"Supply"

Assume a parametric form for $mc(\delta, \theta)$.

Then solve, via brute-force, for equilibrium given either

1. Nash Pricing or
2. Perfectly Collusive pricing

In the system of f.o.c's, this is just a change in the "ownership matrix" Δ in yesterday's

$$s + \Delta(p - mc) = 0,$$

Bresnahan can then:

- Solve for reduced-form p and q
- "Tack on" errors (say they're normal – measurement error?)
- Estimate by MLE under two equilibrium assumptions: Nash in price and collusion.

Given the estimates under the two competing equilibrium assumptions, Bresnahan does a "non-nested" hypothesis test and finds, as conjectured, that collusive pricing fits better in 1954 and 1956, but Nash pricing fits better in 1955!

Critiques:

- The vertical model is way too restrictive. (Maybe better for computers.)
- What identifies demand elasticities when there is no within-year price variation? ("The model").
- The error structure does not allow for unobservables.

Note that we now could "solve for δ" from the demand-side of the vertical model and also estimate from the f.o.c. for price.

BLP 1999

Question of interest: substitution patterns in auto demand; policy issues such as effect of Voluntary Export Restraints (VERs) [1], [2]

- Data: 20 years of public data on p,x,q of approx 100 automobile models per year.
- $u_{ij} = x_j\bar{\beta} - \alpha_i p_j + \sum_k \sigma_k x_{jk}\nu_{ik} + \epsilon_{ij}$
- Costs: $ln(mc) = w\gamma + \psi ln(q_j) + \omega$,
- Equilibrium: multi-product firms, Nash pricing, *mc* parameters estimated from Nash Pricing condition.

The coefficient on price is shifted by income of consumer i, even though no consumer choice data is observed: all this does is shift aggregate demand across the business cycle. Distribution of income is fit to census data.

Econometric issues include simulating the shares, solving for ξ and asymptotics in number of products and/or time (for assymptotics, in products see Berry, Linton, Pakes (2004) [4].

Table 3 from BLP
Results with Logit Demand and Marginal Cost Pricing
2217 observations)

	OLS Logit Demand	IV Logit Demand	OLS $ln(price)$ on w
Variable			
Constant	-10.068	-9.273	1.882
HP/Weight *	-0.121	1.965	0.520
Air	-0.035	1.289	0.680
MP$	0.263	0.052	–
MPG*	–	–	-0.471
Size *	2.341	2.355	0.125
trend	–	–	0.013
Price	-0.089	-0.216	–
No. Inelastic Demands	1494	22	n.a.
(+/- 2 s.e.'s)	(1429-1617)	(7-101)	
R^2	0.387	n.a.	.656

BLP Price Semi-elasticities

% Chg. from $1,000 Incr.

	Mazda 323	Nissan Sentra	Ford Taurus	Buick Century	Lexus LS400	BMW 735i
323	-125.9	1.51	0.85	0.48	0.00	0.00
Sentra	0.70	-115.3	0.90	0.51	0.00	0.00
Taurus	0.06	0.14	-43.6	0.33	0.02	0.00
Century	0.09	0.22	0.93	-66.6	0.03	0.00
LS400	0.00	0.00	0.18	0.07	-11.1	0.08
735i	0.00	0.00	0.17	0.05	0.33	-9.3

Trade Policy

In the VER paper [2], we modify the first-order condition to account for the effects of trade policy and find that, contrary to received wisdom (but consistent with our conversations with GM), the VER's were most binding in the 1980s boom years, not the earlier recession years. On trade policy, see also Goldberg [6], who uses a nested logit and doesn't account for price endogeneity, but who makes important use of some consumer data.

Equilibrium with Quota

Multi-product firms:

$$\pi_{ft} = \Sigma_{j \in \mathcal{J}_{ft}} (p_{jt} - mc_{jt}) M\ s_{jt} + \lambda_f \left(\bar{q}_f - \Sigma_{j \in \mathcal{J}_{ft}} M s_{jt}\right)$$
$$= \Sigma_{j \in \mathcal{J}_{ft}} (p_{jt} - mc_{jt} - \lambda_f) M\ s_{jt}$$

The Lagrange multiplier ends up as a firm/time specific parameter in the "marginal cost" of the firm – just like a firm-specific tariff that has to be estimated.

Note: this means can't also estimate a firm/time dummy in the *mc* equation.

Brambilla looks at Argentina/Brazil free-trade area and adds restriction that *mc* is constant for cars sold in two countries but produced only in one place. This very strong restriction allows her to estimate a richer set of λ parameters describing the trade policy

Findings

- Trade policy more binding during boom, when "quota" appeared to be generous, than in recession when quota limits appeared to be tight.
- U.S. firms benefited
- U.S. consumers hurt
- Overall, an "optimal" quota could maybe give a gain of surplus in U.S.
- But Japanese firms not hurt much either (quota is like a partial cartel)

MicroBLP: Predicted Sales of New Cars

See BLP (2004) [3].
As noted, interactions of consumer characteristics and product characteristics are needed for reasonable cross price elasticities. Now have two such interaction terms.

- Observed consumer characteristics (the z_i) and product characteristics
  (Term is $x_{jk} z_{ir} \gamma_{rk}$.)
- Unobserved consumer characteristics (the ν_i) and product characteristics
  (Term is $x_{jk} \nu_{il} \sigma_{kl}$.)

