Advertising, Structural Change, and U.S. Non-Alcoholic Beverage Demand*

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Galbraith's hypothesis "If advertising affects the distribution of demand between sellers of a particular product, it must also be supposed that it affects the distribution between products" (Galbraith, p.205; see also Duffy 1991) assumes added significance in the context of non-alcoholic beverage advertising. At $1.1 billion in 1994 alone, this group is one of the most heavily advertised in the U.S. economy. Moreover, two items in the group -- milk and fruit juices -- are the target of significant levels of producer-financed generic advertising (over $100 million in 1994). Another $114 million now exists for the milk moustache print campaign funded by milk processors (USDA, AMS). Although substantial research has been done to determine whether generic advertising of milk and fruit juices is profitable (e.g., Blisard *et al*.; Kaiser; Lee and Brown; Ward and Dixon; Wohlgenant and Clary), no study has investigated beverage demand in an integrated framework that takes into account the full array of substitution effects. For example, a successful fluid milk advertising campaign might erode the demand and price for citrus products. In addition, the resulting decrease in citrus price could lower the milk price through second-round or feedback effects. These spillover and feedback effects have not been addressed in the milk and citrus advertising literatures, which could cause the estimated returns to be overstated (Kinnucan, 1996).

In this paper, we determine whether advertising of non-alcoholic beverages has any detectable effect on aggregate demand. Owing to the importance of demand interrelationships, special attention is given to spillover effects, i.e., whether one beverage's advertising affects the demand for related beverages. A secondary objective is to test whether structural change plays a role in the observed consumption pattern, particularly the rise in soft-drink consumption between 1970 and 1994 from 24.3 gallons per person to 52.2 gallons and the decline in milk consumption from 31.3 gallons per person to 24.7 gallons.

Prior to presenting the model and data, we discuss briefly our testing procedure for structural change.

The hypothesis tests, parameter estimates, and elasticities are then presented and discussed. The paper concludes with a summary of the major findings.

Testing for Structural Change

[*This section omitted to conserve space. Contact authors for full paper.*]

Model

The Rotterdam model was selected because it is consistent with demand theory (Theil 1965; Barnett); it is as flexible as any other local approximating form (Mountain); it lends itself to advertising applications (e.g., Brown and Lee; Duffy 1987, 1990); it appears to be robust to alternative separability assumptions (Moschini, Moro, and Green, pp. 64-69); and prior testing indicated that the estimated advertising effects from the Rotterdam model were similar to those obtained from its major rival, the (linear approximate) Almost Ideal Demand System, and from a double-log specification (Xiao).ent with the beverage demand literature (e.g., Ward and Dixon; Brown and Lee).

To conserve degrees of freedom, a two-stage budgeting process is assumed. In the first stage, the consumer allots his or her total income to broad commodity groups, one of which is non-alcoholic beverages. In the second stage, the consumer allots the beverage budget among the individual drinks. The basic specification is:

(1) $\bar{s}_{it}\, Dq_{it} = \mu_i{}' \bar{S}_{Gt}\, DQ_{G\,t} + \sum_j^4 \pi_{ij}\, Dp_{jt} + \sum_j^4 \beta_{ij}\, DA_{jt} + a_i + b_i\, Dage_t + c_i\, Dfafh_t + v_{it}$

and

(2) $\bar{S}_{G\,t}\, DQ_{G\,t} = \mu_G\, DQ_t + \pi_G\, [\sum_j^4 \mu_j{}' Dp_{jt}] + \pi_O\, Dp_t^0 + \beta_G\, [\sum_j^4 \mu_j{}' DA_{jt}] + \beta_O\, DA_t^0$

$+ a_G + b_G\, Dage_t + c_G\, Dfafh_t + v_{Gt}$

where equation (1) corresponds to the second-stage (conditional) demand functions for beverage i (i = 1, 2, 3, 4 for milk, juices, soft drinks, and coffee and tea, respectively) in year t (t = 2, 3,...,25 for 1971 to 1994), and equation (2) corresponds to the first-stage (group) demand function.

