An Empirical Analysis of Strategic Pricing and Advertising for Differentiated Products

Evidence from the U.S. Margarine and Butter Industry

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Objectives

- Test advertising effects:
  - "cumulative" property
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- Test strategic behaviors on price and advertising in a differentiated market

- Estimate the price and advertising elasticity of demand for leading brands of margarine and butter industries. Investigate the degree of market power.

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- Adopt a fully flexible representative consumer model based on nonlinear Almost Ideal Demand Specification (AIDS) and structural first-order conditions for profit maximization.

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  - Gasmi, Laffont, and Vuong (1992) [GLV]: a linear demand, but static advertising
  - Vilcassim, Kadiyali, and Chintagunta (1999) [VKC]: a tow-period linear demand, but static advertising

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  - Different advertising media may have different impacts on the demand system.
  - Advertising may have dynamic effects whereas advertising in GLV and VKC is static.

Demand and Advertising

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- The effects of advertising in the AIDS setting include *shifting* and *rotating* demand curve, which preserve the spirits of the linear theoretical model in Wang and Stiegert (2003).

Demand Specification: AIDS and Goodwill

- For brand i, city l, and time t, advertising goodwill is given by

$$G_{ilt} = \rho_i G_{ilt-1} + A_{ilt}$$

where G_{ilt} is advertising goodwill, ρ is retention rate of advertising goodwill, and A_{ilt} is effective advertising awareness, defined by

$$A_{ilt} = \sum_{m=1}^{M} \varphi_m \ln(a_{milt} + 1)$$

where a_{milt} is dollar expenditure of advertising of medium m, and φ_m is the awareness-to-cost index of medium m

- Consider aligned AIDS

$$
\begin{aligned}
w_{ilt} &= \alpha_{0i} + \sum_{k=1}^{K} \lambda_{ik} Z_{klt} + \sum_{j=1}^{N} \theta_{ij} G_{jlt} + \sum_{j=1}^{N} \gamma_{ij} \ln(p_{jlt}) \\
&+ [\beta_i \ln(M_{lt}) - \beta_i \ln(P_{lt})] + \varepsilon_{ilt}
\end{aligned}
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\ln(P_{lt}) &= \delta + \sum_{m=1}^{N} \alpha_m \ln(p_{mlt}) + \sum_{m=1}^{N} \sum_{k=1}^{K} \lambda_{mk} Z_{klt} \ln(p_{mlt}) \\
&+ \sum_{m=1}^{N} \sum_{j=1}^{N} \theta_{mj} G_{jlt} \ln(p_{mlt}) + \frac{1}{2} \sum_{m=1}^{N} \sum_{j=1}^{N} \gamma_{mj} \ln(p_{mlt}) \ln(p_{jlt})
\end{aligned}
$$

Firm's Objective Function

- Firm h's profits

$$\pi_h = \sum_{t=0}^{\infty} D^t \left\{ \sum_{i=1}^{n_h} \left[(p_{it} - c_{it}) X_{it} - \sum_{m=1}^{M} a_{mit} - U_i \right] \right\}$$

Brand i of firm h faces demand function $X_{it} = X_{it}(p_{it}, p_{-it}; G_{it}, G_{-it})$, where $X_{it}(\cdot)$ can be derived from AIDS.

$\because w_{it} = p_{it} X_{it} / M_t$.

First-Order Conditions

- The first-order conditions in price are given by

$$X_i = -\sum_{k=1}^{n_h} \left[(p_k - c_k) \sum_{j=1}^{N} \frac{\partial X_k}{\partial p_j} \frac{\partial p_j}{\partial p_i} \right], \ \forall i, h.$$

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- The first-order conditions w.r.t. goodwill are

$$\sum_{k=1}^{n_h} \left[(p_k - c_k) \sum_{j=1}^{N} \frac{\partial X_k}{\partial G_j} \frac{\partial G_j}{\partial G_i} \right] = (1 - D\rho_i) \sum_{m=1}^{M} \frac{(a_{milt} + 1)}{\varphi_m}, \forall i, h.$$

LIML Estimation

- Limited Information Maximum Likelihood (LIML): Estimate Demand System first, then estimate first-order conditions.