MicroBLP Data

1. vehicle characteristics, prices, and sales (similar to product level data already in use except of higher quality)
2. household characteristics by vehicle purchased (age, income, family size, . . . broken down by vehicle purchased)
3. second choice vehicles (generated as the reply to the question: "If you did not purchase this vehicle, what vehicle would you purchase?")

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Idea

1. Aggregate sales gives δ_j (product-specific constant)
2. Household data gives γ, parm on z_i / x_j interaction
3. Second choice data gives σ's, parm on random taste coefficients

Single Market

"Second choice" data can generate substitution patterns ("σ's), from the degree to which the consumer interactions are insufficient to explain substitution.

But still have potential problem with the "second stage" regression:

$$\delta_j = x_j\beta - \alpha p_j + \xi_j$$

In the end, calibrate α to other estimates, check for robustness.

Table 6a: Estimates of Interaction Terms, β^o

Vehicle Characteristic	Household Attribute	Full Model	Logit 1^{st}
Price	Constant	−2.18 (0.142)	0.092 (0.0001)
Price	$y_i \times (y_i < 75\ \%)$	0.714 (0.044)	0.299 (0.002)
Price	$y_i \times (y_i > 75\ \%)$	1.17 (0.083)	0.466 (0.091)
Price	Family Size	−0.565 (0.010)	−0.144 (0.001)
Minivan	# Kids	1.973 (0.242)	0.765 (0.098)
# Pass	# Adults	0.203 (0.095)	0.018 (0.0004)
# Pass	Family Size	.536 (0.052)	−0.055 (0.003)
# Pass	Age	0.019 (0.003)	0.002 (0.00001)
Power	Age	−0.002 (0.001)	−0.010 (0.0004)
Access.	Age	0.0004	0.001

Table 6b: Estimates of Interaction Terms, β^u

Parm Name	Full Model	$\beta^o \equiv 0$
Price	0.449 (0.026)	0.055 (0.004)
HP	0.030 (0.016)	.183 (0.020)
Pass	2.74 (0.147)	1.444 (0.055)
Sport	0.002 (0.0004)	2.763 (0.068)
Acc	0.554 (0.078)	0.515 (0.055)
Safe	0.260 (0.130)	0.376 (0.093)
MPG Y	0.488 (0.018)	0.430 (0.017)
Allw	0.740 (0.179)	0.431 (0.049)
Miniv	4.787 (0.353)	6.641 (0.113)
SU	3.076	3.231

Table 11: Discontinuing the Oldsmobile Division

	Old Share	New Share	New-Old Share
All Oldsmobiles	.237	0	-.237
All GM	3.126	3.016	-.110
All Cars	9.711	9.695	-.016
Non-Olds Share Changes.			
Chevy Lumina	0.1354	0.1548	0.0194
Buick LeSabre	0.1216	0.1336	0.0120
Pontiac Grand Am	0.1322	0.1441	0.0119
Honda Accord	0.2955	0.3039	0.0084
Ford Taurus	0.2040	0.2115	0.0075
Saturn SL	0.1465	0.1539	.0074
Toyota Camry	0.2343	0.2415	0.0072
Buick Century	0.0614	0.0683	0.0069
Pontiac Grand Prix	0.0517	0.0584	0.0067
Chevy Cavalier	0.1700	0.1767	0.0067
Pontiac Bonneville	0.0658	0.0721	0.0064

Parental Preferences and School Competition

Hastings et al., NBER WP #11805

Idea

Schools as differentiated products

- Public school choice is becoming increasingly prevalent
- Competitive pressures to improve under school choice depend on preferences, distribution in population
- Good schools compete over broad geography for high-income students, leaving local "monopolists" to serve inelastic poor communities with little demand-side incentive to improve.

Background

- Detailed administrative data from Charlotte-Mecklenburg School District (CMS)
- School Choice Policy Intervention in 2002
- End of race-based bussing for integration Results in large redistricting

Random Coefficients Logit Model

Interactions between "consumer" (student/family) attributes and "product' (school) characteristics. Distance, education interacted with quality, race of child with race of school, etc.

Ranked Choice Data

CMS asked for top 3 choices for school assignment. Great for identification of random coefficients.

Previous Literature

Large literature has used cross regional comparison of measures of school district, regressing "concentration" on measures e.g. Hoxby (2000).

Much like the anti-trust literature. Which schools are in the same "market" when income, distance, race matter?

"Not clear what HHI measures outside of homogeneous goods, symmetric firm, Cournot equilibrium"

Findings

- Mean preferences for academics are increasing in income and student baseline academic ability; variation in preferences across races can be explained by differences in income
- Idiosyncratic preferences for academics vary as much as mean preferences do with observable characteristics
- Idiosyncratic preferences for academics and school proximity are negatively correlated
- those who value academics are willing to drive over broad geography to get kids to better schools.

Incentives for School

School choice will lead to disparate demand-side pressure to improve quality across schools serving low vs. high socio-economic families.

"Vertical separation" instead of "tide that lifts all boats."

