

# Beyond Price Competition: Evidence of Semi-Collusion from the U.S. Butter and Margarine Industry

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  - heterogeneous vs. homogeneous consumer responses
- Test strategic behavior on price and advertising in a differentiated market.
- Estimate the price and advertising elasticities of demand for leading brands of margarine and butter industries. Investigate the degree of market power.

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- The analysis of strategic behavior of firms using a structural model is widely used in the New Empirical Industrial Organization (NEIO) literature.
- Adopt a fully flexible representative consumer model based on nonlinear Almost Ideal Demand System (AIDS) and structural first-order conditions in price and advertising for profit maximization.



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- Semi-collusion
  - Fershtman and Gandal (1994) and Brod and Shivakumar (1999): R&D (or capacity) competition and price collusion

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  - d'Aspremont and Jacquemin (1988) and Kamien, Muller, and Zang (1992): R&D collusion and price competition

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a linear demand, but static advertising
  - Vilcassim, Kadiyali, and Chintagunta (1999) [VKC]:  
a two-period linear demand, but static advertising

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  - Different advertising media may have different impacts on the demand system:  
Yiannaka, Giannakas, and Tran (2002)
  - While advertising in GLV and VKC is static, advertising may have dynamic effects:  
Roberts and Samuelson (1988) and Nerlove and Arrow (1962)  
Advertising enters the demand system in the form of goodwill stock.

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- Pricing and advertising strategies of each brand are not contingent on each other.
- Firms do not change pricing and advertising strategies in the study period.



# 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,  $\rho$  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  $\varphi_m$  is the awareness-to-cost index of medium  $m$

- Consider aligned AIDS

$$w_{ilt} = \alpha_{0i} + \sum_{k=1}^K \lambda_{ik} Z_{klt} + \sum_{j=1}^N \theta_{ij} G_{jlt} + \sum_{j=1}^N \gamma_{ij} \ln(p_{jlt}) \\ + [\beta_i \ln(M_{lt}) - \beta_i \ln(P_{lt})] + \varepsilon_{ilt}$$

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 &+ [\beta_i \ln(M_{lt}) - \beta_i \ln(P_{lt})] + \varepsilon_{ilt}
 \end{aligned}$$

$$\begin{aligned}
 \ln(P_{lt}) &= \delta + \sum_{m=1}^N \alpha_m \ln(p_{mlt}) + \sum_{m=1}^N \sum_{k=1}^K \lambda_{mk} Z_{klt} \ln(p_{mlt}) \\
 &+ \sum_{m=1}^N \sum_{j=1}^N \theta_{mj} G_{jlt} \ln(p_{mlt}) + \frac{1}{2} \sum_{m=1}^N \sum_{j=1}^N \gamma_{mj} \ln(p_{mlt}) \ln(p_{jlt})
 \end{aligned}$$

# Theoretical Restrictions

- Symmetry restrictions:

$$\gamma_{ij} = \gamma_{ji}, \theta_{ij} = \theta_{ji}, \forall i \neq j.$$

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- Homogeneity restrictions:

$$\sum_{i=1}^N \alpha_{0i} = 1; \quad \sum_{i=1}^N \lambda_{ik} = 0, \forall k; \quad \sum_{i=1}^N \gamma_{ij} = 0, \quad \sum_{i=1}^N \theta_{ij} = 0, \forall j;$$

$$\sum_{i=1}^N \beta_i = 0.$$

# Expenditure Endogeneity

- To control expenditure endogeneity, the reduced form expenditure equation is given by

$$\begin{aligned} M_{lt} &= f(\text{time trend, income}) \\ &= \xi Trend_t + \sum_{r=1}^9 \zeta_r D_r + \psi_1 INC_{it} + \psi_2 INC_{it}^2, \quad t = 1, \dots, T. \end{aligned}$$

where  $Trend_t$  is a linear time trend and  $INC_{it}$  is median household income in city  $l$  at time  $t$ .

## Constant Marginal Cost

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$c_{ilt}$  is the observable marginal cost component and specified as

$$c_{ilt} = \mu_0 + \mu_1 UPV_{ilt} + \sum_{j=1}^2 \mu_{2j} MCH_{iltj}$$

where  $UPV_{ilt}$  is the unit per volume and represents the average size of the purchase and  $MCH_{iltj}$  is the in-store marketing, including price reduction and all other merchandising (display and feature).