In (1) and (2), D denotes the logarithmic first-difference operator, i.e., $Dx = \ln x_t - \ln x_{t-1}$; the subscript

G denotes the non-alcoholic beverage group; and the subscript O denotes all other ("non-group") goods. The $\bar{s}_{it}$ term in (1) is the budget share for the ith beverage in year t expressed as an average of the current and preceding year's budget shares, i.e., $\bar{s}_{it} = (s_{it} + s_{it-1})/2$, where $s_i = p_i q_i / \sum_i^n p_i q_i$. Similarly, $\bar{S}_{Gt} = \sum_i^4 \bar{s}_{it}$ is the corresponding group budget share. The term $DQ_{G\,t} = \sum_i^4 (\bar{s}_{it} / \bar{S}_{G\,t}) Dq_{it}$ in (1) and (2) is G's Divisia volume index, which can be interpreted as a third-order approximation of real expenditure on the non-alcoholic beverage group (Goldberger, p. 95). The q_{it} term denotes per capita consumption of beverage item i in year t; p_{jt} is the nominal price of beverage item j in year t; A_{jt} is the real per capita advertising expenditure on beverage item j in year t; age_t is the proportion of the U.S. population less than age five in year t; $fafh_t$ is the ratio of food-away-from-home expenditures to food-at-home expenditures in year t; and v_{it} and v_{Gt} are random error terms. Intercepts a_i and a_G are included in (1) and (2) to test for (non-specific) structural change.

The DQ_t term in (2) is real per capita income in logarithmic first-difference form, which may be interpreted as the Divisia volume index corresponding to total consumer expenditure, "income" for short. The p_t^o term is a price index for non-group goods, and A_t^o is the total real per capita advertising expenditure on non-group goods. Setting $a_G = b_G = c_G = 0$ (no group structural change or demographic effects), equation (2) reduces to Duffy's group-demand equation [1987, p. 1060, eqn.(10)] when price and advertising homogeneity are imposed. In this study, we treat price homogeneity in the group-demand equation ($\pi_G + \pi_O = 0$) as a maintained hypothesis, but impose advertising homogeneity ($\beta_G + \beta_O = 0$) only if it is compatible with the data.

The μ_i' term in (1) is the conditional marginal share of the ith drink, and the corresponding μ_G term in (2) is G's marginal share. As noted by Duffy (1987, p. 1054):

$$\sum_i^4 \mu_i' = 1 \qquad \text{and} \qquad \mu_i' = \mu_i / \mu_G$$

where μ_i is the ith's beverage unconditional marginal share. Notice that the conditional marginal shares play a dual role in this model: to indicate how beverage expenditure is allocated at the margin [see (1)]; and to serve as weights in constructing the group price and advertising indices [the bracketed terms in (2)].

[*Elasticity formulas omitted to conserve space.*]

The theoretical properties of homogeneity in prices and income, Slutsky symmetry, and adding up imply the following parametric restrictions on the conditional demand functions:

(7a) $\sum_{j}^{4} \pi_{ij} = 0$ $i = 1,...,4$ (price homogeneity)

(7b) $\pi_{ij} = \pi_{ji}$ for all i, j (price symmetry)

(7c) $\sum_{i}^{4} \pi_{ij} = 0$ $j = 1,...,4$ (Cournot)

(7d) $\sum_{i}^{4} a_i = \sum_{i}^{4} b_i = \sum_{i}^{4} c_i = 0$ and $\sum_{i}^{4} \mu_i' = 1$ (adding up)

These conditions, along with advertising adding-up (Basmann, p. 57),

(8a) $\sum_{i}^{4} \beta_{ij} = 0$ $j = 1,...,4$

are treated as maintained hypotheses.

With prices and expenditure held constant, Selvanathan (pp. 216 and 218) shows that advertising responses in the absolute price version of the Rotterdam model are homogeneous of degree zero, i.e.,

(8b) $\sum_{j}^{4} \beta_{ij} = 0$ $i = 1,...,4.$

The symmetry condition,

(8c) $\beta_{ij} = \beta_{ji}$ for all i, j

however, does not necessarily hold (Selvanathan, pp. 218-19). In this study, restrictions (8b) and (8c) are tested, and imposed only if they are compatible with the data.

Data

[*Omitted to conserve space.*]

Estimation Procedure

Equations (1) and (2) were estimated jointly using the Iterative Seemingly Unrelated Regression (ITSUR) routine in *Eviews*.

The advertising homogeneity and symmetry conditions [(8b) and (8c)] were tested using the Wald criterion. Based on these tests, an appropriately restricted model was used to test for structural change and the significance of advertising effects. Elasticities are evaluated at mean budget shares for 1990-94, the last five years in the sample.