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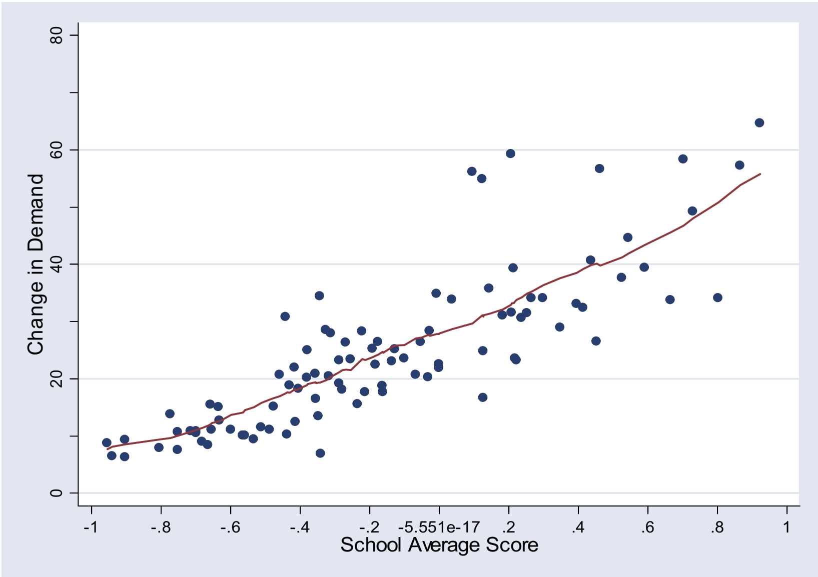
"Vertical separation" instead of "tide that lifts all boats."

Graph: simulate change in expected number of students listing a school as their first choice if it were to increase its average test scores by 0.33 standard deviations (approx. 10 percentile points)

Simulations: 0.34 *dQ/dS versus Ave.Score



Example

- Hospital demand and mergers
- Health Maintenance Organization (HMO) Mergers
- Adverse Selection

Josh Lustig: "The Welfare Effects of Adverse Selection in Privatized Medicare," Yale 2007 job market paper.

Lustig on Medicare HMOs

$$u_{ijft} = \sigma_1 \nu_{i1} g_{jft} + (z_t \gamma + \sigma_2 \nu_{i2}) \, p_{jft} + \xi_{ft} + \epsilon_{ijft}$$

where

- quality $g = x_{jft}\beta$
- ξ is restricted to be firm, not product, specific
- costs depend on the "taste for quality" (this might be *health*)

Lustig, cont.

1. Estimate demand. Instruments are characteristics of firms.
2. Take first order conditions with respect to price and quality to estimate costs.
3. Big question of Adverse Selection: to what degree does taste for quality also increase costs.
4. Intuition: changes in market structure that give "more choices" make the selection problem worse (no selection with only one choice.)

If one could "remove" effects of adverse selection, welfare would increase, especially in markets with many choices. Problem of adverse selection increases as benefit of price competition increases.

Lustig, cont.

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Findings

- If one could "remove" effects of adverse selection, welfare would increase, especially in markets with many choices.
- Problem of adverse selection increases as benefit of price competition increases. Trade-off?

Optimal Product Variety in Radio Markets

Steven Berry, Alon Eizenberg and Joel Waldfogel, in process 2007.
In this paper, we present a model of entry into a discrete product space that allows for point estimates of the parameters of variable profits and bounds on fixed costs.

Applying this model to the Radio Industry, we consider optimal product variety in terms of the number of stations in different radio formats ("rock", "country", etc.)

Extensions include: vertical quality, joint ownership, merger analysis.

Background on Radio

- There is a long theoretical literature on the inefficiency of free entry into oligopolistic markets. New firms "steal business" from existing firms: a negative externality. Lower prices for existing consumers and the intro of new varieties create an offsetting positive externality.
- Excessive entry into radio industry has often been suggested.

Berry and Waldfogel, 1999

They use new data and simple methods to estimate the extent of and welfare loss from excess entry in radio broadcasting.

Results from BW '99

- First, look only at market participants: broadcasters advertisers. Welfare loss from free entry, as opposed to the socially optimum N, is 40% of industry revenue. A big number?
- There is still the positive externality to listeners. If listeners value an hour of listening at about 15 cents an hour, then welfare loss to market participants would be just offset by external benefit to listeners.

But they had to assume symmetric stations, no differentiation by format, etc.

Semi-Parametric Bresnahan & Reiss

Berry and Tamer (2007): For symmetric post-entry firms, estimate function

$$V(N_t, x_t, \theta)$$

from data on market outcomes.
Then have bounds on fixed costs F_t, without any parametric restriction on the distribution of F:

$$V(N_t, x_t, \theta) > F_t > V(N_t + 1, x_t, \theta)$$

BUT, post-entry symmetric firms is very, very strong.

Benefits of Variety

- The introduction of new varieties can reverse the finding of excess entry.
- And radio stations offer a variety of "formats".
- Berry and Waldfogel '99 found that as population increases, additional stations are often in existing formats.
- Most likely problem of *insufficient* entry would occur when there are ZERO stations in a given market.

Variety and Multiple Equilibria

- Can easily introduce variety into the post-entry variable profits model (e.g. BLP, nested logit, etc.), although "product characteristics" can now be endogenous.
- BUT: often lose unique equilibrium
- Example: for 2 varieties (N_1, N_2), both (2,1) and (1,2) might be equilibria.
- This is why Berry & Waldfogel assumed symmetry: otherwise can't estimate via MLE.

Estimation with Multiple Equilibria

- Sutton argues that the general problem means we can't "estimate" models of equilibrium market structure with rich product variety
- Manksi argues in favor of "bounds" methods
- Here, we use a simple extension of the "semi-parametric" B & R bounds, avoid estimating the distribution of F altogether.
- Much simpler than current, general econometric method, but very example-specific.