# 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.

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

# First-Order Conditions

- The first-order conditions in price are given by

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

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

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

# 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.

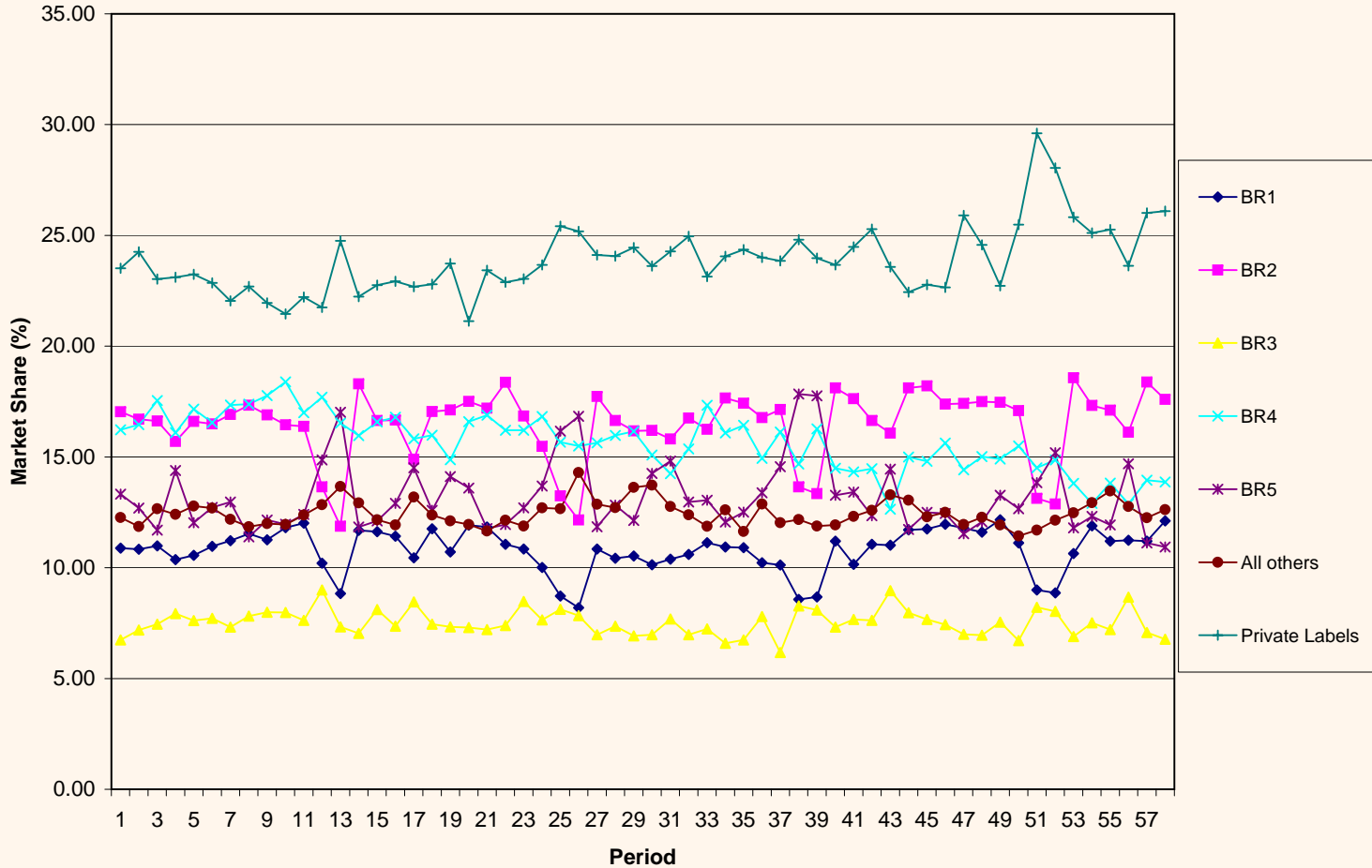
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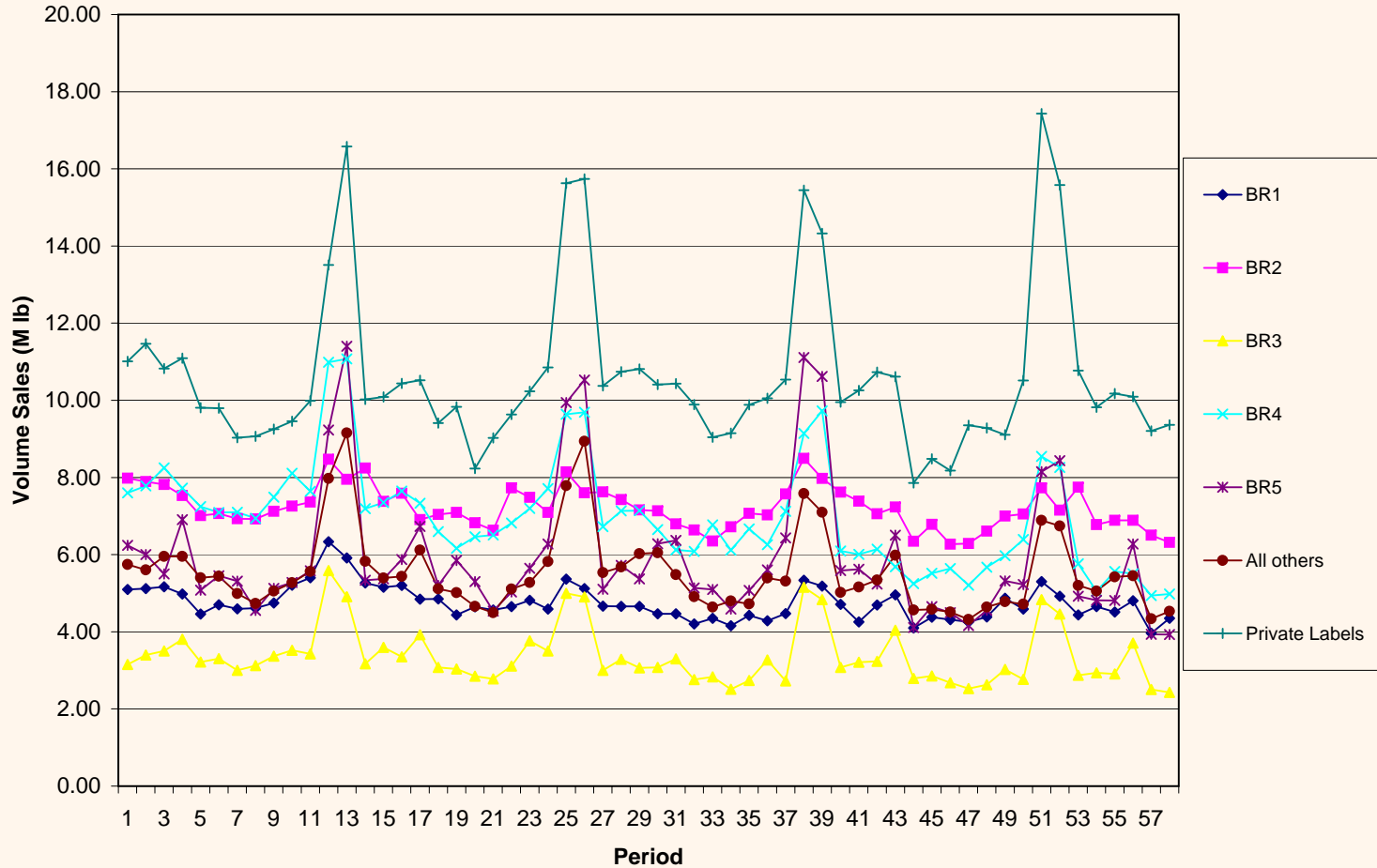
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- Demographic data: Current Population Survey (CPS)  
Initial Goodwill: COMPUSTAT