Results

The Wald tests indicated that advertising homogeneity and symmetry in the conditional demand equations are compatible with the data (table 1). In addition, a *t*-test indicated that advertising homogeneity could not be rejected in the group demand equation. Accordingly, analysis proceeded with advertising symmetry and homogeneity imposed on both (1) and (2).

The hypothesis that trend, either singularly, or in combination with the demographics, can be deleted from the model is rejected at almost no chance of a Type I error [models (1c) and (1g)]. A similar result holds regarding the effects of advertising [model (1h)]. Thus, we conclude that the demand for non-alcoholic beverages in the United States is affected by both advertising and structural change.

All the own-price and expenditure coefficients have the expected sign and most are significant (table 2). The cross-price coefficients are all positive, suggesting that the beverages are conditional net substitutes. Most of the advertising and trend coefficients in the conditional demand equations are significant and most of the demographic coefficients are not, as expected based on the Wald tests. In particular, *age* is significant only in the milk demand equation and the group demand equation; *fafh* is significant only in the milk demand equation and, if a one-tail test is accepted, in the juices' equation. The trend terms (intercepts) are significant in all equations except juices and group demand.

The advertising variables in the group demand equation are not significant (table 3). Thus, the hypothesis that advertising affects the total demand for non-alcoholic beverages is rejected. Combining this result with the results for the conditional demand equations, it appears that advertising affects the market shares of non-alcoholic beverages in the United States, but not the market size. This finding, which is in line with Duffy's (1987, 1990, 1991), casts doubt on Galbraith's hypothesis as it pertains to the U.S. non-alcoholic beverage market as a whole.

The remaining discussion focuses on the elasticities (computed from the simultaneous estimates), as these are the parameters of primary interest in this study. To highlight the importance of taking into account both stages of the posited two-stage budgeting process, we present in tables 4 and 5 both the conditional and the unconditional elasticities.

[*Discussion of price and expenditure effects is omitted to conserve space.*]

Advertising Effects

The estimated advertising elasticities affirm the importance of spillover (table 5). Whereas only half of the own-advertising elasticities are significant, fully two-thirds of the cross elasticities are statistically significant. Moreover, many of the cross-advertising elasticities are larger in absolute value than the own-advertising elasticities, and in some cases exceed the price or income elasticities in table 4. Overall, coffee and tea appear to be the most affected by advertising of other commodities, and milk the least (row). Similarly, juice advertising appears to exert the largest influence within the beverage market, and milk advertising the least (column).

Demographic and Trend Effects

Among the variables indicating structural change, trend has the largest effect and *age* and *fafh* the least. The elasticities for *age* and *fafh*, which are significant only for milk, are absolutely less than 0.3. This suggests that changes in these variables have only modest effects on milk consumption.

Turning to the trend "elasticities," we focus on the conditional estimates, as trend was not significant in the group demand equation. All the conditional trend elasticities, with the exception of juices, are significant and absolutely larger than the price, income, advertising, and demographic elasticities (compare tables 4 and 5). These elasticities (-1.00 for milk, 1.96 for soft drinks, and -3.54 for coffee and tea) indicate the *per annum* percent change in per capita quantity that would take place in the absence of changes in the remaining variables in the model.

Concluding Comments

The dominant pattern in U.S. non-alcoholic beverage consumption over the past 25 years has been a steady increase in per-capita soft-drink consumption, largely at the expense of coffee consumption and, to a lesser extent, milk consumption. Although changes in relative prices, income, and advertising have influenced this pattern, our results suggest that structural change is at work. The basis for this claim, which is new to the literature, is that the trend coefficient in each of the estimated conditional demand equations except juice is significant. Moreover, the trend "elasticities" are much larger than the price, income, and advertising elasticities, which suggests that structural change is the chief factor affecting the consumption pattern. Specific sources of structural change, namely Americans' penchant for dining out and the aging of the U.S. population, appear to be confined in their effects to milk, and to be relatively modest in their impacts.