Outline of Model

1. Stations produce listeners, who make a free choice as to listening. Listeners care about format and within format stations are more "similar". Formally, use nested logit.
2. Stations sell listeners to advertisers. Advertisers' demand is downward sloping in the share of the population who listen. Simple constant elasticity functional form.
3. There is free entry into a discrete product space (formats) and a static Nash equilibrium. No unique equilibrium: entry problem is no longer a Bresnahn-Reiss style ordered probit.

(1) and (2) give variable profit function, (3) adds fixed costs.

Observed Data and Variable Profits

No Variable Cost (but add endogenous fixed cost of "quality" later).

In market t, format k, We observe:

- ad price p_t,
- format share s_{kt},
- stations numbers N_{kt},
- market demographics x_t,
- population M_t.

At observed vector N_{kt}, observed variable profits are

$$V_{kt} = p_t(s_t)M_t s_{kt}$$

At market outcome, variable profit V_{kt} is just observed revenue, R_{kt}.

Counter-Factual Variable Profits

To create bounds on fixed cost, also need variable profits at $N_{kt} + 1$.

To get this counter-factual, need to

1. Estimate model of listening demand $s_{kt}(x_t, N_{kt}, N_{-k,t}, \theta_d, \xi_{kt})$,
2. Estimate model of Advertising Price $p_t(x_t, s_t, \omega_t, \theta)$.

How to Model the Product Space

- **"Ex-Ante" vs. "Ex-Post"**
- **Continuous vs Discrete**

Here

we use ex-ante identical entrants into a discrete space of product "segments".

The Model of Listening.

- Within format, stations are symmetric post-entry, but each new station brings some unique benefit.
- Motivate functional form for listening equation via nested logit utility function for listeners.
- Simplest Nested Logit nests only on formats. Also look at two level nests: listen/don't listen and then format.
- Natural extension is to BLP-style demand with random coefficients logit (see Sweeting, 2007).

Simplest Nested Logit

Utility to listener i tuned to station j in format k in market t is

$$u_{ijt} = \delta_{kt} + \nu_{ikt}(\sigma) + (1-\sigma)\epsilon_{ijt},$$

with

$$\delta_{kt} = x_t\beta_k + \xi_{kt}$$

where

- δ_k is the mean taste for format k,
- ν_{ikt} is a random variable that introduces correlated tastes within format, parameterized by σ,
- ϵ is an station/listener i.i.d. match component,
- x_t are market attributes (demographics),
- ξ_{kt} is an unobserved (to us) taste for the format in this market,
- β_k is a format specific parameter.

Format Nests

For the one-level-nest models, the estimation equations are derived as

$$ln(s_{kt}) - ln(s_{0t}) = x_{kt}\beta_k + (1-\sigma)ln(1/N_{kt}) + \xi_{kt}.$$

Complications:

- Note the endogeneity of RHS N_{kt}.
- We let the mean utility levels (and the ξ's) vary by "in" and "out" metro stations.
- The two-level nests (e.g. "formats" and "in/out" of listening) add an additional parameter ρ that captures the correlation within the upper level nest.

Endogeneity

.

For the endogenous "within nest share", three main instruments are used:

- population (exogenous, and correlated with N)
- number of out-metro stations, N^2, (assumed exogenous)
- number of out-metro stations in the same format

Demand from Advertisers

We treat stations as “producing” listeners and then selling them to advertisers. For now, a very simple inverse ad-demand function.
The demand from advertisers for listeners in market t is modeled by a downward-sloping, constant-elasticity specification:

$$ln(p_t) = x_t\alpha - \eta ln(s_t) + \omega_t$$

Popl. and out-metro stations are instruments for endogenous share. Might be able to have this vary by format / demographic, but data is pretty bad for this.

Equilibrium in Product Segments

Once we have listening demand and the (inverse) advertising demand equation, we have estimated variable profits.

Segment Fixed Costs

To recover fixed-costs (constant across products within segments) need to have a model of equilibrium market structure.

Static Complete Info Nash

A good assumption for work that relies on the cross-sectional nature distribution of market structure. With no explicit dynamics, we would like firms to choose the best-response to ival's actions – otherwise why don't they move? Justification for cross-sectional study is [i] population and demographics are strong instruments and [ii] firms are in "long-run" equilibrium.

In a dynamic model, some private info makes more sense – firms might be surprised to find themselves in a bad location and then move away.

Similar Models

- Bresnahan and Reiss looked at symmetric entry, ex-post differentiation,
- Reiss and Spiller, Berry and Waldfogel estimated variable profits outside the entry model,
- Mazzeo considered discrete product segments ("quality") and ex-post differentiation, needs strong assumptions on order to get unique equil.
- Seim uses private info
- Manski – use incomplete models, maybe get bounds.
- Iishi, Iishi-Ho-Pakes-Porter – similar ordered models plus bounds estimation.

Bounding the Distribution of Fixed Costs

Complete Info Static Nash Equilibrium

- No variable costs. F has to be less than observed revenue.
- Also, F has to be greater than counterfactual revenue at $(N_{kt} + 1)$.
- Construct counterfactual revenue from listening demand and ad-price equation (including values of unobservables.)
- Can't do this for markets with $N_t = 0$; selection discussed below.

Upper Bound on F

We know that

$$R_{kt} > F_{kt}$$

This provides an upper bound for F, making only the assumption that R and F are constant within segment.

Further, the empirical CDF of R_{kt} is a lower bound to the empirical CDF of F across sample markets.