# Market Shares

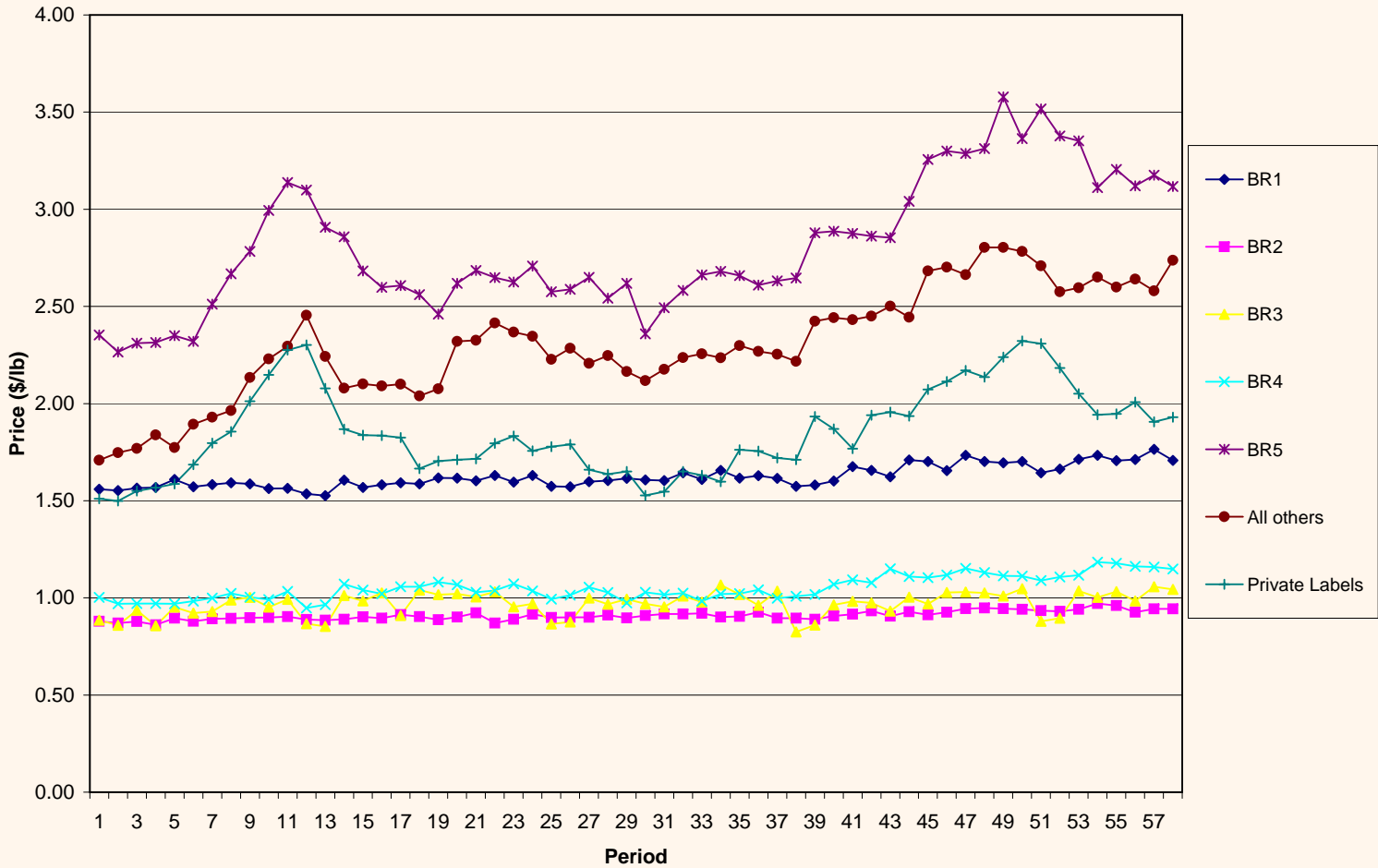


# Volume Sales





# Brand Price



## Market Shares, Advertising Share, and Advertising-Sales Ratio

<b>Brand Name</b>	<b>Market Share %</b>	<b>Advertising Share %*</b>	<b>Advertising-Sales Ratio</b>
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*	%
<b>TV</b>			<b>7,296</b>	<b>307,292</b>	<b>79.46</b>
	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
<b>Radio</b>			<b>154</b>	<b>8,667</b>	<b>2.24</b>
	Spot Radio	Local	113	1,328	0.34
	Network Radio	National	41	7,339	1.90
<b>Print</b>			<b>540</b>	<b>70,779</b>	<b>18.30</b>
	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
<b>Total</b>			<b>7,990</b>	<b>386,738</b>	<b>100.00</b>

\* Thousand dollars.