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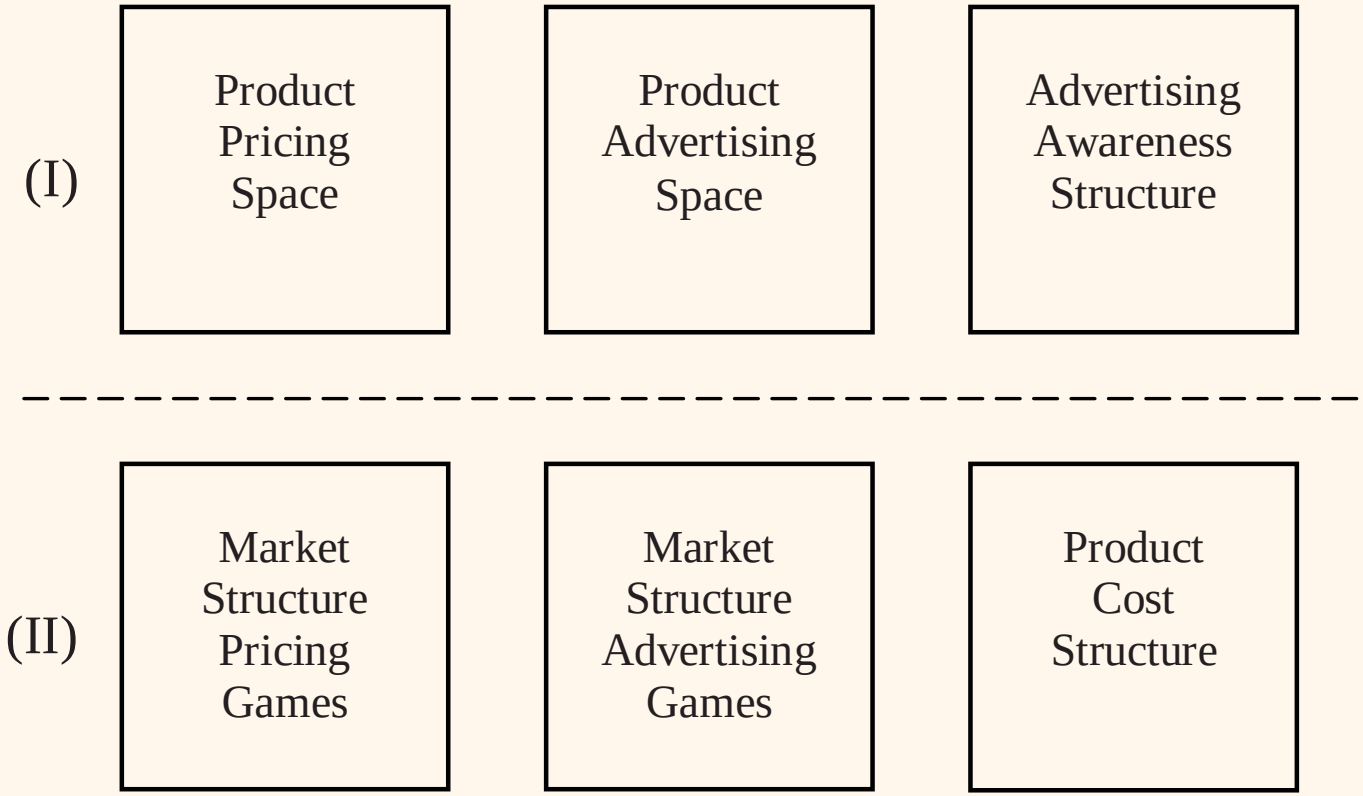
  - in the first stage the demand and advertising equations are estimated
  - the parameters estimated in the first stage are used in a second stage estimation of the first-order conditions in price and advertising.

LIML Estimation



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Step I: Use the Vuong test (VT), Akaike Information Criterion (AIC), and Schwarz Information Criterion (SIC) to determine the best fitted among non-nested models.

Step II: From the best fitted model, estimate the CV parameters and use the Wald test to test different combinations of non-cooperative strategies, including Bertrand, Stackelberg leader, Stackelberg follower, and consistent conjectures.