If we further assume the market data (and F) are i.i.d. across markets, then the true CDF of R_{kt} is a lower bound to the true CDF $\Phi(F)$. Or could estimate "non-parametric" $\phi(F\ X)$.

Lower Bound on F

In equilibrium,

$$V_k(N_{kt}+1, y_t, x_t, \theta_0) < F_{kt}.$$

This provides an lower bound for F_k, again making only the assumption that R and F are constant within segment k.

Further, the empirical CDF of $V_k(N_{kt}+1, y_t, x_t, \theta)$ is an upper bound to the empirical CDF of F across sample markets.

Again, if we further assume that F is i.i.d., then the true CDF of $V_k(N_{kt}+1, y_t, x_t, \theta)$ is an upper bound to the true CDF $\Phi(F)$.

Sampling Error of the Bounds on F

If we want to do within market prediction, holding all market characteristics fixed, then the upper bound R_t has no sampling error (except from the Arbitron survey) and the estimated lower bound $V(N_t + 1, y_t, x_t, \hat{\theta})$ has sampling error only from $\hat{\theta}$.

If we think of the estimate of $\Phi(F)$, then sampling variance comes both directly from the sampling error in estimating the empirical CDFs of R and $V(N_k + 1)$, but also again from $\hat{\theta}$.

Selection Problem

Big problem: sometimes $N_{kt} = 0$, so don't see S_{kt}, p_t, etc.

Problem for

- Estimating Listening equation,
- Calculating Upper and Lower bounds on CDF

Selection in Listening Equation

Difficult problem: multivariate selection on ξ's & F's of all formats, without any known selection rule (possible multiple equilibria).

Solution: estimate only on markets where probability $N_k > 0$ is one. Here assuming (reasonably) a bound to the support of F. There is zero probability that a market the size of New York will have no rock station. Market with large enough Hispanic population will certainly have a "Hispanic format" station.

This solution is worse the finer is the definition of format. Intermediate solution: formats that vary in observables, but share an unobservable ξ.

Selection and Bounds on Φ

Assume that the support of R_k is independent of x. For a lower bound, construct

$$\tilde{R}_{kt} = \begin{cases} R_{kt} & \text{if } N_{kt} > 0 \\ \bar{R}_k & \text{if } N_{kt} = 0 \end{cases}$$

Where $\bar{R}_k$ is largest R_k in the "large" markets not subject to selection. The distribution of $\tilde{R}_t$ is a possible lower bound on Φ.

Similar idea when can't compute $V(N_t + 1)$ – replace with $\underline{F}_t$.

Data Sources

A cross-section of metropolitan radio markets. The market definitions are those of Arbitron (close to MSA definitions) Data from

- *American Radio, By Duncan's American Radio, Spring 2001* – Arbitron's listening figures for its 286 metro markets. Use Average Quarter Hour listeners
- Duncan's Radio Market Guide, 2001-02 Editions. – market-level revenue estimates. There are some problems with these. Also – market demographics (% black, ave. income, college, etc.)
- For now, 163 markets. Can probably expand to 200.

Summary Stats

Table A1: Description of Market-Level Data

Variable	Units	Mean	Std. Deviation
Share in-metro	%	0.111	0.026
Share Out-metro	%	0.015	0.023
N1 (in-metro)	integer	19.577	7.557
N2 (out-metro)	integer	7.184	8.299
Population	millions	1.016	1.687
Ad Price	$	570.480	237.653
Income	10,000$	4.584	0.860
College	%	21.200	5.370

Statistics computed over the 163 markets for which we have full data

Table 1: 10-format configuration

Format Group	Formats Included				
"Mainstream"	Adult Cont. Classic Hits	Hot AC 80s Hits	Modern AC	Soft AC	Adult Altern.
CHR	CHR				
Country	Country	Classic Cntry.	Trad. Country		
Rock	Rock	Active Rock	Modern Rock	Classic Rock	
Oldies	Oldies				
Religious	Religious	Cont. Christ.	Black Gospel	Gospel	S. Gospel
Urban	Urban	Urban AC	Urban Oldies	Rhythmic Old	
Spanish	Spanish Span.-Cl. Hits Span.-Talk Ranchero	Span.-Oldies Span.-EZ Tejano Romantica	Span.-Adult Alt Span.-Hits Tropical	Span.-C. Christ Span.-NT Reg'l Mex.	Span.-CHR Span.-Relig. Span.-Stand.
News/Talk	News/Talk Sports	News Farm	Talk	Hot Talk	Bus. News
Other	Variety Pre-teen A30 Dance	Bluegrass Ethnic N Classical	Blues Silent N A Adult Stand.	cp-new A22 Jazz Easy List.	Americana A26 Smooth Jazz

Format Presence

Table 2: Format Numbers

Format Group	Frequency	Mean N	Max N	Mean format share
Mainstream	100.00%	4.48	11	2.31%
CHR	93.25%	1.66	6	1.16%
Country	99.39%	2.99	9	1.85%
Rock	100.00%	3.42	9	1.88%
Oldies	98.16%	1.48	5	0.79%
Religious	79.75%	1.88	6	0.37%
Urban	73.62%	2.10	6	1.24%
Spanish	40.49%	1.63	15	0.40%
News/Talk	100.00%	4.31	13	1.55%
Other	94.48%	2.80	9	1.09%

Table 3: Comparing listening models

	In/Out	Formats	2-level
in-market	0.1333**	0.6388**	0.1325**
	[0.0248]	[0.0829]	[0.0253]
hispXspan	0.0095	0.3519**	0.0192
	[0.0075]	[0.0358]	[0.0135]
blackXurban	0.0238*	0.5057**	0.0378*
	[0.0100]	[0.0506]	[0.0191]
southXreligious	0.0555**	0.8091**	0.0768*
	[0.0206]	[0.0953]	[0.0323]
southXcountry	0.0087	0.3164**	0.0181
	[0.0159]	[0.0721]	[0.0194]
σ	0.9043**	0.5192**	
	[0.0188]	[0.0630]	
Upper level corr			0.886
			[0.028]**
Lower level corr			0.167
			[0.163]
Observations	1919	1919	1919
Adjusted R-squared	0.9851	0.7199	0.9846

Uninteracted demographics, format dummies and region dummies not shown

Selection Solved via sue of Large Markets?