Table 1. Wald Tests of Restrictions on the Conditional Demand Equations

Model	Restriction	Computed χ^2	*p*-value
Text eq. (1)	Price Homogeneity (PH) and Price Symmetry (PS) (Maintained hypotheses)	--	--
1a	PH, PS and advertising homogeneity (AH)	4.556	0.2073
1b	PH, PS, AH and advertising symmetry (AS)	7.4091	0.2847
1c	PH, PS, AH, AS and $a_i = 0$, all i	19.944	0.0002
1d	PH, PS, AH, AS and $b_i = 0$, all i	5.262	0.1536
1e	PH, PS, AH, AS and $c_i = 0$, all i	5.472	0.1403
1f	PH, PS, AH, AS and $b_i = c_i = 0$, all i	11.867	0.0650
1g	PH, PS, AH, AS and $a_i = b_i = c_i = 0$, all i	66.094	0.0000
1h	PH, PS and $\beta_{ij} = 0$, all i, j	85.802	0.0000

Table 2. Coefficient Estimates of Conditional Demand Equations for Non-Alcoholic Beverages, United States, 1971-94

Equation	Price Coefficients				Advertising Coefficients				Expend.	Intercept	*AGE*	*FAFH*	R^2	*D.W.*
	π_{i1}	π_{i2}	π_{i3}	π_{i4}	β_{i1}	β_{i2}	β_{i3}	β_{i4}	μ_i'	a_i	b_i	c_i		
Recursive Estimates[a]														
Milk	-0.0453				0.0009				0.0850	-0.0028	0.0560	-0.0632	0.47	2.05
	(-4.87)[b]				(1.05)				(2.73)	(-3.46)	(1.23)	(-2.56)		
Juices	0.0310	-0.0670			0.0092	0.0219			0.1909	-0.0016	0.1197	0.0772	0.71	2.58
	(3.78)	(-2.80)			(4.60)	(2.36)			(2.52)	(-0.78)	(1.04)	(1.30)		
Soft Drinks	0.0080	0.0287	-0.0551		-0.0047	0.0068	-0.0377		0.4608	0.0091	-0.0688	-0.0535	0.56	2.11
	(1.01)	(1.63)	(-2.76)		(-1.76)	(0.66)	(-2.02)		(4.78)	(3.42)	(-0.50)	(-0.70)		
Coffee & Tea	0.0063	0.0073	0.0185	-0.0321	-0.0054	-0.0380	0.0355	0.0078	0.2633	-0.0047	-0.1077	0.0395	0.48	2.53
	(1.39)	(0.66)	(1.44)	(-2.42)	(-2.16)	(-4.56)	(2.67)	(0.59)	(2.78)	(-1.88)	(-0.81)	(0.56)		
Simultaneous Estimates[c]														
Milk	-0.0474				0.0008				0.1142	-0.0028	0.0772	-0.0718	0.41	1.92
	(-4.52)				(0.88)				(4.07)	(-3.58)	(1.81)	(-2.91)		
Juices	0.0258	-0.0567			0.0078	0.0213			0.1096	-0.0012	0.0753	0.0900	0.74	2.54
	(2.93)	(-2.39)			(4.04)	(2.09)			(1.54)	(-0.70)	(0.76)	(1.68)		
Soft Drinks	0.0114	0.0288	-0.0596		-0.0037	0.0065	-0.0434		0.5379	0.0085	-0.0561	-0.0471	0.56	2.03
	(1.30)	(1.70)	(-3.05)		(-1.34)	(0.58)	(-2.39)		(7.50)	(3.45)	(-0.47)	(-0.64)		
Coffee & Tea	0.0102	0.0020	0.0194	-0.0316	-0.0050	-0.0356	0.0404	0.0002	0.2382	-0.0045	-0.0964	0.0291	0.54	2.37
	(2.04)	(0.19)	(1.52)	(-2.55)	(-2.03)	(-4.61)	(3.29)	(0.02)	(4.07)	(-2.12)	(-0.90)	(0.46)		

Serial correlation parameter (common to all equations): $\hat{\rho}$ = -0.2618, *t* -ratio = -2.08

[a] Model (1b) of table 1 estimated by ITSUR regression without correction for serial correlation. All coefficients except expenditure are divided by group budget share.
[a] Numbers in parentheses are asymptotic *t*-ratios.
[c] Model (1b) of table 1 estimated jointly with the group demand equation (see table 3) by ITSUR with correction for serial correlation.