Table 1 (b) Number of CV Parameters in Each Model

Number of CV		Advertising								
		D0	D1	D2	D3	D4	C1	C2	C3	C4
Price	D0	84	82	82	82	78	72	72	82	64
	D1	82	80	80	80	76	70	70	80	62
	D2	82	80	80	80	76	70	70	80	62
	D3	82	80	80	80	76	70	70	80	62
	D4	78	76	76	76	72	66	66	76	58
	C1	72	70	70	70	66	60	60	70	52
	C2	72	70	70	70	66	60	60	70	52
	C3	82	80	80	80	76	70	70	80	62
	C4	64	62	62	62	58	52	52	62	44

Note:
D0: each brand operates independently
D1: brand 1+brand 2
D2: brand 2+brand 3
D3: brand 1+brand 3
D4: brand 1+brand 2+brand 3
C1: D4+brand 4
C2: D4+brand 5
C3: brand 4+brand 5
C4: D4+brand 4+brand 5

Data Sources

- The main data set from Information Resources, Inc. (IRI) consists of different measures of sales and prices, and in-store marketing activities. The information is from retail store scanners for 28 cities across the United States and 58 periods based on 4-week interval from January 1998 to June 2002.

- CMR advertising data include national and local monthly data from January 1998 to December 2002. The information consists of units and dollars of advertising expenditure.

- Demographic data: Current Population Survey (CPS)
  Initial Goodwill: COMPUSTAT

Market Shares, Advertising Share, and Advertising-Sales Ratio

Brand Name	Market Share %	Advertising Share %*	Advertising-Sales Ratio
BR1	10.67	13.83	0.0492
BR2	16.22	10.21	0.0426
BR3	7.57	12.29	0.1042
BR4	15.69	10.41	0.0391
BR5	13.42	10.78	0.0177
All Others	12.48	42.48	0.0912
Private Labels	23.95	N/A	N/A

* Advertising of Private Labels is not included.

Advertising Expenditure by Media Category

Category / Media		Type	Frequency	Expenditure*	%
TV			**7,296**	**307,292**	**79.46**
	Spot TV	Local	6299	17,806	4.61
	Cable TV	National	390	62,666	16.20
	Network TV	National	319	169,692	43.88
	Syndication	National	288	57,128	14.77
Radio			**154**	**8,667**	**2.24**
	Spot Radio	Local	113	1,328	0.34
	Network Radio	National	41	7,339	1.90
Print			**540**	**70,779**	**18.30**
	Newspapers	Local	216	2,231	0.58
	Magazines	National	239	64637	16.71
	National Newspapers	National	13	673	0.17
	Sunday Magazines	National	28	2,533	0.66
	Outdoor	Local	44	705	0.18
Total			**7,990**	**386,738**	**100.00**

* Thousand dollars.

Empirical Results

- Advertising Effects
  - Test if the retention rate $\rho = 0$ to see whether advertising has long-lived effects that cannot be adequately captured in a static framework.
  - Test if the homogeneous consumer response holds, $\varphi_1 = \varphi_2$.

- Model Selection: The interactions of firms' decisions in pricing and advertising are identified.

- The price and advertising elasticities and Lerner Indexes are obtained.

Advertising Effects

Retention Rate Matrix

Brands	Estimates
BR1	0.0007 (0.3944)
BR2	**0.9897** (0.0044)
BR3	**0.5855** (0.1120)
BR4	**0.9533** (0.0159)
BR5	**0.9578** (0.0105)
AO	0.0039 (0.5175)
PL	**0.9492** (0.0066)

Awareness-to-Cost (ATC) Index

Media	Estimates
TV & Radio	**0.8395** (0.1016)
Print	0.0169 (0.0100)

Note:
(1) Standard errors are in the parentheses.
(2) Highlighted numbers are significant at the 5% level of significance.
(3) BR1~BR5: Brand 1~Brand 5, AO: All Others, PL: Private Labels.

Market Power

Estimated Lerner Index

Brands	Model 9	Bertrand
BR1	0.5115 (0.0078)	0.3379 (0.0028)
BR2	0.5444 (0.0096)	0.3077 (0.0023)
BR3	0.5376 (0.0044)	0.3737 (0.0017)
BR4	0.5394 (0.0079)	0.6551 (0.0057)
BR5	0.4779 (0.0046)	0.6117 (0.0034)
AO	0.595 (0.0074)	0.7092 (0.0041)
PL	0.5206 (0.0081)	0.7242 (0.0044)

Note:
(1) BR1~BR5: Brand 1~Brand 5, AO: All Others, PL: Private Labels.