We are in the process of looking at robustness to various means of solving for selection – so far choice of method does not greatly change result.

Following graphs (and probits not presented here) demonstrate that large markets almost certainly have $N_k > 0$. (Although "religious format" may still be a problem.)

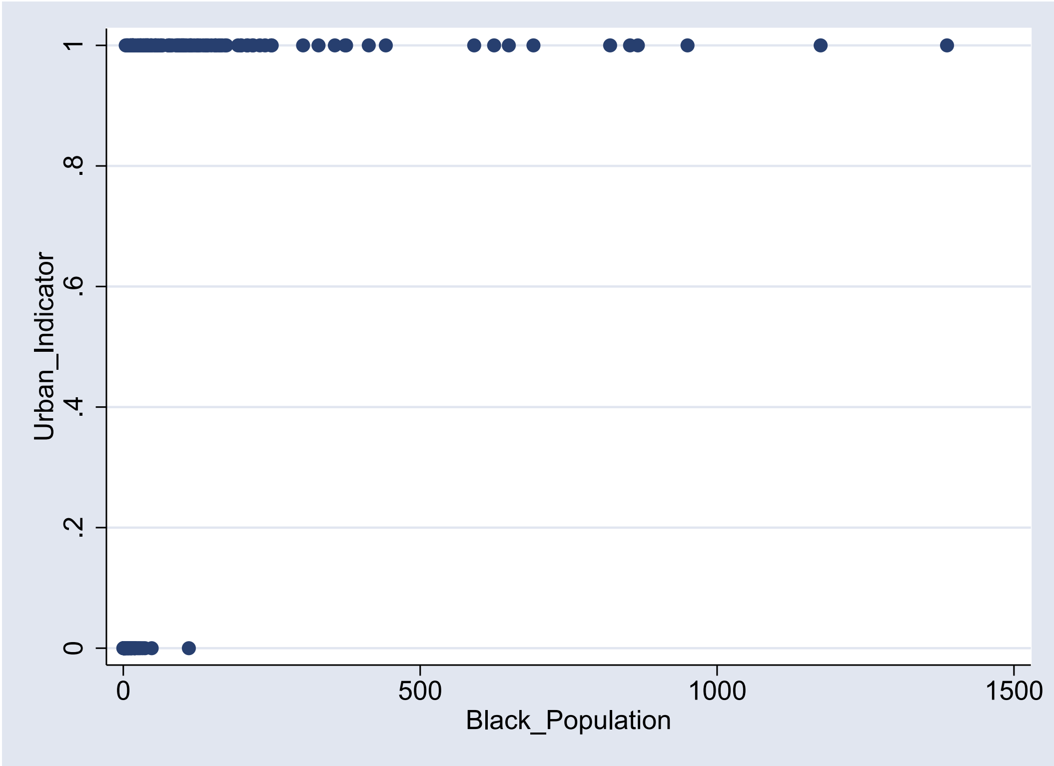

Figure: Presence of Urban Station Plotted against Black Metro Population, in 1000s (NYC Excluded)