# Data Sources: CPS

## Demographic data

- 9 division binaries are from Census Bureau Geography
- 7 other demographic variables are from Current Population Survey – Annual Demographic Survey (March CPS Supplement) and IRI:

PERLT10K (percentage of household earning less than \$10,000)

PERGT50K (percentage of household earning more than \$50,000)

HUNDER15 (average number of people under age 15)

H\_NUMBER (average household size)

A\_AGE (median household age)

FSPANISH (percentage of Hispanics)

POPU (population) from IRI

# Descriptive Statistics

## Mean Purchase Characteristics

Brands	Price (\$/lb)		Expenditure share (%)		Total Revenue (\$M/city)		Advertising Expenditure (\$K/city)	
BR1	1.61	(0.17)	0.11	(0.03)	15.95	(12.27)	784.168	(713.85)
BR2	0.90	(0.12)	0.11	(0.05)	13.58	(8.66)	578.949	(524.90)
BR3	1.03	(0.20)	0.05	(0.02)	6.69	(6.58)	696.841	(642.83)
BR4	1.05	(0.22)	0.14	(0.07)	15.10	(8.99)	590.145	(550.57)
BR5	2.85	(0.54)	0.19	(0.09)	34.63	(43.57)	611.279	(637.86)
All others	2.13	(0.59)	0.14	(0.11)	26.42	(42.28)	2408.932	(2181.36)
Private Labels	1.74	(0.52)	0.26	(0.07)	41.11	(37.14)	17690.744*	(17940.37)

Brands	Unit Per Volume		All Merchandising (%)		Price Reduction (%)		All Others (%) [Display & Feature]	
BR1	0.98	(0.04)	21.56	(13.79)	8.72	(9.00)	12.85	(11.69)
BR2	0.56	(0.05)	24.78	(11.78)	9.89	(8.34)	14.89	(9.87)
BR3	0.93	(0.07)	26.96	(16.13)	10.58	(10.57)	16.37	(14.32)
BR4	0.91	(0.06)	31.19	(13.76)	12.55	(8.74)	18.64	(12.67)
BR5	1.09	(0.04)	34.37	(21.11)	16.37	(14.09)	18.01	(18.68)
All others	1.08	(0.10)	23.66	(15.61)	12.76	(9.78)	10.89	(12.57)
Private Labels	0.90	(0.09)	38.53	(21.41)	16.20	(13.97)	22.33	(17.73)

## Mean Values of Other Explanatory Variables

Variables	Units	Mean	Variables	Units	Mean
PERLT10K	%	8.64 (3.22)	Median Income	\$	44317.32 (6484.37)
PERGT50K	%	44.03 (6.63)	Per Capita Expenditure	\$	0.72 (0.19)
HUNDER15	#	0.58 (0.09)			
H_NUMBER	#	2.57 (0.16)			
A_AGE	Years	34.01 (2.42)			
FSPANISH	%	13.40 (10.74)			
POPU	#	3651213 (3361325)			

\* Expenditure of in-store marketing activities is used as a proxy.

Note: Numbers in parentheses are the standard deviations.

# LIML Estimation

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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.
- Murphy and Topel (1985) argue that the covariance matrix at the second stage of LIML has to be corrected because hypothesis tests based on it are biased, even in large samples.



# LIML Estimation

(I)

Product  
Pricing  
Space  
(3)

Product  
Advertising  
Space  
(1) (2) (3)

Expenditure  
Endogeneity  
(5)

(II)

Market  
Structure  
Pricing  
Games  
(10)

Market  
Structure  
Advertising  
Games  
(11)

Product  
Cost  
Structure  
(8)

# Model Selection Procedures

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**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.

## Number of CV Parameters in Each Model

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

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- **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	<b>0.9897</b> (0.0044)
BR3	<b>0.5855</b> (0.1120)
BR4	<b>0.9533</b> (0.0159)
BR5	<b>0.9578</b> (0.0105)
AO	0.0039 (0.5175)
PL	<b>0.9492</b> (0.0066)

## Awareness-to-Cost (ATC) Index

Media	Estimates
TV & Radio	<b>0.8395</b> (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.