Table 3. Coefficient Estimates of Group Demand Equation for Non-Alcoholic Beverages, United States, 1971-94

Estimation Procedure	Price Coefficients		Advertising Coefficients		Income	Intercept	*AGE*	*FAFH*	R^2	*D.W.*
	π_G	π_O	β_G	β_O	μ_G	a_G	b_G	c_G		
Recursive[a]	-0.00498 (-3.47)	0.00498 (3.47)	0.00009 (0.34)	-0.00009 (-0.34)	0.00165 (0.66)	-0.000036 (-0.46)	-0.00949 (-2.13)	0.00137 (0.69)	0.48	2.10
Simultaneous [b]	-0.00589 (-3.39) [-0.5122]	0.00589 (3.39) [0.5122]	-0.00026 (-0.93 [-0.0225]	0.00026 (0.93) [0.0225]	0.00240 (1.11) [0.2087]	-0.000054 (-0.87) [-0.4696]	-0.01207 (-3.01) [-1.0496]	0.00091 (0.56) [0.07913]	0.48	2.12

[a] Text equation (2) with price and advertising homogeneity imposed estimated by OLS.

[b] Text equation (2) with price and advertising homogeneity imposed and estimated jointly with text equations (1) by ITSUR.

Note: Number in parentheses is *t*-ratio; number in brackets is elasticity.

Table 4. Hicksian Price and Expenditure Elasticities for Non-Alcoholic Beverages, United States, Evaluated at 1990-94 Mean Data Points

Quantity of:	Price of: Milk	Juices	Soft Drinks	Coffee & Tea	Other Goods	Expenditure	Budget Share
	Conditional [a]						
Milk	-0.1685**	0.0917**	0.0405	0.0363**	--	0.4060**	0.2813
Juices	0.1642**	-0.3609**	0.1833	0.0127	--	0.6976	0.1571
Soft Drinks	0.0262	0.0663	-0.1372**	0.0447	--	1.2383**	0.4344
Coffee & Tea	0.0803**	0.0157	0.1528	-0.2488**	--	1.8756**	0.1270
	Unconditional [a]						
Milk	-0.1922**	0.0690*	-0.0709*	-0.0131**	0.2072*	0.0844*	0.0032
Juices	0.1236*	-0.3999*	-0.0082*	-0.0721*	0.3560*	0.1450	0.0018
Soft Drinks	-0.0459*	-0.0030*	-0.4771**	-0.1059*	0.6319*	0.2574*	0.0050
Coffee & Tea	-0.0290**	-0.0892*	-0.3621*	-0.4768**	0.9571*	0.3899*	0.0015

[a] Based on the simultaneous estimates presented in tables 2 and 3. Double asterisk indicates that all of the parameters in the applicable elasticity formula (see text equations (3), (4) and (6)) are individually significant; single asterisk indicates that at least one is significant; no asterisk indicates none is significant.

Table 5. Advertising, Trend, and Demographic Elasticities for Non-Alcoholic Beverages, United States, Evaluated at 1990-94 Mean Data Points

Quantity of:	Advertising of: Milk	Juices	Soft Drinks	Coffee & Tea	Other Goods	Trend	*age*	*fafh*	Advertising Intensity [b]
	Conditional [a]								
Milk	0.0028	0.0277**	-0.0132	-0.0178**	--	-0.9954**	0.2744*	-0.2552**	0.0032
Juices	0.0497**	0.1356**	0.0414	-0.2266**	--	-0.7638	0.4793	0.5729	0.0297
Soft Drinks	-0.0085	0.0150	-0.0999**	0.0930**	--	1.9567**	-0.1291	-0.1084	0.0207
Coffee & Tea	-0.0394**	-0.2803**	0.3181**	0.0016	--	-3.5433**	-0.7591	0.2283	0.0421
	Unconditional [a]								
Milk	0.0018	0.0267*	-0.0181	-0.0200*	0.0091	-1.1853*	-0.1502**	-0.2232*	0.0032
Juices	0.0479*	0.1339*	0.0329	-0.2304*	0.0157	-1.0903	-0.2504	0.6279	0.0297
Soft Drinks	-0.0117	0.0119	-0.1149*	0.0864*	0.0279	1.3773*	-1.4243	-0.0108	0.0207
Coffee & Tea	-0.0442*	-0.2849*	0.2954*	-0.0085	0.0423	-4.4210*	-2.7208	0.3761	0.0421

[a] Based on the simultaneous estimates presented in tables 2 and 3. Double asterisk indicates that all of the parameters in the applicable elasticity formula (see text equations (3), (4) and (6)) are individually significant; single asterisk indicates that at least one is significant; no asterisk indicates none is significant.

[b] Advertising expenditure divided by retail revenue. Advertising intensity for the group as a whole is 0.0199.

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