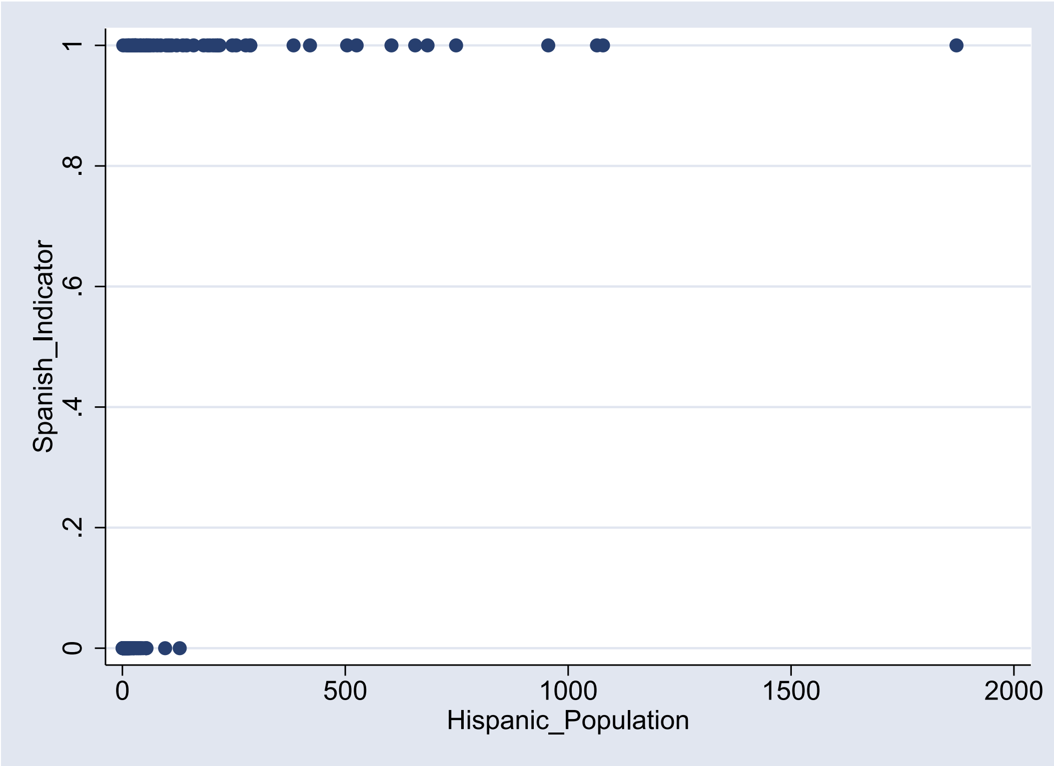

Figure: Presence of Spanish Station Plotted against Hispanic Metro Population, in 1000s (NYC, LA Excluded)

Table 7: Ad Price Equation

	IV Coeff	SE
northeast	-0.0739	[0.0645]
midwest	0.0799	[0.0609]
south	0.0132	[0.0602]
income	0.0606	[0.0302]
college	0.1639	[0.0434]
black	-0.0242	[0.0208]
hisp	-0.0124	[0.0138]
η	0.5101	[0.0737]
Constant	4.5537	[0.1885]
Observations	163	
Adjusted R-squared	0.4929	

Instruments are Population, N_2

Estimated Bounds

We graph these by format.
Preliminary, and we ought to

- Provide Confidence Regions
- Show robustness to treatment of formats, etc.
- Allow distributions to vary with x_t
- Add quality choice (perhaps reduce within segment spread of F)

Could also consider a parametric, multivariate dist. of F.
(Technique more difficult.)

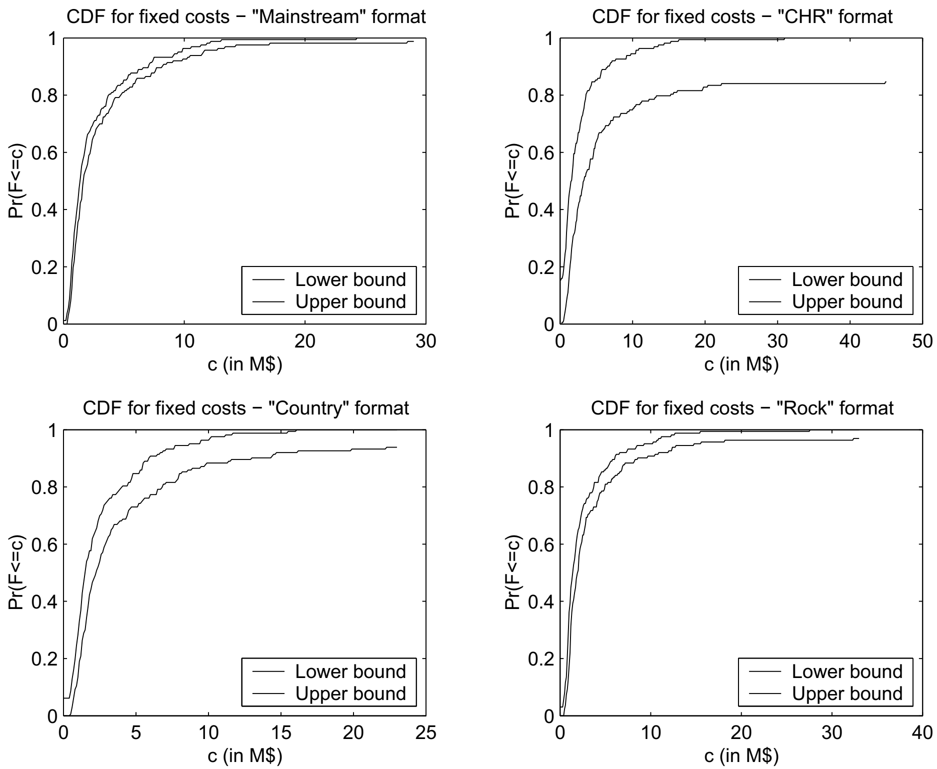

Figure: Estimated bounds on the CDF of fixed costs

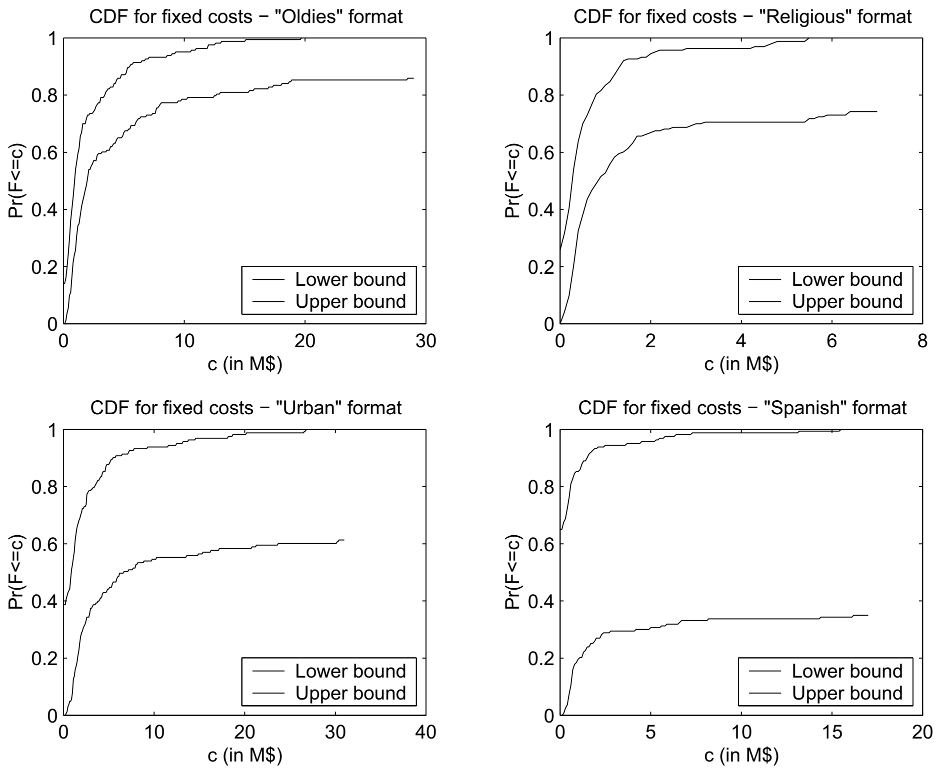

Figure: Estimated bounds on the CDF of fixed costs

Optimal N

Once we have θ and bounds on F, we can place bounds on the optimal number of stations.
Caveats:

- As in B-W '99, we can only look at the welfare of market participants – producers (stations) and consumers (advertisers). Listeners are an unpriced input, who do receive social value.
- Easiest is to hold F at mid-point of the bounds for the market, and then get point estimate of optimal N vector.
- But can also use bounds on F to create bounds on N vector.

Table 9: Comparison of Observed and Optimal Mean Number of In-metro Stations

Format	Observed	Optimal	Percentage Difference
Mainstream	3.35	1.38	0.59
CHR	1.06	0.85	0.20
Country	2.10	1.05	0.50
Rock	2.33	1.09	0.53
Oldies	1.02	0.88	0.14
Religious	1.66	0.81	0.51
Urban	1.50	0.72	0.52
Spanish	1.34	0.60	0.56
News/Talk	3.08	1.35	0.56
Other	2.12	1.07	0.50
Sum	**19.58**	**9.79**	**0.50**

Bounds on Optimal N

The last table used the mid-point of the market-specific bounds on F. It is better to use the bounds themselves.

With an interesting number of formats, there is a non-trivial computational problem in finding optimal N's.

We can get a upper bound on optimal N_k by setting F_k to its market-specific lower bound and for all other formats $(r \neq k)$ setting F_r equal to its upper bound.

The per-market bounds on F are tight enough that it doesn't matter that much. (See the following table).

Observed vs. Optimal Mean Number of In-metro Stations

Format	Observed	Optimal (low)	Optimal (upp)	Optimal ("mid interval")
Mainstream	3.35	1.29	1.60	1.38
CHR	1.06	0.85	0.86	0.85
Country	2.10	0.99	1.10	1.05
Rock	2.33	1.01	1.21	1.09
Oldies	1.02	0.85	0.88	0.88
Religious	1.66	0.75	0.90	0.81
Urban	1.50	0.68	0.77	0.72
Spanish	1.34	0.54	0.67	0.60
News/Talk	3.08	1.22	1.56	1.35
Other	2.12	1.01	1.19	1.07
Sum	**19.58**	**9.20**	**10.75**	**9.79**

Comparison

These are about 50% reductions in stations, compared to 75% in Berry-Waldfogel '99. Adding quality may change this further (which direction?)

And, need to add benefit to listeners

Extensions

- Consider product segments as quality (high, low) plus format. Have to observe "quality" – based on observed station quality (e.g. wattage) and/or mean utility, δ, in station-specific listening equation.
- Consider multi-product firms – now counter-factual profit of one more or one fewer station has to consider effect on jointly owned stations.
  - Let distribution of fixed costs include an economy of joint-ownership,
  - Consider mergers and anti-trust policies toward mergers,
  - Because of bounds on F – will only get bounds on optimal policies.

Extension to Quality segments

How to meaure quality. In terms of x – power in watts? Or in terms of discretized estimated "quality", δ, from demand?

We are working on a quality model that keeps unobservable market tastes for formats, but not market-specific tastes for "quality". "Panel data" structure helps with the endogeneity of quality in the first-stage listening equation. In other market, quality is better measured, here, might try to estimate a station-specific discrete quality level (remaing error is Arbitron sampling error.)

Extension to Multi-Product Firms

Do Multi-product firms have lower costs?

Bounds now need counter-factual effect on other stations in the market.

Also, need to actually estimate (bounds on) distribution of fixed costs.

Bounds on Multiproduct Firms

Condition for "entry" to be profitable is now:

$$R_{kt} > F_{kt} + \left(\sum_{k' \in Z_k} [R_{k't}(N_{k't}, N_{kt} - 1) - R_{k't}] \right)$$

Conclusion for Radio Project

- Dealing with interesting horizontal and vertical variety is now feasible
- In radio, adding horizontal variety in formats means that "optimal" reduction in the number of stations goes from 75% to 50%
- Extensions include radio "quality" and multi-product firms

Overall Conclusion

Highest marginal return may be not to complicated new methods, but to applications that are

- interesting,
- important,
- well matched to market and policy.

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